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# Push-out bond strength of a glass fibre post to root dentin pretreated with novel dentin biomodifiers: An *in vitro* study

**S. Francy Teena[1,*], Bharath Nagareddy[1], S. Shobiya[1], Saranya Sivaraj[1], R. Raghul[2] & L. Gnana Sooriyaa[2]**

[1]Department of Conservative Dentistry and Endodontics, Adhiparasakthi Dental College and Hospital, Melmaruvathur, Tamil Nadu, India; [2]Department of Conservative Dentistry and Endodontics, Sri Venkateshwaraa Dental College, Puducherry, Tamil Nadu; India; *Corresponding author

**Affiliation URL:**
https://apdch.in/
https://svdcpondy.ac.in/

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**Author contact:**
S. Francy Teena - E-mail: switzerland2096@gmail.com
Bharath Nagareddy - E-mail: drbharathendo999@gmail.com
S. Shobiya - E-mail: shobiyakct@gmail.com
Saranya Sivaraj - E-mail: drsaranya@apdch.edu.in
R. Raghul - E-mail: raghulravi1998@gmail.com
L. Gnana Sooriyaa - E-mail: suriyamgpgi98@gmail.com

**Abstract:**
Glass fiber posts are prone to debonding at the post–cement–dentin interface, compromising post-endodontic restorations. Dentin bio modifiers such as baicalein, pomegranate extract and cinnamon bark extract were evaluated for their effect on push-out bond strength. Forty single-rooted teeth were treated, divided into four groups and tested at coronal, middle and apical thirds. Baicalein showed the highest bond strength across all regions, followed by pomegranate and cinnamon, with all bio modifiers outperforming controls. Thus, pre-treatment with natural bio modifiers significantly enhances fiber post retention, with baicalein emerging as the most promising agent for clinical application.

**Keywords:** Dentin, glass fibre post, Baicalein, *Punica granatum*, push-out bond strength

**Background:**
Glass fiber posts are widely used for the restoration of endodontically treated teeth. Among the post systems, glass fiber posts have gained popularity because their elastic modulus is closer to that of root dentin, thereby reducing stress concentrations within the root and potentially decreasing the risk of root fracture. Nevertheless, one of the principal failure modes of post-retained restorations remains debonding at the post–cement–dentin interface. The long-term integrity of that interface is therefore critical for the success of post-endodontic restorations **[1].** The root canal environment presents significant challenges to achieving durable adhesive bonding because of its anatomical and procedural complexities **[2].** Under these conditions, the retention of a fiber post depends not only on the adhesive properties of the luting cement but also on the condition of the intraradicular dentin substrate **[3].** Dentin bio modification has emerged as a promising strategy to enhance the durability of the resin–dentin interface by stabilizing the collagen matrix and reducing enzymatic degradation **[4]**. Natural and synthetic bio modifiers act primarily through collagen cross-linking and inhibition of collagen-degrading enzymes. Although most of the published work has focused on coronal adhesive procedures (*e.g.,* resin–dentin bonding in cavities), there is growing interest in applying bio modification strategies to intraradicular dentin in post-endodontic contexts **[5]**. Among the potential dentin bio modifiers, baicalein, a naturally occurring flavonoid, has been shown to inhibit mmps and cathepsins while improving resin–dentin bond durability **[6].** Similarly, *punica granatum* (pomegranate) extract exhibits antioxidant properties and helps preserve the adhesive interface. Cinnamon bark extract, known for its antioxidant and collagen-stabilizing properties, has been minimally investigated as a dentin bio modifier and may represent a promising agent for intraradicular dentin treatment **[7].** However, evidence regarding the effect of dentin bio modifiers on the push-out bond strength of glass fiber posts to intraradicular dentin remains limited. The push-out bond strength test is a widely accepted method for evaluating fiber post retention **[8].** Pre-treatment of intraradicular dentin with bio modifiers may improve substrate quality, enhance adhesive bonding and increase the long-term retention of fiber posts **[9].** Therefore, it is of interest to assess and compare the push-out bond strength of glass fiber posts to root dentin that has been treated with novel dentin bio modifiers (namely baicalein, pomegranate peel extract and cinnamon bark extract) versus untreated controls.

