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INVESTIGATION OF THE EFFECT OF BORIC ACID IN DIFFERENT CONCENTRATIONS ON DENTIN MICROHARDNESS

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ABSTRACT

Purpose: This study compared the effects of different irrigation solutions on the microhardness of root dentin.

Methods: Fifty single-rooted human teeth were chosen, and the roots were randomly divided into five groups (n = 10) according to the irrigant used for 5 min: 17% ethylenediaminetetraacetic acid (EDTA), 2% boric acid (BA), 5% BA, 10% BA, and distilled water (DW). After the irrigation procedure, dentin surface microhardness was calculated using a Vickers indenter 100 µm from the root canal lumen. Comparisons between the groups were performed with a two-way ANOVA test and and Tukey's multiple comparison test ($p = 0.05$).

Results: All irrigation solutions decreased the microhardness of root canal dentin. The DW and 2% BA had a minimum effect on the microhardness of root canal dentin, whereas a significant decrease in surface microhardness was found in 10% BA group ($p < 0.05$). The coronal third of the 10% BA group showed the lowest percentage decrease, with a significant difference between the apical and middle thirds ($p < 0.05$).

Conclusion: In this study, 5% BA and 17% EDTA showed similar effects on the microhardness of root canal dentin. Further clinical research is required to evaluate the biocompatibility and safety of BA solutions.

Keywords: Boric acid; endodontics; irrigation solution; microhardness.

INTRODUCTION

The main objective of endodontic treatment is to chemomechanically eliminate bacteria and remove infected dentin (1). The irrigation procedure is one of the critical parts of endodontic therapy for root canal system disinfection and cleaning. During efficient root canal irrigation, infected material is flushed out, organic tissue is dissolved, microbial byproducts are destroyed, and the leavings of untouched areas by mechanical instrumentation are re moved (2). During endodontic instrumentation, an irregular layer of material that contains dentin, soft-tissue remnants, and some bacteria is formed on the root canal wall, called a smear layer (SL) (3,4).Several chemicals have been examined as irrigants to remove the SL, but to date, no irrigating solution has the ability to affect both the organic and inorganic parts of the SL. The most common procedure for SL removal is the use of ethylenediaminetetraacetic acid (EDTA) and sodium hypochlorite (NaOCl). NaOCl is used to remove the organic matrix of SL, whereas EDTA is used to remove the inorganic components of SL (5). EDTA was first introduced to endodontics as a chelator; it forms a stable complex with the calcium ions in dentine and has a demineralization effect on dental tissue (6,7).It has been commonly used as an irrigant in endodontics since 1957, and it is also used to remove the SL and increase dentin permeability (6). However, depending on its concentration and application time, EDTA can cause erosion in dentin tubules (8). In addition to EDTA, alternative chelating solutions have been studied for SL removal, such as peracetic and citric acids, phytic acid, and boric acid (BA) (9,10). BA is a weak inorganic acid form of boron, which has metal and non-metal properties (11). Since the 1860s, BA has been used in medicine as a fungicide, a bactericide, and an antiseptic (12). Boron can arrange the oxidant–antioxidant level of affected tissues (13).Recently, some studies have been conducted on the use of BA as a root canal irrigation agent and the different concentrations of BA solution have been used at 2%, 4%, 5%, 6%, or 10% (10,14-16). Aside from antimicrobial properties and the ability to remove the SL, the effects of the changes on the structure of dentin are also important in evaluating the effectiveness of chemical solutions. Much of the research on endodontic irrigation has focused on the effects of irrigation solutions and chelation agents on dentin microhardness (17-19). Many studies have shown that irrigation solutions can have softening effects on root canal dentin and cause de mineralization over time (20,21). Alternative chelating solutions for dentin microhardness have been studied, such as Q Mix and MTAD (22), fulvic acid (23), citric acids, and phytic acid (24). To the best of the authors' knowledge, no previous studies have compared the efficacies of different concentrations of BA on root dentin microhardness. Therefore, in this in vitro study, it was aimed to compare the effects of different concentrations of BA solution on the microhardness of root dentin. The null hypothesis was that there would be no significant difference between the EDTA and BA solutions in terms of decreasing microhardness.

