ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 9, Issue – 3, May – 2026, Page No. : 78 – 84

Effect of Bamboo Salt on The Push-Out Bond Strength of An Bioceramic Sealer to Etidronate Treated Root Dentin: An in Vitro Study

[1]Dr. Raghul R, Department of Conservative Dentistry and Endodontics, Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry, India

[2]Prof. Dr. Bikash Jyoti Borthakur, Department of Conservative Dentistry and Endodontics, Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry, India

[3]Prof. Dr. Ganesan S, Department of Conservative Dentistry and Endodontics, Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry, India

[4]Prof. Dr. Swathika B, Department of Conservative Dentistry and Endodontics, Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry, India

Corresponding Author: Dr. Raghul R, Department of Conservative Dentistry and Endodontics, Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry, India

Citation of this Article: Dr. Raghul R, Prof. Dr. Bikash Jyoti Borthakur, Prof. Dr. Ganesan S, Prof. Dr. Swathika B, "Effect of Bamboo Salt on The Push-Out Bond Strength of An Bioceramic Sealer to Etidronate Treated Root Dentin: An in Vitro Study", IJDSIR- May – 2026, Volume – 9, Issue – 3, P. No. 78 – 84.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Successful endodontic treatment requires effective disinfection of the root canal system and durable adhesion between the root canal sealer and dentin. Continuous chelation using etidronate (HEDP) has been introduced to minimize dentinal erosion associated with conventional irrigation protocols. However, residual oxidizing agents produced by sodium hypochlorite may adversely affect the bonding ability of root canal sealers. Bamboo salt, a mineral-rich traditional preparation with antioxidant properties, may improve dentin–sealer interaction. The present in vitro study was conducted to evaluate the effect of bamboo salt on the push-out bond strength of a bioceramic sealer to etidronate-treated root dentin. Forty-five extracted human mandibular premolars with single canals were selected. Following decoronation, biomechanical preparation was performed using rotary nickel–titanium instruments up to size 30/.06 taper. Continuous chelation irrigation was carried out using a mixture of 3% sodium hypochlorite and etidronate during instrumentation. The specimens were randomly divided into three groups: Group 1 – Control group, Group 2 – 25% bamboo salt-treated group, and Group 3 – 50% bamboo salt-treated group. Obturation was completed using a bioceramic sealer and gutta-percha cones. Two millimeter-thick sections obtained

from the middle third of the roots were subjected to push-out bond strength testing using a universal testing machine. The obtained data were statistically analyzed using one-way ANOVA and Welch's t-test with significance set at $p < 0.05$. The 50% bamboo salt-treated group demonstrated the highest push-out bond strength values, followed by the 25% bamboo salt-treated group, whereas the control group exhibited the lowest values. Statistical analysis revealed a significant difference among the groups ($p < 0.05$). Within the limitations of the present study, bamboo salt significantly improved the push-out bond strength of the bioceramic sealer to etidronate-treated root dentin, with higher concentrations demonstrating greater enhancement in sealer adhesion.

Keywords: Bamboo Salt, Bioceramic Sealer, Push-Out Bond Strength, Continuous Chelation, Sodium Hypochlorite, HEDP

Introduction

The long-term success of endodontic treatment primarily depends on effective disinfection of the root canal system followed by a three-dimensional obturation that prevents reinfection. An ideal obturation should establish a fluid-tight seal between the dentinal walls, sealer, and core filling material, thereby minimizing both apical and coronal microleakage. Strong adhesion between the root canal sealer and dentin is therefore considered essential for improving the durability and prognosis of endodontically treated teeth. [1,2]

Chemical irrigation is an indispensable part of root canal preparation because mechanical instrumentation alone cannot completely eliminate microorganisms and organic debris from the complex anatomy of the canal system. Among the currently available irrigants, sodium hypochlorite (NaOCl) is extensively used because of its broad antimicrobial spectrum and capacity to dissolve organic tissues.[3] Ethylenediaminetetraacetic acid (EDTA) is commonly employed as a chelating agent for smear layer removal.[3&4] Conventionally, these irrigants are used sequentially during canal preparation. However, this approach has been reported to produce undesirable alterations in dentin, including excessive demineralization, erosion of intertubular dentin, enlargement of dentinal tubules, and reduction in dentin mechanical properties.[5] Moreover, the chemical interaction between NaOCl and EDTA reduces the availability of free chlorine, which may compromise the effectiveness of NaOCl.[3]

To minimize these adverse effects, the concept of continuous chelation was introduced by Matthias Zehnder.[4] This technique utilizes etidronic acid, also referred to as 1-hydroxyethylidene-1,1-bisphosphonate (HEBP/HEDP), as a mild chelating agent that can be combined with sodium hypochlorite without immediate chemical degradation.[5&6] The continuous chelation protocol permits simultaneous irrigation and smear layer control throughout instrumentation while maintaining better preservation of dentin structure.[6]