**Materials and Methods:**

**Preparation of dentin bio modifiers:**
Baicalein (sigma-aldrich), *punica granatum* (pomegranate) powder (bixa botanical, India) and cinnamon bark powder were processed using a standardized hydroethanolic extraction method. Briefly, the powders were extracted in 50% ethanol under magnetic stirring for 4 hours, followed by filtration through what man filter paper and solvent evaporation to obtain the respective extracts. The final concentrations used for dentin pretreatment were 2.5% baicalein, 10% *p. Granatum* and 6.5% cinnamon extract.

**Specimen preparation:**
Forty freshly extracted intact single-rooted human teeth, obtained for orthodontic or periodontal reasons, were collected following institutional ethical approval and stored in 0.1% thymol solution until use. The crowns were removed to standardize the root length to 14 mm. Root canal treatment was performed using ProTaper gold rotary instruments up to size f3 with 3% sodium hypochlorite irrigation. The smear layer was removed using 17% EDTA, after which the canals were obturated with gutta-percha and ah plus sealer. Post spaces were prepared using a #3 peeso reamer while maintaining 5 mm of apical gutta-percha. The post-space smear layer was removed with 17% EDTA, followed by etching with 37% phosphoric acid, rinsing and drying.

**Experimental groups:**

The specimens were randomly allocated into four groups (n = 10):

**[1] Group a:** control (no dentin pretreatment)
**[2] Group b:** 2.5% baicalein
**[3] Group c:** 10% *punica granatum* extract
**[4] Group d:** 6.5% cinnamon extract

The respective bio modifier solutions were applied into the post space for 5 minutes with intermittent agitation, followed by rinsing and drying.

**Fiber post cementation:**

A dual-cure adhesive system (ExciTE F DSC, ivoclar vivadent) was applied according to the manufacturer's instructions. Glass fiber posts were cemented using dual-cure resin cement (variolink, ivoclar vivadent), light-cured and the specimens were stored in distilled water at room temperature for 24 hours before testing.

**Push-out bond strength evaluation:**

Each root was sectioned perpendicular to its long axis into 1-mm-thick slices representing the coronal, middle and apical thirds. Push-out bond strength was evaluated using a universal testing machine at a crosshead speed of 0.5 mm/min until post dislodgement. Bond strength values were calculated in megapascals (mpa). Failure modes were subsequently examined under an optical microscope at 40× magnification.

**Statistical analysis:**

Data were analyzed using SPSS version 26.0 (IBM corp., armonk, NY, USA). Normality was assessed using the shapiro–wilk test. Differences among groups were analyzed using one-way analysis of variance (ANOVA), followed by tukey's post-hoc test for pairwise comparisons. Statistical significance was established at $p < 0.05$.

**Results:**

The mean ± standard deviation of the push-out bond strength values (MPa) for all experimental groups at different levels of the post space are presented in **Table 1.** The control group exhibited the lowest bond strength across all regions, with values ranging from 8.52 ± 2.3 MPa apically to 11.72 ± 3.87 MPa in the middle third. In contrast, pre-treatment with 2.5% baicalein resulted in the highest bond strength values at all levels, with coronal, middle and apical measurements of 28.2 ± 5.62, 22.5 ± 2.87 and 21.9 ± 4.7 mpa, respectively. The 10% *Punica granatum* group showed intermediate values (22.4 ± 4.75, 18.24 ± 4.02 and 18.1 ± 3.5 MPa), while the 6.5% cinnamon group showed comparatively lower improvements (17.8 ± 4.8, 15.5 ± 2.3 and 14.4 ± 2.9 MPa). Across all groups, a consistent coronal > middle > apical trend was observed, indicating higher bond strength in the coronal third compared to deeper regions of the canal. Statistical analysis revealed significant differences among the groups at each level of the post space ($p = 0.001$), confirming that dentin bio modifier pre-treatment significantly enhanced the bond strength of fiber posts compared to the untreated control.