MATERIALS AND METHODS

This study was approved by the research ethics committee of Rama Dental College. An alpha level of 0.05, a power of 0.80, and an effect size of 0.01 for every variable were assumed when an independent t-test was used to establish the significance of correlations. Fifty single-rooted teeth extracted for periodontal or orthodontic reasons were chosen for the study. Debris and soft-tissue remnants on the outer root surface of each tooth were cleaned with an ultrasonic tip. The teeth were kept in 0.9% distilled water (DW) until further processing. Dental crowns and roots were sectioned with a water-cooled cutting device.A total of 50 samples were embedded in auto polymerizing acrylic blocks, and a 2.00 mm-thick longitudinal slab was prepared from each center of the tooth using a diamond separator under water cooling. Silicon carbide sandpaper was used to polish the den tin surface (3M, St. Paul, MN, USA) to obtain a smooth surface.The four experimental groups and the control group are as follows (10 samples per group):

• Control group: The samples were exposed to DW for 5 min.

• Group 1: The samples were exposed to 17% EDTA (EN DO-Solution, Cerkamed, Nisko, and Poland) for 5 min.

• Group 2: The samples were exposed to 2% BA (Eti maden, Ankara, and Turkey) for 5 min.

• Group 3: The samples were exposed to 5% BA for 5 min.

• Group 4: The samples were exposed to 10% BA for 5 min. After all specimens were irrigated with 5 mL of each solution for 5 min, the specimens were rinsed immediately with DW and dried. Each specimen was subjected to a Vickers hardness tester (Shimadzu, Kyoto, and Japan). All testing indentations were applied using a Vickers diamond indenter 100 µm away from the canal lumen in the coronal, middle, and apical regions of the root dentin surface, with a force of 300 g and a dwell time of 20 s. The diagonals of the pyramid shaped mark that formed on the dentin surface were measured under a stereomicroscope at ×40 magnification. Statistical Analysis The data were analyzed using IBM SPSS Statistics for Windows version 24 (Armonk, NY, and USA). The suitability of the parameters to the normal distribution was evaluated by Kolmogorov–Smirnov and Shapiro–Wilks tests and it was determined that the parameters showed normal distribution. The effect of irrigation solutions on the dentin microhardness at different root distances was evaluated with a two-way ANOVA test and Tukey's multiple comparison test, with a significance level of $p < 0.05$.

	DW		EDTA		2% BA		5% BA		10% BA		P value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Apical third	59.75 A	10.60	42.84C	6.88	53.51B	5.86	42.41C	5.29	33.34bD	5.73	0.038
Middle third	57.02A	8.70	42.39B	6.42	53.30A	4.14	42.01B	3.35	32.95bC	4.71	0.042
Coronal third	54.75A	6.11	45.27B	5.60	52.56A	4.57	42.41B	4.57	36.19aC	4.95	0.049
p	0.608		0.074		0.752		0.858		0.041		

Table 1. The microhardness measurements among the different irrigation solution groups at the different root sections

RESULTS

Table 1 shows the microhardness measurements among the irrigation solution groups in different root sections. There was no significant difference between the apical, middle, and coronal thirds of the same specimen ($p > 0.05$) except the 10% BA group ($p = 0.041$). The coronal third of the 10% BA group showed the lowest percentage decrease with a significant difference between the apical and middle thirds ($p < 0.05$), with no significant difference between them. The microhardness results of the EDTA and 5% BA groups were similar in all root sections. When the samples were analyzed according to each root section, there were statistically significant differences between the groups (Table 1; $p < 0.05$).