Despite the advantages associated with NaOCl irrigation, residual oxidizing substances formed on the dentin surface may interfere with the adhesion of sealers to root dentin. These oxidizing remnants can alter the organic matrix of dentin and negatively influence the bonding capacity of obturation materials.[7,8] Previous investigations have demonstrated that antioxidant agents are capable of neutralizing these residual oxidants and restoring the bonding properties of dentin.[9]

Bamboo salt is a traditional Korean salt preparation obtained through repeated roasting of sea salt within bamboo cylinders sealed with mineral-rich clay. This process enriches the salt with several trace elements and minerals, including iron, manganese, boron, copper, and strontium. Bamboo salt has been reported to exhibit

antioxidant, antimicrobial, and anti-inflammatory activities.[10&11] Owing to its antioxidant potential, bamboo salt may counteract the oxidizing effects produced by sodium hypochlorite and improve the interaction between dentin and root canal sealers.

Bioceramic sealers have become increasingly popular in endodontics because of their superior sealing ability, biocompatibility, hydrophilic nature, and bioactive properties. These materials are capable of forming chemical bonds with dentin through hydroxyapatite formation, thereby enhancing adaptation to canal walls.[12&13] Since dentin surface characteristics significantly influence the bonding effectiveness of bioceramic sealers, the use of antioxidant agents may further improve their adhesion.[14]

Although several natural antioxidants have been investigated in restorative and endodontic procedures, limited evidence is available regarding the influence of bamboo salt on the bond strength of bioceramic sealers to etidronate-treated dentin. Therefore, the present in vitro study was designed to evaluate the effect of bamboo salt on the push-out bond strength of a bioceramic sealer to etidronate-treated root dentin.

Materials And Methods

Sample Selection

Forty-five freshly extracted human mandibular premolars with single roots and single canals were selected for the study. Teeth with visible cracks, carious lesions, internal or external resorption, calcified canals, or previous endodontic treatment were excluded. Soft tissue remnants and surface deposits were removed using an ultrasonic scaler, and the specimens were stored in distilled water until further use.

Specimen Preparation

The crowns were sectioned at the cementoenamel junction using a low-speed diamond disc under continuous water irrigation to obtain a standardized root length of 12 mm. Canal patency was verified with a #10 K-file, and the working length was established 1 mm short of the apical foramen. Biomechanical preparation was carried out using rotary nickel–titanium instruments up to size 30/.06 taper.

A continuous chelation irrigation regimen was followed during canal preparation. The irrigating solution was prepared by mixing two capsules of etidronate (0.42 g each) with 10 mL of 3% sodium hypochlorite according to the manufacturer's recommendations. The solution was used between each instrument change throughout instrumentation. Each canal was irrigated with 5 mL of solution for a standardized contact time of 3 minutes.

The specimens were randomly divided into three groups:

- **Group 1:** Control group
- **Group 2:** 25% bamboo salt-treated group
- **Group 3:** 50% bamboo salt-treated group

Following instrumentation and irrigation, the canals were dried using sterile paper points. A bioceramic sealer was introduced into the canal space with the help of a lentulo spiral, and obturation was completed using 30/.06 gutta-percha cones. The access cavities were sealed with intermediate restorative material, and the specimens were stored under suitable conditions until testing.

Each specimen was vertically embedded in autopolymerizing acrylic resin using cylindrical molds. After complete polymerization, 2 mm-thick sections were obtained from the middle third of each root using a precision saw under continuous water cooling. The sections were subjected to push-out bond strength analysis using a universal testing machine (figure 1). A metallic plunger measuring 0.5 mm in diameter was used to apply compressive force in an apico-coronal direction at a crosshead speed of 1 mm/min until bond failure occurred.

The maximum force required to dislodge the filling material was recorded in Newtons (N), and the push-out bond strength was calculated and expressed in megapascals (MPa).

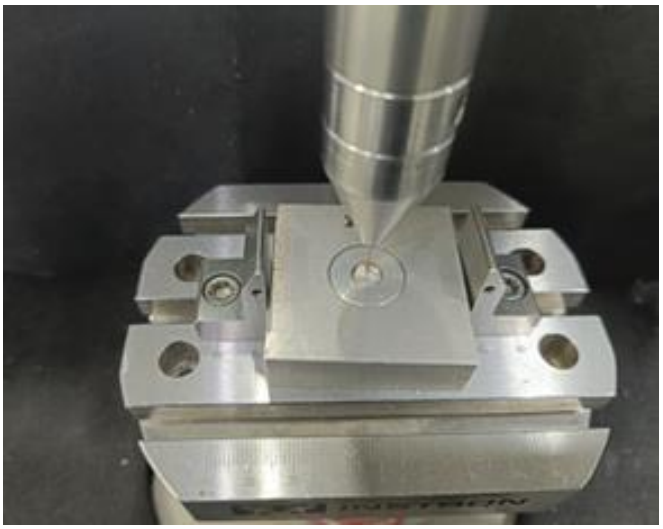

Fig 1: universal testing machine

Statistical Analysis

The obtained data were tabulated and subjected to statistical analysis using IBM SPSS Statistics software. One-way analysis of variance (ANOVA) followed by Welch's t-test was used to compare the mean push-out bond strength values between the groups. Statistical significance was set at $p < 0.05$.

