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ORIGINAL RESEARCH

EVALUATION OF PUSH-OUT BOND STRENGTH OF GLASS FIBER POSTS USING DIFFERENT LUTING CEMENTS

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ABSTRACT

Objective: To evaluate the push-out bond strength of glass fiber posts (GFPs) luted with three different materials—bulk-fill resin composite, resin-modified glass ionomer cement (RMGIC), and self-adhesive resin cement—across various root canal regions.

Materials and Methods: Thirty extracted human mandibular premolars were decoronated and endodontically treated. Specimens were divided into three groups based on the luting agent (n = 10). After post cementation, the roots were transversely sectioned into coronal, middle, and apical thirds. Tukey's post hoc test ($p < 0.05$) and two-way ANOVA were used to examine the results after push-out bond strength was determined using a universal testing machine.

Results: Bond strength was strongly impacted by the type of luting agent and the root canal area ($p < 0.001$). The highest mean bond strength was found in the apical third luted with bulk-fill resin (27.20 ± 1.20 N), while the middle third luted with self-adhesive resin exhibited the lowest (8.16 ± 1.20 N).

Conclusion: Bulk-fill resin composite demonstrated superior bonding performance across all root levels. The interaction between anatomical location and luting agent should be carefully considered in clinical post-endodontic restorations.

Keywords: Glass fiber, resin-modified glass cement, push-out bond strength, endodontic restoration

1.INTRODUCTION

Restoring teeth that have undergone treatment frequently involves strengthening them because they may have significant structural damage caused by decay and procedures, like cavity preparation and biomechanical instrument use. Intracanal posts serve a pivotal role in retaining core restorations, especially in cases with substantial loss of coronal tooth structure. Because of their similar elastic modulus to dentin, glass fiber posts (GFPs) have become a popular substitute for conventional metal posts because they improve stress distribution and lower the risk of root fracture [1,2]. However, the longevity of post-retained restorations is significantly affected by the quality of attachment between the post, the luting cement, and the surrounding dentin. Failures at these interfaces can compromise the overall structural integrity of the restoration. Therefore, the choice of luting cement is critical for the long-term clinical success of such restorations.

Resin-modified glass ionomer cements (RMGICs) have been commonly used due to their chemical adhesion and ease of manipulation. Self-adhesive resin cements simplify the procedure by eliminating the need for etching and bonding steps. Bulk-fill resin composites are gaining attention for post space applications owing to their low polymerization shrinkage, increased depth of cure, and improved mechanical properties [3,4].

Despite the availability of these materials, limited comparative data exists regarding their bonding effectiveness in intraradicular applications, particularly in different root regions (coronal, middle, apical). The root canal's anatomical complexity, variable tubule density, and high C-factor significantly influence cement penetration and bond formation [5,6,7].

The goal of this analysis is to assess the push-out bond strength of GFPs luted with three distinct materials, focusing on the effects of root canal placement on each material's bonding efficiency. The null hypothesis posited that there was no discernible variation in the tested cements' push-out bond strengths.

2. MATERIALS AND METHODS

2.1 Sample Collection and Storage This experimental in vitro study utilized 30 freshly extracted human mandibular second premolars. Teeth were selected from donors aged 18–24 years who underwent extractions for orthodontic reasons. Inclusion criteria required intact roots with no cracks, fractures, resorption, or previous endodontic treatment. Immediately post-extraction, soft tissues were removed, and the teeth were dipped in 5.25% (NaOCl) for 10 min. for disinfection, next by store in distilled water at 37°C for 24 hours to simulate clinical hydration conditions [8].

2.2 Root Canal Preparation To standardize the root length to 14 mm, a diamond disc was used to decoronate each tooth at the cementoenamel junction while being cooled by water. To find the working length, a #10 K-file was inserted until it was visible at the apical foramen, and then 1 mm was subtracted.

Crown-down root canal preparation was carried out with ProTaper Universal rotary files (Dentsply Sirona, USA) up to size F3. During instrumentation, 2.5% NaOCl was used for irrigation. Five milliliters of 17% EDTA and five milliliters of distilled water were used for a final rinse.

