Comparative Analysis Of Bonding Systems For Quartz Fiber Posts In Root Dentine

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ABSTRACT

Background: *The success of bonding quartz fiber posts to root dentin hinges on various factors, including the bonding system. This experimental study aimed to investigate pull-out bond strength (PBS) of quartz fiber post toward root denting using different adhesive systems.*
Method: *Thirty six human teeth (n=12) were embedded in acrylic resin blocks. Crowns were sectioned, leaving the root portion 20mm in length. Root canals were treated with standard endodontic protocols using the rotary instrument, obturated with gutta percha, and prepared for post cementation, leaving a 4mm apical seal. Root canals were prepared uniformly. After simple randomization, samples were divided into three groups according to the adhesive systems (Allcem core dual resin, NOVA resin self-adhesive, and GC FUJI Luting & Lining). Cementation procedures followed to manufacturer instructions. Post cementation was tested for PBS using a Universal Testing Machine (TN20 MD) until the posts were detached. Data were analyzed using the Kruskal-Wallis and Mann-Whitney U post hoc test (α=0.05)*
Result: *The Kruskal-Wallis test indicated significant differences among the groups (P < 0.001), with GC FUJI Luting & Lining showing the significantly lowest PBS.*
Conclusion: *Different cementation materials exhibit varying bond strengths. GC FUJI Luting & Lining provided inferior bond strength, making it the least recommended choice for bonding quartz fiber posts to root dentin.*

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INTRODUCTION

Both the root canal treatment's success and the restoration technique employed have an impact on the results of endodontically treated teeth[1,2]. Restoring endodontically treated teeth often requires posts to provide support and retention for crowns or other restorations[1]. Quartz fiber posts are a popular option in clinical practice because they provide improved aesthetics and better stress distribution within the root system. The ability of glass fiber-reinforced posts (GFPs) to adhere to the root canal makes them popular. Unidirectional fiber-reinforced composite posts and recent developments in adhesive technology offer fresh approaches to restoring teeth that have received root canal therapy. Compared to conventional cast metal posts and cores, these composite fiber posts provide a better option. Choosing suitable restorative materials can result in prosthetic restorations with mechanical properties that closely resemble natural dentin. The posts are designed to be bonded to the root canal using resin composites, with the core subsequently built up using a similar material type[3].

The strength of the bond between the post and root dentine significantly impacts the long-term success of restorations using quartz fiber posts. Strong, long-lasting adhesion is crucial to avoid post debonding, which can jeopardize the tooth's structural integrity and result in restorative failure. When the tooth is exposed to both functional and parafunctional stresses over time, the adhesive bond between the post and dentine is crucial. Finding bonding techniques that can consistently improve the adherence of quartz fiber posts to root dentine has thus emerged as a crucial field of study[4].

Quartz fiber posts are widely preferred because of their beneficial characteristics, such as a high strength-to-weight ratio, elasticity that closely matches dentin, and aesthetic qualities that enable minimal tooth reduction[5]. However, achieving a durable bond between the quartz fiber post and the root dentin is crucial for the long-term success of the restoration. Debonding of the post can lead to leakage, recurrent caries, and ultimately, post failure. The success of bonding quartz fiber posts to root dentin depends on various factors, such as the surface treatment of the dentin, the characteristics of the post material, and the type of adhesive system used[6]. Other factors impacting retention include post length, post diameter, post design, and surface configuration[7].

Cementation materials play a crucial role in maintaining post retention and minimizing coronal microleakage, which can lead to root canal filling failure[8]. Currently, several types of cement materials are available, including regular resin cement, self-adhesive resin cement, and glass ionomer cement (GIC)[2]. Typically, resin cement is used for fiber post cementation. However, resin cement is sensitive to application and carries a high risk of bonding failure. An alternative, self-adhesive resin cement, is easier to apply but tends to be expensive. Moreover, self-adhesive resin cement sometimes requires additional materials like silane to improve retention. Compared to resin cement, GIC-based cement is more affordable and easier to apply[9]. GIC also offers better viscoelastic properties, which are advantageous for maintaining bond integrity during polymerization shrinkage, as opposed to resin cement[10].