Results

The present study evaluated the effect of different concentrations of bamboo salt on the push-out bond strength of a bioceramic sealer to etidronate-treated root dentin. The mean push-out bond strength values varied among the experimental groups, indicating that the final irrigation protocol had a considerable influence on the adhesion of the sealer to root canal dentin.

Among all the groups tested, the specimens treated with 50% bamboo salt demonstrated the highest push-out bond strength values. The 25% bamboo salt-treated group also showed improved bond strength when compared with the control group. In contrast, the control group exhibited the lowest resistance to dislodgement, suggesting reduced adhesion between the bioceramic sealer and dentinal walls.

Statistical evaluation of the obtained data revealed a significant difference in push-out bond strength among the three groups ($p < 0.05$). Intergroup comparison demonstrated that both bamboo salt-treated groups showed significantly higher bond strength values than the control group. Additionally, the 50% bamboo salt group exhibited superior bond strength compared with the 25% bamboo salt group, indicating that increased concentration of bamboo salt enhanced the bonding ability of the bioceramic sealer.

The improved bond strength observed in the bamboo salt-treated groups may be attributed to the cleansing ability and mineral-rich composition of bamboo salt, which could have contributed to better dentin surface characteristics and enhanced penetration of the bioceramic sealer into dentinal tubules. These findings suggest that bamboo salt may positively influence the interaction between root dentin and bioceramic sealers following etidronate irrigation.

Table 1 : Mean Maximum Force [N] and Mean Compressive stress at Maximum Force [MPa] of group 1,2 and 3.

Groups	Mean Maximum Force [N]	Mean Compressive stress at Maximum Force [MPa]
Group 1	4.02	0.14
Group 2	11.01	0.38
Group 3	19.02	0.53

Discussion

The long-term success of endodontic treatment is primarily dependent on thorough disinfection of the root canal system and the establishment of a three-dimensional seal that prevents reinfection. Following biomechanical preparation, the obturating material and sealer should adhere effectively to the dentinal walls in order to minimize apical and coronal microleakage. [1&2] Therefore, evaluation of bond strength has become an important aspect in endodontic research, as it reflects the ability of the filling material to resist displacement during functional stresses and maintain the integrity of the seal over time.

Push-out bond strength testing is widely accepted as a reliable and reproducible method for assessing the adhesion between root dentin and root canal filling materials.[15] This method closely simulates clinical conditions by applying force parallel to the dentin–sealer interface until debonding occurs. Higher push-out bond strength values indicate improved resistance to dislodgement and stronger interaction between the sealer and root dentin.

In the present study, the bamboo salt-treated groups demonstrated significantly higher push-out bond strength values compared with the control group. Among the experimental groups, the 50% bamboo salt-treated group showed the greatest bond strength, followed by the 25% bamboo salt group. These findings suggest that bamboo salt enhanced the adhesion of the bioceramic sealer to etidronate-treated root dentin and that the effect may increase with higher concentrations.

The improvement in bond strength observed after bamboo salt application may be associated with its antioxidant activity. Sodium hypochlorite is one of the most commonly used endodontic irrigants because of its excellent antimicrobial efficacy and tissue-dissolving capability.[3] Despite these advantages, NaOCl has been reported to adversely affect the structural and chemical composition of dentin. [7] It can degrade the collagen matrix and alter the organic components of dentin, thereby compromising the adhesion of restorative and endodontic materials. [8] In addition, residual oxygen-rich free radicals produced following NaOCl irrigation may inhibit the proper setting and bonding of sealers to dentin surfaces.[9]

Antioxidants have been investigated in endodontics for their ability to reverse the oxidizing effects of sodium hypochlorite.[9] These agents neutralize residual free radicals and help restore the redox potential of dentin, thereby improving the interaction between dentin and adhesive materials. Bamboo salt possesses potent antioxidant properties due to its unique preparation process and mineral-rich composition. [10&11] The antioxidant effect of bamboo salt may have neutralized residual oxidizing agents on the dentin surface, thereby improving the bonding environment for the bioceramic sealer.

