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Evaluating the Impact of Boric Acid at Varying Concentrations on the Microhardness of Dentine

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Boric Acid, Dentin Microhardness, Endodontic Filling

Abstract
Introduction- Following mechanically driven drill post-space planning, a smear layer of endodontic filling material plasticized residues and dentin fragments forms over the dentin surface. Methodology: Fifty human teeth with a single root were selected, and the roots were assigned at random to five groups (n = 10) based on the irrigant utilised for five minutes: distilled water (DW), 17% ethylenediaminetetraacetic acid (EDTA), 2% boric acid (BA), 5% BA, and 10% BA. Following the irrigation process, a Vickers indenter placed 100 µm from the root canal lumen was used to measure the dentin surface microhardness. Tukey's multiple comparison test ($p = 0.05$) and a two-way ANOVA test were used to compare each group. **Results-** The microhardness of the root canal dentin was lowered by all irrigation treatments. The root canal dentin's microhardness was least affected by the DW and 2% BA, but the 10% BA group showed a significant ($p < 0.05$) drop in surface microhardness. The 10% BA group's coronal third had the least percentage drop, with the apical and middle thirds differing significantly ($p < 0.05$). **Conclusion**; the microhardness of root canal dentin was found to be similarly affected by 5% BA and 17% EDTA in this investigation. Additional clinical investigation is necessary to assess the safety and biocompatibility of BA solutions.

Introduction

Following mechanically driven drill post-space preparation, a smear layer comprising endodontic filling material plasticized residues and dentin fragments forms over the dentin surface [1, 2]. The adhesion interface between the cementation system and fibre post may be adversely affected by these residues, which may function as a physical barrier [3]. Following post-space preparation, a number of irrigants and mechanical agitation techniques are suggested to reduce its production and/or eliminate sealer residues from the root dentin [4, 5]. The most advised technique throughout endodontic therapy is root canal irrigation with sodium hypochlorite and ethylenediaminetetraacetic acid (EDTA) [6, 7]. But the smear layer formed after post-space preparation differs significantly from that formed following chemical-mechanical preparation of the root canals [1, 2, 7]. As a result, the post-space dentin cleaning process needs to be able to successfully remove sealer residues, like gutta-percha and/or endodontic sealers based on epoxy resin [3]. Since acidic solutions effectively remove the smear layer, they are indicated for final irrigation in endodontic therapy and also make for interesting post-space irrigation [8, 9]. Furthermore, it is preferable to use irrigants that have antibacterial activity, like sodium hypochlorite [10, 11]. Irrigation with 1%–10% citric acid is possible. It is a low pH (1-2) organic acid that breaks down into citrate and tends to mix with dentin's calcium [12].

Citric acid has the potential to be erosive depending on the concentration employed; therefore, it is combined with other irrigants to reduce dentin damage during endodontic irrigation. As an alternative to the irrigants previously reported, boric acid, especially at concentrations of 5%–10%, eliminates the smear layer from the post-space dentin and has no effect on the adhesion interface with the cementation system. But in order for the boric acid solution to work, it needs to be heated beyond 55˚C, which could make it less useful in clinical settings. Combining these two acidic solutions has been suggested as a way to lessen their harmful effects because of the erosive potential of citric acid and the drawbacks of heating boric acid. The mixture of citric acid and boric acid has shown promising outcomes in terms of cleaning efficacy of the root dentin. The suitable cleaning and etching of the dentin surface are crucial for forming a stable and adequate adhesive interface with the cementation system [2, 3]. Although most acid solutions generate by-products that remain on the dentin surface, they can have a negative impact on the adhesive contact with the

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adhesive system and dual resin cementation system, depending on their chemical properties.7. Although they may react with basic tertiary amines and jeopardise the integrity of the adhesive interface, these acid residues can adversely affect the polymerization of certain resin-based materials. It is unclear, nevertheless, if dual-cured resin cement devoid of tertiary amines in its chemical makeup also experiences similar effect. Numerous dentin microhardness chelating solutions, including fulvic acid, citric acids, phytic acid, QMix, and MTAD, have all been examined. As far as the authors are aware, no prior research has contrasted the effectiveness of various concentrations.

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 Method

This study was carried out in the Amaltas Medical College's dentistry department in Dewas, Madhya Pradesh. For the study, fifty single-rooted teeth that had been removed due to periodontal or orthodontic issues were selected. Each tooth's outer root surface debris and soft tissue remnants were cleansed using an ultrasonic tip. Until further processing, the teeth were stored in 0.9% distilled water (DW). Water-cooled cutting tools were used to segment dental crowns and roots. Fifty samples in all were embedded in autopolymerizing acrylic block. A longitudinal slab, measuring 2.00 mm in thickness, was produced from each tooth centre using a diamond separator while being cooled with water. The dentin surface was polished using silicon carbide sandpaper to create a flat surface. The following (10 samples per group) are the four experimental categories and the control group:

- Control group: The samples were exposed to DW for 5 min.
- Group 1: The samples were exposed to 17% EDTA (ENDO-Solution, Cerkamed, Nisko, and Poland) for 5 min.
- Group 2: The samples were exposed to 2% BA (Etimaden, 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.

Every sample was put through a Vickers hardness test. A Vickers diamond indenter was used to apply all testing indentations, with a force of 300 g and a dwell period of 20 s, in the coronal, middle, and apical regions of the root dentin surface, 100 µm far from the canal lumen. Using a stereomicroscope at a ×40 magnification, the diagonals of the shaped like a mark that developed on the outermost layer of dentin were determined. IBM SPSS Statistics for Windows version 24 (Armonk, NY, USA) was used to analyse the data. Kolmogorov-Smirnov and Shapiro-Wilks tests were used to assess the parameters' appropriateness for a normal distribution. The results showed that the parameters did indeed exhibit a normal distribution. Using a two-way ANOVA test and Tukey's multiple comparison test, the impact of irrigation solutions on dentin microhardness at various root distances was assessed, with a significance level of $p < 0.05$.

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 ($p = 0.041$).

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

	DW		EDTA		2% BA		5% BA		10% BA		p-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Apical third	59.75A	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

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p		0.608		0. 0 7 4			0. 7 5 2		0.858		0. 0 4 1		

Despite a significant difference ($p < 0.05$) among the apical and middle thirds and no significant difference between them, the coronal third of the 10% BA group displayed the lowest percentage drop. In every root section, the microhardness outcomes for the EDTA and 5% BA groups were comparable. There were statistically significant variations across the groups when the samples were analysed based on each root segment (Table 1; $p < 0.05$). Fig. 1 displays a box plot of the microhardness values of the irrigation solutions that were evaluated.

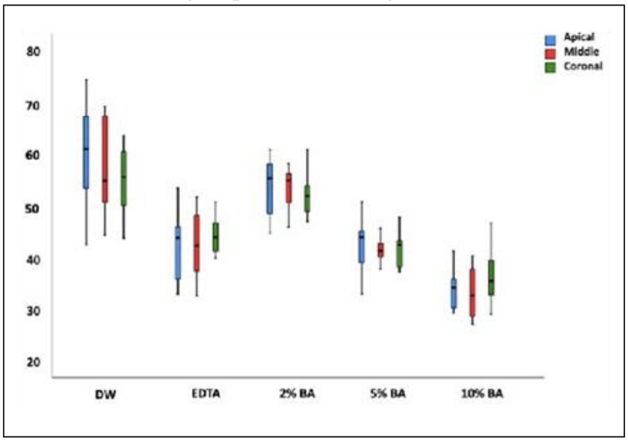

Fig. 1. Box plot of the microhardness values of the tested irrigation so-lutions.

Discussion

The impact of various BA solution concentrations on the decrease in dentin microhardness were assessed in this study. The root canal dentin's microhardness was reduced by each of the chelating agents that were evaluated. For the 10% BA group, the null hypothesis was rejected; however, for the 2% and %5 BA groups, it was accepted. It has been noted that certain endodontic chelation agents alter the chemical makeup of the dentin structure, and that certain procedures can significantly alter the dentin's surface morphology. Dentin's structure—that is, its mineral content, dentinal tubule density at various sites, and the amount of hydroxyapatite in the intertubular substance—as well as the concentration and pH of irrigation solutions and the length of time the solution is in contact with agents determine dentin's microhardness.[13,14] There is considerable debate in the literature regarding the ideal contact time to apply an irrigant solution to dentin in order to eliminate the SL. The recommended duration for eliminating the SL while utilising EDTA is one minute (30). According to Calt and Serper15, in order to prevent harmful effects on the root dentin during endodontic treatment, EDTA should not be used for longer than one minute. On the other hand, Goldberg and Spielberg found that 15 minutes would be the ideal working time to remove the SL entirely.16 To examine the micro-hardness of the root dentin, De-Deus et al. (2017) and Ulusoy and Gorgul (2018) employed root canal irrigants for five minutes. In line with these investigations, we employed EDTA and BA irrigation in this work for 5 min.

Numerous studies have assessed how different chemicals used during root canal irrigation affect the microhardness of dentin. 17% EDTA is one of the solutions that alters dentin's mechanical characteristics the most. The literature has investigated new alternative agents that can overcome the shortcomings of prior methods and eliminate the SL without compromising the dentin characteristics. Culhaoglu et al. (19) shown that whilst 5% BA was unable to entirely re-move SL, 10% BA entirely eliminated SL when utilised as an irrigation agent. Turk et al.20 stressed that the best way to get rid of the SL was to utilise 5% BA along with a solution like citric acid. The most promising irrigant for radicular post-space cleaning has been suggested to be a combination of 5% BA and 1% citric acid since it exhibits the lowest incidence of residue on the dentin surface. All experimental chelating agents raised the Ca/P ratio in a prior study examining the effects of 5% BA, citric acid, and EDTA on the mineral structure of dentin. It was determined that 5% BA might be taken into account as a different kind of chelating agent. Various concentrations of the BA irrigation solution were compared to the EDTA solution in the current investigation. These three BA solution concentrations (2%,

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5%, and 10%) were selected with reference to earlier research.[19,20] While the microhardness of root canal dentin was not significantly affected by the 2% BA solution, 10% BA resulted in a substantial decrease in surface micro-hardness ($p < 0.05$). With the exception of the 10% BA group ($p = 0.041$), there was no statistically significant difference observed between the root canal sections in the previous study. The lack of variation among the apical, middle, and coronal thirds may be attributed to the production of a 2.00 mm thick longitudinal slab from each sample and subsequent preservation of these slabs in the solution. The outcomes could have been altered if the irrigation procedure had been used prior to the samples' longitudinal separation. In this investigation, an irrigation protocol meant to mimic clinical treatment was not employed. While the experimental methodology posed a constraint on the study's ability to showcase clinical endodontic treatment, it may also have contributed to the study's uniformity in terms of solution interface with all dental surfaces.

The samples' mean microhardness values were found to be similar between the 17% EDTA and 5% BA groups when they were analysed based on each root section. The root dentin's microhardness dropped as the concentration of the BA solution rose. These findings suggest that 10% BA solution may have a greater impact on dentin's mineral structure and content than BA solution at lower concentrations. This outcome was consistent with the research by Culhaoglu et al. (19), which found that 10% of BA were successful in moving SL. As indicated by a prior study, lower quantities of BA solution might work better when combined with a solution like citric acid.[20]

Conclusion

The experimental chelating solutions all decreased the root dentin's microhardness. The amount of microhardness that decreased in the 5% BA and 17% EDTA solutions was not significantly different from one another. The root dentin's microhardness dropped as the BA solution's concentration rose.

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