To create a solid micromechanical bond at the dentin-post interface, the adhesive system is essential. Understanding how these variations affect bond strength with quartz fiber posts is crucial since different adhesive systems employ distinct bonding methods and procedures. To achieve the best clinical outcomes, this study assists dentists in selecting the best adhesive. To improve clinical procedures for effective post and core restorations, this study will investigate how various bonding techniques impact the bond strength between quartz fiber posts and root dentin.

MATERIALS AND METHODS

This research was approved by the Ethical Committee, Faculty of Dentistry, UNISSULA, with registration number No. 463/B.1-KEPK/SA-FKG/IV/2023. In this study, 36 human mandibular second premolars with their crowns removed were used. Materials and instruments involved in the study are listed in Table 1. The root canals were prepared sequentially using ProTaper rotary files SX, S1, and S2 (Dentsply Maillefer, Switzerland), according to the working length. Root canal preparation was completed with finishing procedures using files F1 and F2 (Dentsply Maillefer, Switzerland). The procedure followed standard endodontic protocols, including irrigation using 2.5% sodium hypochlorite and 17% EDTA between each file change. In this study, root canal preparation was performed using an endodontic motor. The torque and speed settings were applied, as shown in Table 2.

Gutta-percha (MetaBiomed, Korea) and endodontic sealer (Endoseal, Prevest DentPro, India) were used to obturate the canals following preparation utilizing the lateral condensation technique. After a day, Gates Glidden drills were used to prepare the gutta-percha further, leaving a 4mm apical seal. Before cementation, all samples were washed and dried with paper points. The samples were randomly divided using a simple random sampling method into three groups based on the cementation materials (as shown in Table 3). Each group underwent fiber post cementation following the manufacturer's recommended procedures. Samples were kept in an incubator for a full day following the cementation processes.

Before the bond strength test, all samples were mounted in the acrylic block to hold the teeth (Figure 1). The bond strength was evaluated using a pull-out test on a Universal Testing Machine (TN20 MD) at a 0.5mm/min rate until the post dislodged from the tooth (Figure 2). The data were not normally distributed when assessed for normality by the Shapiro-Wilk test, which showed that the data were not normally distributed. Therefore, the Kruskal-Wallis non-parametric test was used to analyze the differences in bond strength between the cementation materials. Data were processed using SPSS software (SPSS 27.0, IBM Software Solutions, New York, NY, USA). The significance level was set at $\alpha = 0.05$.

Table 1. Materials used in the study

Materials and Instruments	Manufacturer
Allcem CORE dual resin	FGM Dental Group, Brazil
NOVA RESIN self-adhesive	Imicryl, Turkey
GC Fuji 1 Luting & Lining	GC Corp, Japan
High-intensity quartz fiber post	AAA Dental, China
Gutta percha	MetaBiomed, Korea
Endoseal	Prevest DentPro, India
ProTaper Universal	Dentsply Maillefer, Switzerland
Hillon self-curing acrylic	S. Court Limited, England

Table 2. Endodontic motor working parameter

File Size	Torque (Ncm)	Speed (rpm)

ProTaper® Universal SX	3	
ProTaper® Universal S1	3	
ProTaper® Universal S2	1,5	250
ProTaper® Universal F1	1.5	
ProTaper® Universal F2	2	

Table 3. Sample grouping and treatment

Group	Adhesive system	Application method[a]
1	Allcem CORE dual resin	1. Dentin surface washed with air/water spray 2. Air-dried gently (5s at 20cm) 3. Acid etching with 37% phosphoric acid (Primo Etch, Sincera Technology, Changchun, China) (15s), rinsing (15s) and dried with cotton pellet and paper point leaving dentin surface moist 4. Application of bonding agent (3M™ Single bond Universal Adhesive, 3M ESPE), gently air-dried (5s at 20cm) 5. Light-cured for 40s at 800mW/cm^2 6. Application of adhesive system (Allcem CORE dual resin) using intra-canal tip and covering entire post surface 7. Put post into root canal 8. Light-cured for 40s at 800mW/cm^2
2	*NOVA RESIN self-adhesive*	1. Dentin surface washed with air/water spray 2. Dried with cotton pellet and paper point leaving dentin surface moist 3. Application of adhesive system (NOVA RESIN self-adhesive) using automix syringe into root canal and covering entire post surface 4. Put post into root canal 5. Light-cured for 40s at 800mW/cm^2
3	GC Fuji 1 Luting & Lining	1. Dentin surface washed with air/water spray 2. Dried with cotton pellet and paper point leaving dentin surface moist 3. Mixing powder and liquid of GC Fuji 1 (GC Corp)Luting and lining according to manufacturer's instruction (powder to liquid ratio=1.8g/1.0g) 4. Applied adhesive system into root canal using micro-brush and covering entire post surface 5. Put post into root canal 6. Wait until 4mins and 30s