DISCUSSION

This study evaluated the effects of different concentrations of BA solutions on the reduction of dentin microhardness. All the tested chelating agents decreased the microhard ness of the root canal dentin. The null hypothesis was rejected for the 10% BA group, while it was accepted for the 2% and %5 BA groups. Some endodontic chelation agents have been reported to cause changes in the chemical composition of the den tin structure, and procedures may induce considerable changes in the surface morphology of dentin (25,26). The microhardness of dentin depends on the structure of the dentin (i.e., mineral content, dentinal tubule density at different locations, and amount of hydroxyapatite in the intertubular substance), properties of irrigation solutions (i.e., concentration and pH), and contact time with agents (27-29). The optimum contact time for the irrigant solution to be applied on dentin to remove the SL is still controversial in the literature. When using EDTA, the recommended time for removing the SL is 1 min (30). Calt and Serper (8) stated that EDTA should not be prolonged >1 min during endodontic treatment to avoid deleterious effects on root dentin. On the contrary, Goldberg and Spiel berg reported that the optimum working time should be approximately 15 min for optimal results for removing the SL (31). De-Deus et al. (32) and Ulusoy and Gorgul (33) used the root canal irrigants for 5 min to test the micro hardness of root dentin. Similar to these studies, in the present study, we used EDTA and BA irrigation solutions for 5 min. Several studies have evaluated changes in dentin micro hardness after root canal irrigation with various agents (34-36). One of the solutions that causes the greatest change in the mechanical properties of dentin is 17% EDTA (37). New alternative agents that can remove the SL without damaging the dentin properties and overcoming the deficiencies of previous solutions have been inves tigated in the literature. Culhaoglu et al. (16) showed that the SL was completely removed when 10% BA were used as irrigation agent, while 5% BA could not completely re move SL. Turk et al. (10) emphasized that the use of 5% BA in combination with a solution such as citric acid was more effective in removing the SL. A mixture of 5% BA and 1% citric acid has been proposed as a promising irrigant for radicular post-space cleaning, as it shows the lowest incidence of residue on the dentin surface (38). In a previous study investigating the effects of 5% BA, citric acid, and EDTA on the mineral structure of dentin, all experimental chelating agents increased the Ca/P ratio. It was concluded that 5% BA could be considered an alternative chelating agent (14). In the present study, different concentrations of the BA irrigation solution were compared with the EDTA solution. These concentrations (2%, 5%, and 10%) of BA solution were chosen with refe ence to previous studies (10,14-16). Although the 2% BA solution had a minimum effect on the microhardness of root canal dentin, a significant decrease in surface micro hardness was found in 10% BA ($p < 0.05$). In the present study, there was no statistically significant difference between the root canal sections except the 10% BA group ($p = 0.041$). The preparation of a 2.00-mm-thick longitudinal slab from each sample and then keeping these slabs in the solution could be explained as the reason why there was no difference between the apical, middle, and coronal thirds. The results might have been different if the irrigation protocol had been applied before the samples were separated longitudinally. An irrigation protocol simulating clinical treatment was not used in this study. Although this experimental procedure was a limitation of this study in terms of demonstrating clinical endodontic treatment, it could be considered as an advantage of the study in terms of standardization on equal contact of solution to all dentinal surfaces. When the samples were analyzed according to each root section, the mean microhardness values of the 17% EDTA and 5% BA groups were found to be similar. As the con centration of the BA solution increased, the microhardness of the root dentin decreased. According to these results, 10% BA solution could affect the mineral composition and structure of dentin more than lower concentrations of BA solution. This result was similar to the study of Culhao glu et al. (16), who stated that 10% of BA successfully re moved SL. Lower concentrations of BA solution could be more effective if mixed with a solution such as citric acid, as highlighted in a previous study (10). This study has some limitations. First, the effects of the BA solution on the removal of the SL and erosion of dentin were not evaluated. Second, as the initial microhardness of root dentin was not evaluated, comparative results could not be obtained for the same solution. Further research is needed to evaluate the effect of BA on the microhardness of root dentin at different time periods. The SL removal ability of the BA solution should be investigated as an al ternative chelating solution. It should also be noted that the use of irrigation solutions for 5 min may cause erosion of the dentin and this is a limitation for this study.

CONCLUSION

All experimental chelating solutions reduced the micro hardness of root dentin. There was no significant difference between the 17% EDTA and 5% BA solutions in terms of decreasing microhardness. As the concentration of the BA solution increased, the microhardness of the root dentin decreased.

REFERENCES

1. Siqueira JF Jr. Aetiology of root canal treatment failure: why well-treated teeth can fail. Int Endod J 2001; 34: 1–10. [CrossRef]

2. Hargreaves KM, Cohen S, Berman LH. Cleaning and shaping the root canal system. In: Peters OA, Peters CI, Basrani B, editors. Cohen's Pathways of the Pulp. St. Louis, Mo: Mosby Elsevier; 2012. p. 209–13.

3. Çiçek E, Özerol NB. Evaluation of two different root canal sealer, using different irrigation solution on push out bond strenght to dentin. [Article in Turkish]. J Dent Fac Atatürk Uni 2014; 24: 16–21.

4. Sen BH, Wesselink PR, Turkun M. The smear layer: a phenomenon in root canal therapy. Int Endod J 1995; 28: 141–8. [CrossRef]

5. Chandler N, Chellappa D. Lubrication during root canal treatment. Aust Endod J 2019; 45: 106–10. [CrossRef]

6. Ostby N. Chelating in root canal therapy. Ethylene-di amine tetraacetic acid for cleansing and widening of root canals. Odontol Tidskr 1957; 65: 3–11.

7. Violich DR, Chandler NP. The smear layer in endodontics - a review. Int Endod J 2010; 43: 2–15. [CrossRef]

8. Calt S, Serper A. Time-dependent effects of EDTA on dentin structures. J Endod 2002; 28: 17–9. [CrossRef]

9. Cobankara FK, Erdogan H, Hamurcu M. Effects of che lating agents on the mineral content of root canal dentin. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 112: 149–54. [CrossRef]

10. Turk T, Kaval ME, Şen BH. Evaluation of the smear layer removal and erosive capacity of EDTA, boric acid, citric acid and desy clean solutions: an in vitro study. BMC Oral Health 2015; 15: 104. [CrossRef]

11. Kanoriya D, Singhal S, Garg V, et al. Clinical efficacy of subgingivally-delivered 0.75% boric acid gel as an adjunct to mechanotherapy in chronic periodontitis: a randomized, controlled clinical trial. J Investig Clin Dent 2018; 9.

12. Quarles W. Boric Acid, Borates and Household Pests. The IPM Practioner. Bio Integral Research Center, Berkeley, CA. 2001; 23: 1–12.

13. Ince S, Kucukkurt I, Cigerci IH, et al. The effects of dietary boric acid and borax supplementation on lipid peroxida tion, antioxidant activity, and DNA damage in rats. J Trace Elem Med Biol 2010; 24: 161–4. [CrossRef]

14. Akman M, Belli S, Olcay K, et al. The effect of boric acid on root dentin mineral content and bond strength of AH Plus: a SEM-EDX study. Turkiye Klinikleri J Dental Sci 2016; 22: 14–20. [CrossRef]

15. Zan R, Hubbezoglu I, Ozdemır AK, et al. Antibacterial effect of different concentration of boric acid against en terococcus faecalis biofilms in root canal. Marmara Dent J 2013; 2: 76–80.

16. Culhaoglu AK, Özcan E, Kilicarslan MA, et al. Effect of boric acid versus conventional irrigation solutions on the bond strength between fiber post and root dentin. J Adhes Dent 2017; 19: 137–46.

17. Ari H, Erdemir A, Belli S. Evaluation of the effect of end odontic irrigation solutions on the microhardness and the roughness of root canal dentin. J Endod 2004; 30: 792–5.

18. Cruz-Filho AM, Sousa-Neto MD, Savioli RN, et al. Effect of chelating solutions on the microhardness of root canal lumen dentin. J Endod 2011; 37: 358–62. [CrossRef]

19. Bosaid F, Aksel H, Makowka S, et al. Surface and struc tural changes in root dentine by various chelating solutions used in regenerative endodontics. Int Endod J 2020; 53: 1438–45. [CrossRef]

20. Akbulut MB, Guneser MB, Eldeniz AU. Effects of fruit vinegars on root dentin microhardness and roughness. J Conserv Dent 2019; 22: 97–101.

21. Baldasso FER, Roleto L, Silva VDD, et al. Effect of final irrigation protocols on microhardness reduction and erosion of root canal dentin. Braz Oral Res 2017; 31: e40. [CrossRef]

22. Arun DR, Sujatha V, Mahalaxmi S. Effect of 5% carbo hydrate derived-fulvic acid on smear layer removal and root dentin microhardness - an in vitro study. Eur Endod J 2022; 7: 156–60.

23. Muana HL, Nassar M, Dargham A, et al. Effect of smear layer removal agents on the microhardness and roughness of radicular dentin. Saudi Dent J 2021; 33: 661–5. [CrossRef]

24. Hennequin M, Pajot J, Avignant D. Effects of different pH values of citric acid solutions on the calcium and phos phorus contents of human root dentin. J Endod 1994; 20: 551–4. [CrossRef]

25. Dogan H, Qalt S. Effects of chelating agents and sodium hypochlorite on mineral content of root dentin. J Endod 2001; 27: 578–80. [CrossRef]

26. Das A, Kottoor J, Mathew J, et al. Dentine microhard ness changes following conventional and alternate irriga tion regimens: an in vitro study. J Conserv Dent 2014; 17: 546–9. [CrossRef]

27. Sayin TC, Serper A, Cehreli ZC, et al. Calcium loss from root canal dentin following EDTA, EGTA, EDTAC, and tetracycline-HCl treatment with or without subsequent NaOCl irrigation. J Endod 2007; 33: 581–4. [CrossRef]

28. Gutiérrez-Salazar MdP, Reyes-Gasga J. Microhardness and chemical composition of human tooth. Mater Res 2003; 6: 367–73. [CrossRef]

29. Lottanti S, Gautschi H, Sener B, et al. Effects of ethylene diaminetetraacetic, etidronic and peracetic acid irrigation on human root dentine and the smear layer. Int Endod J 2009; 42: 335–43. [CrossRef]

30. Goldberg F, Spielberg C. The effect of EDTAC and the variation of its working time analyzed with scanning elec tron microscopy. Oral Surg Oral Med Oral Pathol 1982; 53: 74–7. [CrossRef]

31. De-Deus G, Paciornik S, Mauricio MH. Evaluation of the effect of EDTA, EDTAC and citric acid on the microhard ness of root dentine. Int Endod J 2006; 39: 401–7. [CrossRef]

32. Ulusoy OI, Gorgul G. Effects of different irrigation solu tions on root dentine microhardness, smear layer removal and erosion. Aust Endod J 2013; 39: 66–72. [CrossRef]

33. Saleh AA, Ettman WM. Effect of endodontic irrigation solutions on microhardness of root canal dentine. J Dent 1999; 27: 43–6. [CrossRef]

34. Saha SG, Sharma V, Bharadwaj A, et al. Effectiveness of various endodontic irrigants on the micro-hardness of the root canal dentin: an in vitro study. J Clin Diagn Res 2017; 11: ZC01–4. [CrossRef] 36. Aranda-Garcia AJ, Kuga MC, Chavéz-Andrade GM, et al. Effect of final irrigation protocols on microhardness and erosion of root canal dentin. Microsc Res Tech 2013; 76: 1079–83. [CrossRef]

35. Tsenova-Ilieva I, Karova E. Effect of endodontic irrigants on root dentin microhardness: a systematic review. Int J Sci Res 2020; 9: 491–6.

36. Belizario LG, Piragine TL, Girotto AC, et al. Effect of dif ferent irrigants on the adhesive interface and influence on the push out strength of fiber posts. Oper Dent 2022; 47: 211–21. [CrossRef]