**Table1:** Mean ± standard deviation of the push out bond strength (MPa) of all the groups at different levels of the post space

| Groups | Coronal | Middle | Apical |
|---|---|---|---|
| **Control** | 10.25 ± 2.55 | 11.72 ± 3.87 | 8.52 ± 2.3 |
| **2.5% baicalcin** | 28.2 ± 5.62 | 22.5 ± 2.87 | 21.9 ± 4.7 |
| **10% p. Granatum** | 22.4 ± 4.75 | 18.24 ± 4.02 | 18.1 ± 3.5 |
| **6.5% cinnamon** | 17.8 ± 4.8 | 15.5 ± 2.3 | 14.4 ± 2.9 |
| **P-value** | **0.001*** | **0.001*** | **0.001*** |
| **P- value- <0.05*** | | | |

**Discussion:**

The success of post-endodontic restorations largely depends on the durability of the post–cement–dentin interface. The hybrid layer is widely recognized as the most vulnerable component of this interface because of its susceptibility to hydrolytic and enzymatic degradation **[10]**. This may explain the predominance of adhesive failures observed in the control group. Our findings are consistent with previous studies reporting that untreated dentin surfaces compromise resin infiltration and reduce bond durability. These observations support the use of dentin bio modification to improve the stability of the adhesive interface. Dentin bio modification enhances collagen stability and limits enzymatic degradation, thereby improving adhesive performance **[11]**. In the present study, all three herbal bio modifiers - baicalein, *punica granatum* and cinnamon produced significantly higher push-out bond strength than the untreated control, indicating that dentin pretreatment enhances fiber post retention. These findings agree with previous reports showing improved resin–dentin adhesion following the use of collagen cross-linking agents such as proanthocyanidins, tannic acid and genipin **[12]** among the tested bio modifiers, baicalein consistently showed the highest push-out bond strength at the coronal, middle and apical root levels. This superior performance may be attributed to its ability to inhibit matrix metalloproteinase activity, thereby reducing collagen degradation and improving hybrid layer stability **[13]**. The present findings are consistent with previous studies showing enhanced resin–dentin bond durability with baicalein and extend its potential application to intraradicular dentin. Clinically, baicalein may represent a promising adjunct irrigant for improving fiber post retention and minimizing long-term deboning of post-endodontic restorations. *Punica granatum* extract also produced significantly higher bond strength than the control, although its effect was less pronounced than that of baicalein. Its polyphenolic constituents promote collagen stabilization and may enhance hybrid layer integrity, contributing to improved adhesive performance **[14]**. Although less effective than baicalein, pomegranate remains a promising natural bio modifier because of its biocompatibility and antioxidant properties. Cinnamon extract showed the lowest bond strength among the experimental groups but still significantly outperformed the control. This finding may be attributed to its comparatively weaker collagen-stabilizing potential. Nevertheless, its antimicrobial properties may provide additional clinical benefits during post-space preparation **[15, 16]**. Bond strength decreased progressively from the coronal to the apical third in all groups. This finding agrees with previous reports and is attributed to anatomical differences in

root dentin, including reduced dentinal tubule density, increased sclerosis, limited adhesive penetration and less effective polymerization in the apical region **[17, 18]**. The present findings support the use of natural dentin bio modifiers as adjuncts to improve fiber post retention. Among the tested agents, baicalein showed the greatest improvement and may have potential for clinical application as an adjunct irrigant. Although pomegranate and cinnamon produced comparatively lower bond strengths, both significantly enhanced adhesion compared with untreated dentin **[19]**. The present study has several limitations. As an *in vitro* investigation, it did not replicate the complex intraoral environment or evaluate the long-term effects of thermocycling and mechanical loading on bond durability. Future studies should incorporate artificial aging protocols, assess cytotoxicity and biocompatibility, evaluate dentinal tubule penetration and biofilm disruption and validate these findings through well-designed clinical studies.

**Conclusion:**

Herbal biomodifiers significantly improved the push out bond strength of glass fibre posts compared with untreated controls. Baicalein showed the highest bond strength, followed by *Punica granatum* and cinnamon, with values decreasing from coronal to apical thirds. Natural biomodifiers, especially baicalein, may be promising adjuncts for fibre post retention, but require further long term validation.

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