[a]According to the manufacturer's instructions

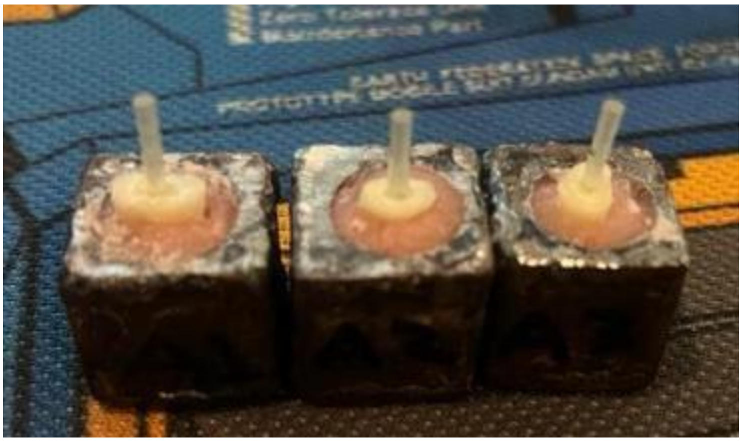

Figure 1. Samples were mounted in the acrylic block prior to the pull out test

Figure 2. Pull out test using Univeresal Testing Machine (TN20 MD)

RESULTS

Table 4 and Figure 3 present the mean PBS values, standard deviations (SD), and results of the Shapiro-Wilk normality test for each experimental group. The normality test for Group 2 (NOVA resin self-adhesive) yielded a p-value of 0.02, indicating that the data were not normally distributed. As a result, a non-parametric test (Kruskal-Wallis) was selected for statistical analysis rather than the parametric ANOVA test.

The Kruskal-Wallis test revealed statistically significant differences among the bonding systems ($p < 0.001$), highlighting the influence of different adhesive approaches on bond strength. Pairwise comparisons between groups, performed using the Mann-Whitney U test (Table 5), further clarified these differences. Specifically, Group 3 showed a significantly lower bond strength compared to Groups 1 and 2 ($p < 0.05$), suggesting that the bonding efficacy of the system used in Group 3 was inferior. Although Groups 1 and 2 did not exhibit a statistically significant difference from each other ($p=0.192$), the results indicated that Group 1 demonstrated a higher bond strength compared to Group 2.

Table 4. Means and standard deviations (SD) of shear bond strength results (Mpa)

	Mean	SD	95% CI for mean Lower bound	95% CI for mean Upper bound	SW	KW
Allcem core dual	14.37	1.97	13.11	15.62	.595	<0.001
NOVA resin self adhesive	13.33	2.93	11.47	15.20	.020	
GC Fuji 1	9.60	2.60	7.95	11.26	.893	

SD: Standard deviation; CI: Confidence interval; SW: Saphiro-Wilk; KW: kruskal-Wallis