Gutta-percha cones and AH Plus sealer (Dentsply Sirona) were used to obturate the canals using lateral condensation after they had been dried with sterile paper tips. To allow for full setting, the samples were incubated for seven days at 37°C and 100% humidity after the coronal access was sealed with temporary filling material.

2.3 Post Space Preparation and Cementation Post space was prepared by removing gutta-percha to a depth of 10 mm according to the producer drill (Reforpost, Angelus, Brazil), preserving a 4 mm apical seal. Canal walls were washed with D.W. and dry. Glass fiber posts (size 2, Angelus) were decontaminated with alcohol and silanized with Monobond Plus (Ivoclar Vivadent).

Three groups of ten samples each were randomly assigned to the following groups:
• Group I: Bulk-fill resin compound (Ivoclar Vivadent, Tetric EvoCeram Bulk Fill)
• Group II: Glass ionomer cement modified by resin (FujiCEM, GC Corporation)
• Group III: Resin cement that adheres to itself (RelyX U200, 3M ESPE)

The manufacturer's recommendations were followed for mixing and applying the cements. An LED curing unit (1000 mW/cm2) was used to light-cure the posts for 40 seconds after they were inserted.The samples were kept for a full day at 37°C and 100% humidity.

2.4 Specimen Sectioning A diamond precision saw operating under water cooling was used to cut each root into sections perpendicular to its long axis (Isomet, Buehler Ltd.). To obtain 3-mm-thick slices corresponding to coronal, middle, and apical thirds. The thickness of slices was confirmed using a digital caliper (accuracy ±0.01 mm).

2.5 Test of Push-Out Bond Strength A global test machine (Instron, USA) was used to apply compressive load to each slice, which was fixed on a specially made jig. At 0.5 mm/min crosshead speed, a plunger that was marginally smaller than the post diameter was applied until post dislodgement happened. The following formula was used to record the greatest force (N) and convert it to bond strength (MPa):

Bond Strength (MPa) = Force (N) / Adhesive Area (mm²)

The adhesive area was calculated using the formula:

$A = \pi(R + r) \sqrt{(R - r)^2 + h^2}$

where h is the thickness of the slice and R and r are the coronal and apical post radii that correspond to each other.

2.6 Analysis of Failure Modes In order to categorize failure modes as sticky, fractured specimens were examined using a stereo electron microscope (SEM) at 75x and 200x magnification., cohesive (within post or cement), or mixed types [8].

2.7 Statistical Analysis Statistical evaluation was conducted using SPSS v25. Shapiro-Wilk test confirmed normality. The effects of the luting agent and root region were assessed using a two-way ANOVA. To do post hoc comparisons, Tukey's test was used. The threshold for statistical significance was $p < 0.05$.

3. RESULTS

Table 1 displays the values of push-out bond strength derived from the three luting agents that were tested in various root canal areas. The bulk-fill resin composite exhibited the highest mean bond strength overall, with the greatest values found in the apical third (27.20 ± 1.20 N). In contrast, self-adhesive resin cement consistently demonstrated the lowest bond strengths, particularly in the middle third (8.16 ± 1.20 N).

Table 1. Push-Out Bond Strength (M ± SE in Newtons) for Glass Fiber Posts by Root Region and Luting Agent

Root Region	Bulk-Fill Resin	RMGIC	Self-Adhesive Resin
Apical	27.20 ± 1.20	15.25 ± 1.20	14.10 ± 1.20
Middle	20.84 ± 1.20	18.92 ± 1.20	8.16 ± 1.20
Coronal	20.67 ± 1.20	24.89 ± 1.20	9.33 ± 1.20

The findings of the two-way ANOVA (Table 2) demonstrated a significant interaction between the root canal region ($p < 0.001$) and the type of luting agent ($p < 0.001$), as well as statistically significant effects for both ($p < 0.001$).

Table 2. Two-Way ANOVA Summary for Effects of Luting Agent and Root Region

Source	Sum of Squares	df	Mean Square	F	Sig.
Root Region	346.183	2	173.092	9.497	<0.001
Luting Agent	1149.522	2	574.761	31.527	<0.001
Region * Agent	750.063	4	187.516	10.285	<0.001
Error	1464.727	81	18.089		

The results of the post hoc Tukey's test (Table 3) showed that the differ in bond strength among the middle and both apical and coronal regions were substantial ($p < 0.001$), but not among the apical and coronal regions ($p = 0.431$).

Table 3. Tukey's Post Hoc Analysis of Root Region Comparison

Comparison	Mean Difference (N)	Std. Error	Sig.
Apical vs. Coronal	0.55	0.68	0.431
Apical vs. Middle	2.88	0.68	<0.001
Coronal vs. Middle	2.33	0.68	0.001

Bond strength differences among luting agents were also significant. Bulk-fill resin showed significantly higher values than both RMGIC and self-adhesive resin (Table 4).

Table 4. Luting Agent Post Hoc Pairwise Comparisons

Comparison	Mean Difference (N)	Std. Error	Sig.
Bulk-Fill vs. RMGIC	1.667	0.704	0.019
Bulk-Fill vs. SA	6.332	0.697	<0.001
RMGIC vs. SA	4.665	0.698	<0.001

4.DISCUSSION

the results of this study indicate that both the luting agent and the anatomical region of the root canal significantly influence the push-out bond strength of glass fiber posts (GFPs). Bulk-fill resin composite consistently provided the highest bond values, especially in the apical third, suggesting better adaptation and mechanical interlocking in confined post spaces. Bulk fill resins provide benefits such as reduced polymerization shrinkage and improved depth of cure. These qualities are especially advantageous in environments with a C factor like root canals [9,10]. The transparency of GFPs helps light penetrate into the canal sections to enhance polymerization and bolster bonding strength, in the bottom portion [10]. Moreover the enhanced flow and flexibility of bulk fill resins allow for contact with the walls of the canal which reduces empty spaces, between interfaces and enhances the thickness of the hybrid layer resulting in better micromechanical attachment as confirmed by Lins *et al* ., research findings (2019) [11]. Resin modified glass ionomer cements (RMGICs) have the ability to bond chemically with dentin and release fluoride but exhibit moderate bond strength. Their higher viscosity and susceptibility to moisture could pose challenges in filling narrower canals; however, they are effective in the upper portion of the tooth. Potentially due to better exposure to light and reduced stress, from C factor [12,13]. Self-adhesive resin cements showed bond strengths in all areas primarily because of their limited ability to demineralize and infiltrate effectively which led to the formation of weaker hybrid layers. Their effectiveness in the portion was notably low possibly due to lower dentinal tubule density and difficulties, in light penetration resulting in incomplete polymerization [14]. The substantial relationship observed between the root canal area and the type of cement underscores the importance of selecting materials tailored to each site within the tooth structure. According to a study by Oliveira et al., published in 2023 a decrease in bond strength was noted in the section of the root attributed to anatomical differences and a lower number of dentinal tubules [15]. Similarly, Aksornmuang *et al*., in 2011 discovered that variations in configuration and stress related to shrinkage play a role, in determining bond efficacy across different levels of the root structure. In a setting such results back the adoption of bulk fill resin composites to enhance post retention in intricate and deep canal systems [16]. Also, optimal bonding efficiency can be achieved by incorporating methods, like ultrasonic irrigation relining with flowable composites and refining light curing procedures while employing less retentive luting agents [17]. The findings align with the increasing amount of research that backs the effectiveness of fiber reinforced posts in harmony, with root dentin biomechanics. This is especially true when paired with resin-based cements [18,19].

5. CONCLUSION

In a lab experiment investigating materials for treating removed teeth samples researchers discovered that bulk fill resin composite demonstrated better effectiveness as a bonding agent for glass fiber posts compared to other materials tested. The position within the root canal and the type of cement used were found to influence how well these posts stayed secured in place. Medical professionals are advised to consider both the attributes of materials and the location, in the body when choosing what to use.

6. