ORIGINAL ARTICLE

Effects of Sodium Hypochlorite Irrigation on Dentine Hardness

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ABSTRACT

Introduction: An endodontic treatment consists of removing all contents of the root canal system during the shaping phase. Irrigation is presently the best method for the removal of tissue remnants and dentine debris during instrumentation. Irrigation solutions also provide gross debridement, lubrication, and destruction of microbes and dissolution of tissues. The aim of this study was to investigate the effect of the two different concentrations of sodium hypochlorite (5.25% and 2.25%) on hardness of dentin.
Materials and Methods: Forty eight single rooted extracted human teeth were selected, and preserved in sterile water. Crowns of the teeth were sectioned from the roots at the cemento-enamel junction using a diamond bur in a high-speed hand-piece. Cleaning and shaping of the roots using K-files was commenced. Canals were irrigated with 1 ml of sterile water after each file used. After that each root was placed in the brass holder of a diamond wheel saw and transversely sectioned into cervical, middle and apical sections, each of 3 mm thickness. The apical surface of the root sections were covered with an adhesive tape to seal the canal entrance and then placed upside down (i.e. with the coronal surface lowermost) on a sticky sheet in a polypropylene ring frame. Self-cure acrylic was mixed to a thin consistency and poured into the frame until the root section was covered. Each acrylic disc was then polished using sand paper of decreasing abrasivity until a smooth surface was achieved, and then dried. Hardness testing was carried out using a Wallace Hardness Tester. After measurement of the initial hardness, specimens were randomly allocated into two groups, each of 24 roots and treated in two different concentrations of irrigation solutions (5.25% and 2.25%). Final hardness was measured and compared.
Results: Data obtained from the test was analysed using SPSS (Version 15.0, SPSS Inc., USA). Descriptive analysis was executed in form of mean ± standard deviation for Hardness of each group. Paired "t" test was used to evaluate the significance of difference in the dentine hardness within the groups. The level of significance was set at 0.05. Analysis showed that there was a significant decrease (p=0.00) in the hardness of dentine after treatment with 2.25% and 5.25% sodium hypochlorite concentrations. The level of significance was set at 0.05.
Conclusion: Irrigation with 2.25% and 5.25% concentrations of sodium hypochlorite resulted in a statistically significant decrease in hardness of root dentine both for the whole root and at coronal, mid and apical levels at 1mm depth.

Keywords: Dentine, Hardness, Vickers Hardness Number.

INTRODUCTION

The aim of endodontic treatment is the abolition and elimination of every microorganisms from the root canal system.[1] Undoubtedly, the major factors associated with endodontic failure are the persistence of microbial infection in the root canal system and/or the periradicular area.[2] Mechanical endodontic instruments alone cannot achieve the biological objectives when the typical configurations of any given root canal system are considered.[3-4] It is generally accepted that "endodontic files" shapes the root canals and irrigants provided cleaning,[5] an appropriate irrigant should be used for effective root canal treatment.[6] However, the use of some irrigants may cause changes in the physical and chemical properties of dentine.[5] Currently, the most commonly used irrigating solution is sodium hypochlorite (NaOCl).[5-6] NaOCl is a well-known non-specific proteolytic agent and demonstrates effective removal of organic components from biological materials at room temperature.[7] It dissolves seven times as much organic tissue as citric acid, chelating agents, oxidizing agents, normal saline and distilled water.[8]

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Various concentrations of NaOCl in the range of 0.5% up to 6% are used clinically.[8] 5.25% concentration has demonstrated effective antimicrobial properties. Clinical and laboratory studies have shown that this solution destroys most microorganisms found in the root canal system after exposure of 1 minute or less.[8] The antimicrobial efficacy of sodium hypochlorite is due to its ability to oxidize and hydrolyse cell proteins and, to some extent, osmotically draw fluids out of cells due to its hypertonicity.[9] However, sodium hypochlorite react with the organic dentine component, thus affecting the physical, chemical and mechanical properties of dentine.[10-11]

Several studies have investigated the effect of irrigants on dentine hardness.[12-13] In 1999, Saleh and Ettman[11] evaluated the effect of several endodontic irrigation solutions on the microhardness of root canal dentine and concluded that by alternating hydrogen peroxide with sodium hypochlorite and EDTA, dentine microhardness was significantly reduced.[9] Cruz-Filho *et al.*[14] studied the effect of 1%, 3% and 5% EGTA on the microhardness of the root dentine of the cervical third of human teeth and concluded that use of all three concentrations resulted in a statistically significant reduction in dentine microhardness.[14] In addition, the effect of calcium hydroxide,[15] NaOCl, EDTA, Chlorexhidine, H2O2,[16] and NaOCl as irrigants on dentine microhardness have been studied.[16-17] and found variable results. It has been established that sodium hypochlorite with EDTA produces the best results but the effect of different concentrations of sodium hypochlorite on dentine has not been established. The aim of this study was to investigate the effect of the two different concentrations of sodium hypochlorite (5.25% and 2.25%) on hardness of dentin hardness. The hypothesis tested therefore was no difference in the dentine hardness before and after exposure to the two different concentrations of sodium hypochlorite.

MATERIALS AND METHODS

It was an experimental interventional in vitro study. The study was conducted in the department of Endodontics, University of Manchester, UK. Duration of study was Six months. Human permanent, forty eight single rooted teeth extracted due to periodontal reasons were selected. The teeth with caries and resorption were excluded from the study.

All extracted human teeth that were selected were preserved in sterile water. All teeth had at least 10 mm of root length, and were free from cracks, caries and restorations in the root. None of the teeth had previously undergone root canal treatment. Crowns of the teeth were sectioned from the roots at the cemento-enamel junction using a diamond bur in a high-speed hand-piece. A size 15 K-file was introduced into the canal until it was just seen to exit from the apical end. The working length was determined by measuring the length of the file from point of entry into the canal to the point of exit from the canal and subtracting 1 mm from that length.

Cleaning and shaping of the roots using K-files was commenced. Canals were irrigated with 1 ml of sterile water after each file used. After that each root was placed in the brass holder of a diamond wheel saw (South Bay Technology Inc., CA, USA) and transversely sectioned into cervical, middle and apical sections, each of 3 mm thickness.

The apical surface of the root sections were covered with an adhesive tape to seal the canal entrance and then placed upside down (i.e. with the coronal surface lowermost) on a sticky sheet in a polypropylene ring frame**.** Self-cure acrylic was mixed to a thin consistency and poured into the frame until the root section was covered. The adhesive tape prevented entry of acrylic into the canal lumen.

After the self-cure acrylic had set, the acrylic discs in which the root segments were embedded, were removed from the polypropylene ring frame and the sticky sheet removed to expose the coronal surfaces of the segments at which the hardness testing would be performed and any excess acrylic trimmed away. Each acrylic disc was then polished using sand paper of decreasing abrasivity until a smooth surface was achieved, and then dried.

Hardness testing was carried out using a Wallace Hardness Tester® (H.W. Wallace Co. Ltd., Kingston, UK). Each acrylic disc containing the root sections was positioned and immobilized in the tester such that the test surfaces of the root sample were oriented at 90° to the indenter axis. The indenter was then brought into contact with the specimen surface. A load of 1g was applied for 5 s to stabilise contact between the indenter and surface of specimen. The depth indicator on the dial gauge was adjusted to zero. A load of 300 g was applied for 10 s and the indentation depth number was recorded. The dial readings were subsequently converted into reciprocal penetration (mm^{-1}).

Every root section was divided into four quarters (Fig 1). Two markings were made in the acrylic for each quarter to define area for hardness measurement; the first mark for pre-irrigation and the second for post-irrigation measurement. Each quarter received one indentation 1 mm away from the pulp lumen. Each root segment received a series of four pre-irrigation indentations made around the pulp space, i.e. collectively for each root there were 12 readings, four each for the coronal segment, the middle segment and the apical segment. The mean for each segment was calculated.

Figure 1: Root sections embedded in the acrylic disc with marking to Identify locations for hardness Measurement, sample no.48

After measurement of the initial hardness, specimens were randomly allocated into two groups, each of 24 roots. For Irrigation 12% (w/v) (NaOCl) solution (BDH, VWR International Ltd., UK) was diluted using sterile water to the concentrations of 5.25% and 2.25%.

The dentine surfaces of the coronal cut stump of each root section were masked with a non-porous, water-resistant adhesive tape for protection from direct action of the irrigant and to limit the effect of the irrigants to the lumen of the canal only.

In Group A, the canal portion of the root segments was irrigated with 5.25% NaOCl, using an irrigating syringe with a 27-gauge needle. The lumen was completely filled with the irrigant, and left for 1h. Although the coronal surface of the root sections was masked with non-porous adhesive tape, caution was exercised to avoid over flooding the canal. If the level of irrigant decreased, more solution was added to keep the lumen filled. After 1h, the irrigant was washed away with sterile water and the samples dried. Hardness was measured again as described above at the same depth at the location sites described above. Root sections in Group B were treated as for those in Group A apart from a 2.25% solution being used.

When not being used during the experiment, specimens were placed in a plastic container in plastic bags containing sterile water to prevent dehydration.

Statistical Analysis: Data obtained from the test was analysed using SPSS (Version 15.0, SPSS Inc., USA). Descriptive analysis was executed in form of mean ± standard deviation for Hardness of each group. Paired "t" test was used to evaluate the significance of difference in the dentine hardness within the groups. The level of significance was set at 0.05.

RESULTS

Pre-irrigation values obtained for the test served as the control, so there was no need for a separate control group in the test. Hardness values obtained before and after treatment with different concentrations of sodium hypochlorite for the whole root are presented in Table 1 and graphically in Figure 2. The hardness of each root section was also measured. Hardness values for coronal, middle and apical sections are presented in Table 2 and Figure 3.

Statistical analysis showed that there was a significant decrease (p=0.00) in the hardness of dentine after treatment with 2.25% or with 5.25% sodium hypochlorite concentrations.

Both 5.25% and 2.25% sodium hypochlorite solutions were found to cause a significant decrease (p=0.00) in dentine hardness in all of the root sections at coronal, middle and apical levels when compared to the pre-irrigation measurements. There was no statistically significant difference (p=0.35) in reduction in dentine hardness between the coronal, middle and apical root sections.

Table 1: Means and standard deviations of hardness values

Sodium Hypochlorite concentrations	Dentine Hardness		P value
	Before Mean (±S.D)	After Mean (±S.D)	
Group A (5.25%)	3.28 (±0.48)	2.53 (±0.45)	0.000
Group B (2.25%)	3.34 (±0.36)	2.75 (±0.61)	0.000

Table 2: Means and standard deviations in parenthesis of Vickers Hardness Number for the different root sections before and after introduction of the irrigants.

Sodium Hypochlorite Concentrations	Tooth Surface	Before Mean (±S.D)	After Mean (±S.D)	P value
5.25%	Coronal	3.05 (± 0.54)	2.37 (±0.42)	0.000
	Middle	3.62 (±0.31)	2.85 (±0.50)	
	Apical	3.47 (±0.47)	2.76(±2.44)	
2.25%	Coronal	3.45 (±0.46)	2.63 (±0.44)	0.000
	Middle	3.71 (±0.35)	3.18 (±0.57)	
	Apical	3.26 (±0.63)	2.79 (±0.61)	

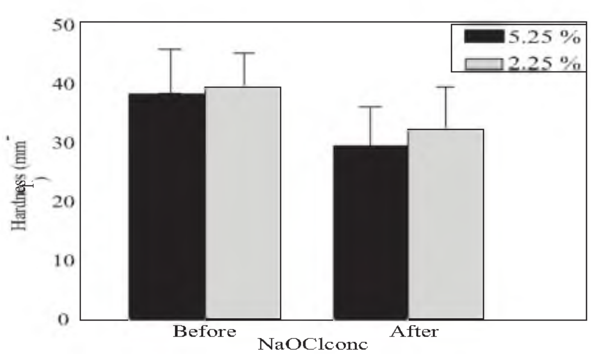

Figure 2: Hardness (mm^{-1}) for the whole root before and after NaOCl irrigation of 5.25 % and 2.25 % conc. for 1 hour.

DISCUSSION

The success of endodontic treatment depends on the eradication of microbes from the root-canal system and prevention of reinfection.[1] The root canal is shaped with hand and rotary instruments under constant irrigation to remove the inflamed and necrotic tissue, microbes/biofilms, and other debris from the root-canal space.[2-3] The main goal of instrumentation is to facilitate effective irrigation, disinfection, and filling.[4-5] NaOCl is commonly used in concentrations between 0.5% and 6%.[8] It is a potent antimicrobial agent, killing most bacteria instantly on direct contact.[8] It also effectively dissolves pulpal remnants and collagen, the main organic components of dentin.[9]

The aim of this study was to evaluate the effect of the two commonly used concentrations of sodium hypochlorite (2.25% and 5.25%) on dentine hardness. Results indicated that irrigation of root canals with either 2.25% or 5.25% NaOCl reduced the hardness of dentine. Slutzky-Goldberg[17] evaluated the effect of sodium hypochlorite on dentin microhardness and concluded reduction in the modulus of elasticity of dentine. Grigoratos[18] also evaluated the effect of exposing dentine to sodium hypochlorite and calcium hydroxide on its flexural strength and elastic modulus and found the same results.

Comparison of dentine hardness values pre and post irrigation treatment was made within the same root sample. This was done to minimize the effect of the structural variations between teeth and to establish a reasonable baseline for evaluation purposes.[10] Also any significant effect of sodium hypochlorite on the samples would be reflected in the findings irrespective of variability between specimens.[19]

The results of this study indicated treatment of dentine with 2.25% or 5.25% sodium hypochlorite solutions caused a significant decrease in dentine hardness. The organic-tissue dissolving properties of NaOCl on the collagen component may account for this observation.[20] Sakae and Mishima, et al.[10] in there study concluded that the effect of sodium hypochlorite on dental hard tissues is the removal of organic material (and possible minerals).[21] Our results are in agreement with sakae and mishima[10] results.
Barbosa[22] observed that dissolution of organic tissues by sodium hypochlorite solutions is based on the action of chloride over the proteins, forming chloramines, which are soluble in water. Mountouris[23] concluded that collagen fibers were seen to be completely removed from the dentine surface after NaOCl treatment.

Initially it was considered that the higher concentration of sodium hypochlorite would have a greater effect on dentine hardness than the lower concentration.[20] Ozturk[24] found no statically significant difference with various concentrations of sodium hypochlorite. The results of this study was in agreement with ozturk. Although the 2.25% concentration appeared to result in a greater decrease in hardness than the 5.25% concentration, statistical analysis did not show this decrease to be statistically significant. Likewise, other studies[17,19,25] showed that different concentrations of sodium hypochlorite resulted in a decrease in modulus of elasticity, flexural strength and surface strain of dentine, but no statistically significant difference between the different concentrations of sodium hypochlorite used was found.

A possible explanation was proposed by other researchers.[26-28] Their research indicated that a concentration of 2.25% sodium hypochlorite was as effective a tissue-dissolving agent as a 5.25% concentration, either at room or body temperature. Therefore, both would affect dentine hardness similarly.

CONCLUSIONS

Under the conditions of this study, it was concluded that Irrigation with 2.25% and 5.25% concentrations of sodium hypochlorite resulted in a statistically significant decrease in hardness of root dentine both for the whole root and at coronal, mid and apical levels at 1mm depth and there was no statistically significant difference in the decrease of dentine hardness between the 5.25% and the 2.25% concentrations at 1mm depth both for the whole root and at coronal, mid and apical levels. Concentration of 2.25% sodium hypochlorite was as effective as 5.25% concentration in tissue-dissolving.

REFERENCES

1. Chong BS, Pitt Ford TR, Watson TF, Wilson RF. Sealing ability of potential retrograde root filling materials. Endod Dent Traumatol 1995; 11: 264-9.
2. Lin LM, Skribner JE, Gaengler P. Factors associated with endodontic treatment failures. J Endod 1992; 18: 625–7.
3. Yang SF, Rivera Em,Walton RE, Baumgardner. Canal debridement: effectiveness of sodium hypochlorite and calcium hydroxide as medicaments. J Endod 1996; 22: 521-5.
4. Siqueira JF Jr, Araújo MC, Garcia PF, Fraga RC, Dantas CJ. Histological evaluation of the effectiveness of five instrumentation techniques for cleaning the apical third of root canals. J Endod 1997; 23: 499-502.
5. Levin M, Digital Technologies in Endodontic Practice. In: Pathways of the Pulp by S. Cohen and R. Burns, ed. Mosby: St Louis, Chp 26, pp 665-682, 2002.
6. Zehnder M, Lehnert B, Schönenberger K, Waltimo T Irrigants and intracanal medicaments in endodontics. Schweiz Monatsschr Zahnmed 2003;113: 756-63.
7. Prati C, Chersoni S, Pashley DH. Effect of removal of surface collagen fibrils on resin-dentin bonding. Dent Mater 1999; 15: 323-31.
8. Harrison JW. Irrigation of the root canal system. Dent Clin North Am1984; 28: 797-808.
9. Hauman CH, Love RM. Biocompatibility of dental materials used in contemporary endodontic therapy: a review. Part 1. Intracanal drugs and substances. Int Endod J 2003; 36: 75-85.
10. Sakae T, Mishima H, Kozawa Y. Changes in bovine dentin mineral with sodium hypochlorite treatment. J Dent Res 1988; 67: 1229-34.
11. Saleh AA, Ettman WM.Effect of endodontic irrigation solutions on microhardness of root canal dentine. J Dent 1999; 27: 43-6.
12. Slutzky-Goldberg I, Liberman R, Heling I. The effect of instrumentation with two different file types, each with 2.5% NaOCl irrigation on the microhardness of root dentin. J Endod 2002; 28: 311-2.
13. Haikel Y, Gorce F, Allemann C, Voegel JC. In vitro efficiency of endodontic irrigation solutions on protein desorption. Int Endod J 1994; 27: 16-20.
14. Cruz-Filho AM, Paula EA, Pécora JD, Sousa-Neto MD. Effect of different EGTA concentrations on dentin microhardness. Braz Dent J 2002; 13: 188-90.
15. Yoldaº O, Doðan C, Seydaoðlu G. The effect of two different calcium hydroxide combinations on root dentine microhardness. Int Endod J 2004; 37: 828-31.
16. Ari H, Erdemir A, Belli S. Evaluation of the effect of endodontic irrigation solutions on the microhardness and the roughness of root canal dentin. J Endod 2004; 30: 792-5.
17. Slutzky-Goldberg I, Maree M, Liberman R, Heling I. Effect of sodium hypochlorite on dentin microhardness. J Endod. 2004; 30 : 880-2.
18. 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.
19. 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.
20. Goldsmith M, Gulabivala K, Knowles JC. The effect of sodium hypochlorite irrigant concentration on tooth surface strain. J Endod 2002; 28: 575-9.
21. Correr GM, Alonso RC, Grando MF, Borges AF, Puppin-Rontani RM. Effect of sodium hypochlorite on primary dentin--a scanning electron microscopy (SEM) evaluation. J Dent 2006; 34: 454-9.
22. Barbosa SV, Safavi KE, Spångberg SW. Influence of sodium hypochlorite on the permeability and structure of cervical human dentine. Int Endod J 1994; 27: 309-12.
23. Mountouris G, Silikas N, Eliades G. Effect of sodium hypochlorite treatment on the molecular composition and morphology of human coronal dentin. J Adhes Dent 2004; 6: 175-82.
24. Ozturk B, Ozer F Effect of NaOCl on bond strengths of bonding agents to pulp chamber lateral walls. J Endod 2004; 30: 362-5.
25. Machnick TK, Torabinejad M, Munoz CA, Shabahang S Effect of MTAD on flexural strength and modulus of elasticity of dentin. J Endod 2003; 29: 747-50.
26. Sim TP. Effect of sodium hypocholrite on the resilience of teeth. Int Endod J 1996; 24: 130-9.
27. Trepagnier CM, Madden RM, Lazzari EP. Quantitative study of sodium hypochlorite as an in vitro endodontic irrigant. J Endod 1977 3: 194-6.
28. Cunningham WT, Balekjian AY. Effect of temperature on collagen-dissolving ability of sodium hypochlorite endodontic irrigant. Oral Surg Oral Med Oral Pathol 1980; 49: 175-7.