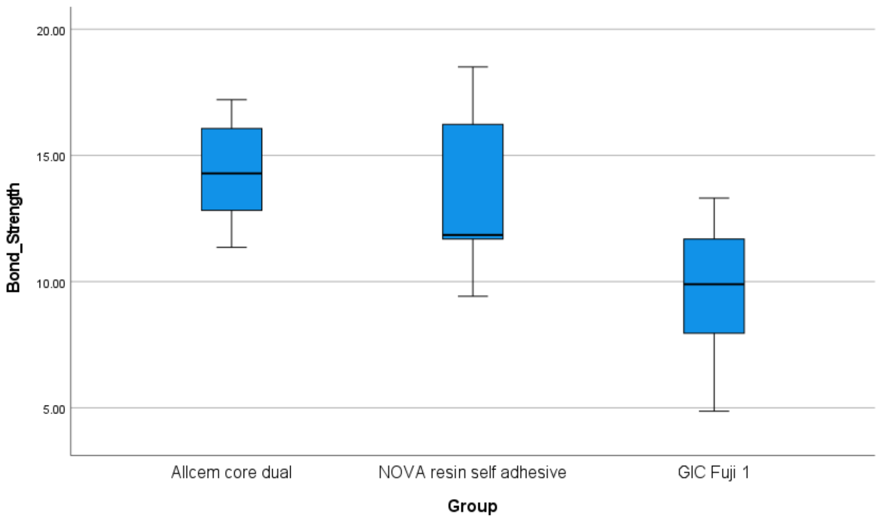

Figure 3. Mean bond strength values of three groups of bonding systems plotted at significant levels.

DISCUSSION

In post and core restoration treatments, the failure of fiber post adhesion is the most common cause of failure in post restorations. The retention of fiber posts not only depends on the bond between the post and the cement but also relies on the bond formed between the intraradicular dentin and the cementing material[11]. This dual bonding is essential for the long-term success of post restorations, as the stability of the post within the root canal relies on the strength of both connections. When a post is cemented into the root canal, two bonds are established: one between the post and the cement, and another between the cement and the surrounding intraradicular dentine[12]. Achieving strong adhesion at both interfaces is crucial to ensure the integrity and durability of the restoration.

The null hypothesis that different bonding system types do not affect the bond strength of quartz fiber posts towards root dentine was rejected. The study's findings indicate that GIC Fuji 1's bond strength was noticeably weaker than that of the other two groups, which are adhesive systems based on resin. The results highlight a clear correlation between the type of adhesive system used and the bond strength. Resin-based systems, such as Allcem Core Dual Resin and Nova

Resin Self-Adhesive, produced significantly higher bond strengths compared to the glass ionomer-based GIC GC Fuji 1 luting cement. This is in line with recent research that has demonstrated that, generally speaking, resin cements outperform glass ionomer cements in terms of shear bond strength[13–17].

The low bonding strength of GIC is attributed to its lack of flexibility, sensitivity to contamination, and the formation of porosity[15–17]. Porosity or voids in GIC can result from trapped air or uneven hydration of the powder by the liquid. The risk of porosity increases when GIC is mixed using hand-mixing techniques, as improper ratios between the powder and liquid and inconsistent material texture can occur[18,19]. However, a study by Kremeier mentioned that GIC-based adhesive systems outperformed other luting materials when used for cementing gold posts[5].

On the other hand, the other two groups demonstrated no significant differences, although Allcem Core Dual had slightly higher bond strength than Nova Resin Self-Adhesive. This indicates that both adhesive systems are capable of delivering satisfactory bond strength for luting quartz fiber posts to root dentine. Allcem Core Dual is a traditional resin-based adhesive system requiring surface pretreatment with phosphoric acid and a bonding system before cementation. In contrast, Nova Resin Self-Adhesive doesn't need such surface pretreatment, simplifying the treatment process. Adhesive systems lacking hydrophilic properties or proper chemical bonding agents may weaken bonds. For instance, certain self-adhesive systems, while easier to apply, are known to exhibit lower bond strength compared to multi-step adhesive systems that offer more control over dentin conditioning and bonding layers[20]. Several studies have shown that self-adhesive resin cement's tensile bond strength is lower than resin cement using the total-etch mechanism. This is because self-adhesive resin cements with methacrylated phosphoric acid esters cannot entirely remove the smear layer. The remaining layer creates a weak zone in the bond between the dentin and the cementing material[21].

CONCLUSIONS

The GIC-based adhesive system (i.e., GC Fuji 1) is not fully suitable for cementing quartz fiber posts to root dentine due to its lower bond strength compared to resin-based adhesive systems. Although both resin-based adhesive systems deliver satisfactory bond strength, multi-step adhesive systems (i.e., Allcem Core Dual) offer slightly higher bond strength compared to self-adhesive resin cement. Self-adhesive resin cement provides clinicians a more convenient working procedure due to its fewer steps. Further work is needed to establish the best procedures in this complex area. Besides mechanical testing and modeling, aging in the biological environment would provide complementary long-term perspectives.

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