Another factor that may have contributed to the enhanced bond strength is the alkaline nature of bamboo salt. Enhanced wettability allows better penetration of the sealer into dentinal irregularities and tubules, resulting in improved micromechanical interlocking. The mineral content present in bamboo salt may also facilitate favorable chemical interactions at the dentin–sealer interface, thereby enhancing adhesion.

In the current study, continuous chelation with etidronate (HEDP) was employed during instrumentation. Conventional irrigation protocols involving sodium hypochlorite followed by EDTA are effective in smear layer removal; however, they may also produce excessive dentin erosion and reduction in dentin microhardness when used for prolonged periods.[5] HEDP is a weaker

chelating agent that can be combined directly with sodium hypochlorite, enabling simultaneous irrigation and chelation throughout canal preparation. [4&6] This approach has been shown to minimize dentinal erosion while maintaining the antimicrobial effectiveness of sodium hypochlorite. [6] Preservation of dentin integrity through continuous chelation may have provided a more favorable substrate for sealer adhesion in the present study.

Bioceramic sealers have gained considerable popularity in contemporary endodontics because of their bioactive and hydrophilic properties.[12] These materials are capable of forming hydroxyapatite during the setting reaction and can chemically bond with dentin.[13] Their hydrophilic nature enables them to utilize residual moisture within dentinal tubules, resulting in better adaptation to canal walls.[14] Furthermore, bioceramic sealers exhibit dimensional stability and slight expansion upon setting, which contributes to improved sealing ability. The enhanced bond strength observed in the bamboo salt-treated groups may therefore be attributed to improved interaction between the conditioned dentin surface and the bioactive sealer.

The results of the present study are in accordance with previous investigations that reported improved bonding performance following the use of antioxidant agents after NaOCl irrigation.[9] Studies evaluating natural antioxidants have shown their ability to restore dentin properties and enhance adhesion of endodontic materials. Bamboo salt, being a natural substance with antioxidant and mineral-rich characteristics, may serve as a promising adjunct in endodontic irrigation protocols.

References

1. Pathways of the Pulp Hargreaves KM, Berman LH. Pathways of the Pulp. 11th ed. St Louis: Elsevier; 2016.
2. Cohen's Pathways of the Pulp Cohen S, Hargreaves KM. Cohen's Pathways of the Pulp. 10th ed. St Louis: Mosby Elsevier; 2011.
3. Zehnder M. Root canal irrigants. J Endod. 2006;32(5):389-98.
4. Zehnder M, Schmidlin P, Sener B, Waltimo T. Chelation in root canal therapy reconsidered. J Endod. 2005;31(11):817-20.
5. De-Deus G, Zehnder M, Reis C, Fidel S, Fidel RA, Galan J Jr, et al. Longitudinal co-site optical microscopy study on the chelating ability of etidronate and EDTA using a comparative single-tooth model. J Endod. 2008;34(1):71-5.
6. Tartari T, Oda DF, Zancan RF, da Silva TL, de Moraes IG, Duarte MAH, et al. Mixture of sodium hypochlorite and etidronate promotes continuous chelation and increases cleaning ability. J Appl Oral Sci. 2017;25(5):514-22.
7. Ari H, Erdemir A. Effects of endodontic irrigation solutions on mineral content of root canal dentin using ICP-AES technique. J Endod. 2005;31(3):187-9.
8. Morris MD, Lee KW, Agee KA, Bouillaguet S, Pashley DH. Effects of sodium hypochlorite and RC-Prep on bond strengths of resin cement to endodontic surfaces. J Endod. 2001;27(12):753-7.
9. Lai SCN, Mak YF, Cheung GSP, Osorio R, Toledano M, Carvalho RM, et al. Reversal of compromised bonding in bleached enamel. J Dent Res. 2002;81(7):477-81.
10. Kim MJ, Kim HK. Antioxidative and antimicrobial effects of bamboo salt. J Korean Acad Dent Health. 2002;26:475-84.
11. Shin HY, Lee EH, Kim CY, Shin TY, Kim SD, Song YS, et al. Anti-inflammatory activity of

Korean bamboo salt. Immunopharmacol Immunotoxicol. 2003;25(3):377-84.

12. Koch K, Brave D. Bioceramic technology: closing the endo-restorative circle, part 1. Dent Today. 2010;29(2):100-5.
13. Zhang W, Li Z, Peng B. Ex vivo cytotoxicity of a new calcium silicate-based canal filling material. Int Endod J. 2010;43(9):769-74.
14. Nagas E, Uyanik MO, Eymirli A, Cehreli ZC, Vallittu PK, Lassila LVJ, et al. Dentin moisture conditions affect the adhesion of root canal sealers. J Endod. 2012;38(2):240-4.
15. Pane ES, Palamara JE, Messer HH. Critical evaluation of the push-out test for root canal filling materials. J Endod. 2013;39(5):669-73.