Original Article

Comparative Evaluation of Antioxidant Effects of 25% Bamboo Salt and 3% Green Tea Extract on Push-out Bond Strength of AH Plus Sealer after Sodium Hypochlorite Irrigation: An *In vitro* Study

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Abstract

Context: Sodium hypochlorite (NaOCl), a commonly used intracanal irrigant, adversely affects the organic content of dentin, impacting the bond strength of sealer to root dentin. **Aim:** The aim of the study was to compare the antioxidant effects of 25% bamboo salt and 3% green tea extract on the push-out bond strength of AH Plus sealer after NaOCl irrigation. **Subjects and Methods:** Forty-five single-rooted mandibular premolars were selected, decoronated, and standardized to a length of 12 mm. During the canal preparation process, ProTaper Next rotary files were used, with each step accompanied by the irrigation of 5 ml of 5.25% NaOCl. Following the instrumentation, the canals were flushed with an additional 5 ml of 5.25% NaOCl and 17% ethylenediaminetetraacetic acid. The specimens were then categorized into three groups (n = 15 each): Group 1, treated with saline; Group 2, treated with a 25% bamboo salt solution; and Group 3, treated with a 3% green tea extract solution. From the coronal and middle thirds of each root, 1.5 mm thick slices were prepared. These slices were then tested for push-out bond strength using a universal testing machine. **Statistical Analysis:** The data collected were subjected to one-way analysis of variance, followed by Tukey's *post hoc* analysis for detailed examination. **Results:** The use of 5.25% NaOCl resulted in a significant reduction in the bond strength of AH Plus to dentin ($P < 0.05$). Among the treated groups, the samples irrigated with 3% green tea extract exhibited a notably higher push-out bond strength compared to those treated with 25% bamboo salt. **Conclusion:** Within the limitations of this *in vitro* study, all experimental groups showed significant changes in push-out bond strength after antioxidant treatment.

Keywords: *Bamboo salt, green tea extract, push-out bond strength*

Introduction

Root canal therapy is an essential procedure in endodontics that aims to clean, shape, and seal the root canal system to prevent reinfection.[1] Chemomechanical preparation, which involves the use of manual, rotary, and reciprocating instruments along with various chemical irrigants, is crucial for effectively preparing and contouring the root canal systems.[1] The choice of irrigants and their effects on the dentin surface play a significant role in the success of the treatment. Various chemical irrigants used during biomechanical preparation can alter the surface composition of the dentin, which ultimately affects the interaction between the dentin and the restorative material.[2]

One of the most commonly used irrigants is sodium hypochlorite (NaOCl), known for its potent antimicrobial properties and ability to dissolve organic tissue. However, its use is limited due to its toxicity and the structural changes it induces in the organic components of dentin.[3] When NaOCl interacts with organic matter in the root canal, it breaks down into chloramines and protein-derived radicals, which result in the deterioration of the collagen within the root dentin. This process significantly affects the mechanical properties of dentin by lowering its elastic modulus and flexural strength. As a result, the bond strength of sealers to root dentin is compromised.[1,4]

The degradation of collagen in the dentin matrix by NaOCl results in a reduced ability of epoxy resin sealers, such as AH Plus, to bond effectively. Methacrylate resins and epoxy resins are the two primary types of sealers used in endodontic therapy. Epoxy resin sealants like AH Plus (Dentsply

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Sirona Endodontics, USA) are designed to chemically bond with the collagen of dentin, while methacrylate resin-based sealers form micro-mechanical bonds by penetrating the tiny pores left in the dentin substrate by acidic primers.[5] However, the presence of NaOCl residues and oxidative by-products such as hypochlorous acid and hypochlorite ions, inhibits the polymerization of methacrylate resins and the bonding of epoxy resins, ultimately compromising the sealer's bond to root dentin.[4,6]

To mitigate the adverse effects of NaOCl on dentin, antioxidants can be employed to restore the diminished bond strength of dentin treated with NaOCl. Antioxidants are widely used in general clinical practice due to their ability to neutralize free radicals and repair oxidative damage. The role of free radical oxidative damage in human diseases has garnered significant interest, suggesting potential applications in dental practice as well.[4] Antioxidative agents can enhance bond strength by breaking free radical chains, chelating metals, repelling free radicals, and reacting with secondary products of NaOCl to neutralize them.[6]

Naturally derived antioxidants, such as green tea extract, grape seed extract, tocopherol, lycopene, ascorbic acid, and bamboo salt, have been shown to chemically alter collagen without harming healthy tissue, thus enhancing the characteristics of the dentin matrix protein.[4] Green tea extract, rich in polyphenolic compounds such as catechins, particularly epigallocatechin-3-gallate (EGCG), and epicatechin-3-gallate, is known for its potent antioxidant properties. Research has shown that green tea extract can effectively reverse the compromised bond strength of NaOCl-treated dentin. Similarly, bamboo salt, known for its antibacterial, antioxidant, and anti-inflammatory properties, has shown promise in restoring the bond strength of AH Plus to NaOCl-treated dentin.[4]

The current study aims to evaluate the antioxidant effects of 25% bamboo salt and 3% green tea extract on the push-out bond strength of AH Plus sealer to root dentin treated with 5.25% NaOCl. By comparing the effectiveness of these two naturally derived antioxidants, the study seeks to identify potential treatments that can enhance the bond strength of sealers to NaOCl-treated dentin. This *in vitro* study will provide insights into the practical applications of these antioxidants in improving the outcomes of root canal therapy and ensuring the long-term success of endodontic treatments. The findings could lead to more effective strategies for managing the adverse effects of NaOCl on dentin, thereby improving the overall success rates of endodontic procedures.

Subjects and Methods

This study involved 45 single-rooted mandibular premolar teeth that were extracted for orthodontic or periodontal reasons. Ethical clearance was obtained from the institution for the study (ref: 2075/2020–21). The teeth were gathered and preserved in distilled water until use to prevent dehydration and maintain their physical properties. The collected sample teeth were then decoronated at the cementoenamel junction to standardize their lengths to 12 mm, which ensured uniformity in the testing conditions. Using a #15 K-file, the patency of each root canal was examined to verify the canals were not obstructed and to establish the working length, which was determined to be 1 mm short of the apex to avoid over-instrumentation and potential damage to the apical tissues.

The cleaning and shaping of the root canals were carried out using ProTaper Next rotary files up to size X2. During the instrumentation process, 5 ml of 5.25% NaOCl was used as an irrigant between each file to disinfect the canal and dissolve organic tissue. This was followed by a final rinse with 5 ml of 17% ethylenediaminetetraacetic acid (EDTA) for 1 min to remove the smear layer, which is composed of organic and inorganic debris created during instrumentation. The smear layer can prevent the sealer from effectively bonding to the dentin, so its removal is crucial for enhancing the adhesion of the sealer. After the EDTA rinse, another 5 ml of 5.25% NaOCl was used to ensure the complete removal of any residual organic material.

After the canal preparation, the 45 specimens were split into three groups at random according to the irrigation protocol's outcome. The first group (n = 15) served as the control and was irrigated with 5 ml of saline for 5 min. The second group (n = 15) was irrigated with 5 ml of 25% bamboo salt solution for 5 min, while the third group (n = 15) was treated with 5 ml of 3% green tea extract solution for 5 min [Figure 1]. Following the irrigation procedures, the canals in the second and third groups were additionally rinsed with 5 ml of distilled water to remove any residual irrigant solution. All samples were then dried using paper points to ensure the canals were free of moisture, which is critical for the effective adhesion of the sealer.

Each canal was coated with AH Plus sealer using a Lentulo spiral (size 2) to ensure an even distribution of the sealer

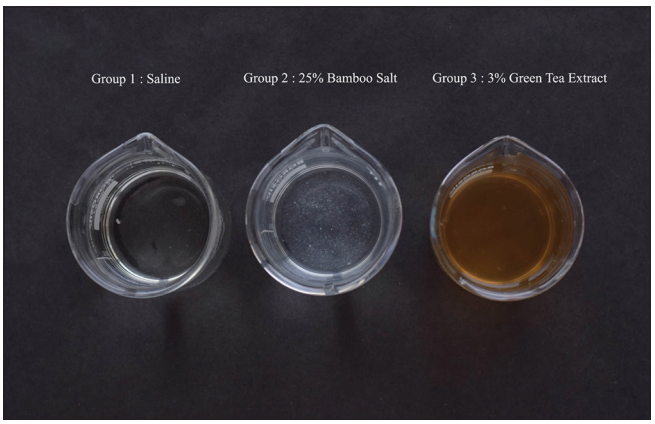

Figure 1: Irrigating solutions according to the experimental groups

along the canal walls. The canals were then obturated with a single gutta-percha cone using the single-cone technique, a method that provides consistent and reliable obturation. In order to stop any leaks, intermediate restorative material was used to seal the coronal sections of the root samples. The samples were stored in distilled water at 37°C for 7 days to allow the sealer to set completely and to simulate the conditions in the oral cavity.

After the storage period, the roots were embedded vertically in cylindrical molds filled with auto-polymerizing acrylic resin to provide support during testing [Figure 2]. Each root was then sectioned perpendicular to its long axis to obtain 1.5 mm thick slices from the coronal and middle thirds of the root [Figure 3]. These slices were subjected to a push-out bond strength test using a universal testing machine (INSTRON) equipped with a metallic indenter with a round cross-section and a diameter of 0.7 mm. The test was conducted at a crosshead speed of 1 mm/min to ensure consistent and controlled application of force.

The data obtained from the push-out bond strength test were analyzed using SPSS version 22.0 (IBM, Armonk, New York, United States). The mean and standard deviation (SD) of the bond strengths was calculated for each group. Statistical analyses were performed using the independent *t*-test, one-way analysis of variance (ANOVA), and Tukey's *post hoc* test to determine any significant differences between the groups. The level of statistical significance was set at $P < 0.001$.

This comprehensive methodology ensures the rigorous testing and accurate assessment of the effects of bamboo salt and green tea extract on the bond strength of AH Plus sealer to NaOCl-treated root dentin, providing valuable insights into potential improvements in endodontic treatment protocols.

Results

The study's results revealed significant findings regarding the AH Plus sealer's push-out bond strength to NaOCl-treated root dentin when treated with different irrigants. The mean and SD of the push-out bond strengths was calculated for each group, and SPSS 22.0 (SPSS Inc., Chicago, IL, USA) was used to statistically examine the data.

The results indicated that the group irrigated with 5.25% NaOCl followed by saline (Group 1) exhibited the lowest mean push-out bond strength. This finding aligns with previous research suggesting that NaOCl, while effective in disinfection, can adversely affect the adhesion of sealers to dentin due to its collagen-damaging properties and the presence of by-products of oxidation, like hypochlorous acid, which inhibits the methacrylate resin polymerization can weaken the adherence of epoxy resin.

In contrast, Group 2, which was irrigated with 25% bamboo salt solution, showed an improvement in bond strength compared to the control group. Bamboo salt, known for its antibacterial, antioxidant, and anti-inflammatory properties, appeared to mitigate some of the adverse effects of NaOCl on dentin, thereby enhancing the bonding capability of AH Plus.

Group 3, treated with 3% green tea extract, demonstrated the highest mean push-out bond strength among all groups. Green tea extract, rich in antioxidants, was particularly effective in counteracting the oxidative damage caused by NaOCl, thus significantly improving the bond strength of the AH Plus sealer to the dentin [Table 1].

Statistical analysis using one-way ANOVA and Tukey's *post hoc* test confirmed that the differences in push-out bond strength between the groups were significant ($P < 0.001$). Specifically, the bond strength in the green tea extract group was significantly higher than that in the bamboo salt and saline groups.

These findings suggest that both bamboo salt and green tea extract can effectively improve the bond strength of AH Plus to NaOCl-treated dentin, with green tea extract showing the most pronounced effect. This highlights the potential of natural antioxidants in enhancing endodontic treatment outcomes by improving the adhesion of sealers to dentin.

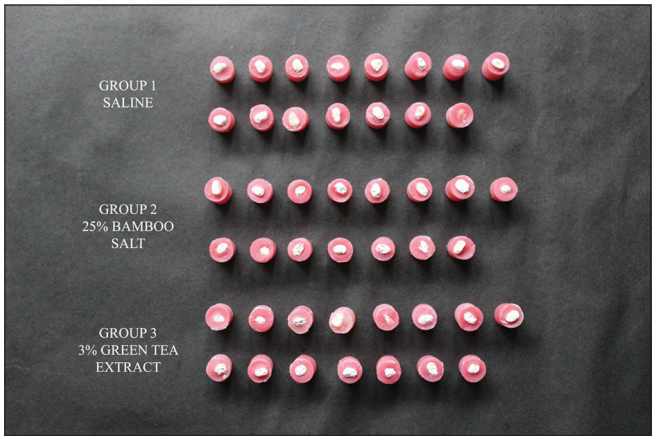

Figure 2: Samples embedded in autopolymerizing resin

Figure 3: 1.5 mm thick section made using diamond disc

Table 1: The mean force push-out bond strength in the coronal and middle third of the different experimental group

Groups	*n*	Mean	SD	SEM
Saline				
Coronal third	15	0.6213	0.36288	0.09370
Middle third	15	0.9387	0.25357	0.06547
Bamboo salt				
Coronal third	15	2.0807	0.30497	0.07874
Middle third	15	2.2407	0.38540	0.09951
Green tea extract				
Coronal third	15	3.2520	0.40100	0.10354
Middle third	15	3.0020	0.39017	0.10074

SD: Standard deviation; SEM: Standard error of mean

Discussion

The findings of this study provide critical insights into the influence of antioxidant treatments on the push-out bond strength of AH Plus sealer to NaOCl-treated root dentin. NaOCl is a widely utilized endodontic irrigant due to its powerful antibacterial characteristics and ability to disintegrate organic tissue. However, its application can adversely affect dentin's structural integrity and bonding properties.[7,8] This study aimed to evaluate the efficacy of natural antioxidants, namely 25% bamboo salt and 3% green tea extract, in counteracting the deleterious effects of NaOCl on dentin and improving the bond strength of AH Plus sealer.

Impact of sodium hypochlorite on dentin

NaOCl decomposes into chloramines and protein-derived radicals when it comes into contact with organic material in the root canal. This process results in significant collagen degradation within the dentin, compromising the mechanical properties essential for the effective sealing and bonding of endodontic sealers. Previous studies have shown that NaOCl exposure leads to a delayed, uneven breakdown of the organic phase in dentin, leaving inorganic components such as calcium hydroxyapatite and carbonate apatite unaltered. This disruption in the organic-inorganic balance of dentin can significantly reduce the bond strength of sealers like AH Plus, which rely on forming covalent bonds with collagen fibers in the dentin matrix.[9,10]

Role of antioxidants in restoring bond strength

The use of antioxidants in endodontics aims to neutralize the oxidative by-products of NaOCl and restore the structural integrity of collagen in dentin. In this study, both 25% bamboo salt and 3% green tea extract were evaluated for their potential to improve the bond strength of AH Plus sealer to NaOCl-treated dentin.[4]

Bamboo salt

Bamboo salt has gained attention for its antioxidant, antibacterial, and anti-inflammatory properties. It has been demonstrated to effectively restore the bond strength of AH Plus to NaOCl-treated dentin, similar to other well-known antioxidants like proanthocyanidins. The antioxidant activity of bamboo salt helps neutralize free radicals and reactive oxygen species generated by NaOCl, thereby preventing further degradation of collagen fibers. This study's results showed that the use of 25% bamboo salt solution significantly improved the push-out bond strength compared to the saline control group, although not as much as green tea extract.[11,12]

Green tea extract

Green tea extract is rich in polyphenolic compounds, particularly catechins such as EGCG, which possess strong antioxidant properties. These compounds can effectively scavenge free radicals and chelate metal ions, thereby stabilizing the dentin matrix and enhancing the bonding of resin-based sealers. The findings of this study indicated that the 3% green tea extract provided the highest increase in push-out bond strength among the experimental groups. This superior performance can be attributed to the potent antioxidant activity of green tea catechins, which can penetrate the dentin matrix and protect collagen fibers from oxidative damage.[13,14]

Comparative analysis and clinical implications

The statistical analysis confirmed that there were significant differences in bond strength between the groups, with green tea extract showing the most substantial improvement. The effectiveness of green tea extract in enhancing the bond strength suggests that it may be a superior alternative to other antioxidants in clinical practice. The use of green tea extract in endodontic procedures could potentially lead to better sealing and long-term success of root canal treatments by ensuring stronger adhesion of sealers to dentin.

While this study provides promising results, it is essential to acknowledge its limitations. The study was conducted *in vitro* using extracted teeth, which may not fully replicate the conditions within the oral cavity. Factors such as the dynamic environment of the mouth, the presence of saliva, and the interaction with other dental materials can influence the outcomes in a clinical setting. Further research involving larger sample sizes, long-term studies, and clinical trials is necessary to validate these findings and explore the practical applications of antioxidants such as green tea extract and bamboo salt in endodontics.

Conclusion

This *in vitro* study demonstrated that natural antioxidants, specifically 25% bamboo salt and 3% green tea extract, significantly enhance the push-out bond strength of AH Plus sealer to NaOCl-treated root dentin. Among the tested agents, green tea extract exhibited the highest increase in bond strength, suggesting its superior efficacy in counteracting the adverse effects of NaOCl. These findings

highlight the potential clinical benefits of incorporating antioxidants into endodontic protocols to improve sealer adhesion and the overall success of root canal treatments. Further clinical studies are needed to confirm these results and explore the practical applications of these antioxidants in everyday dental practice.

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Conflicts of interest

There are no conflicts of interest.

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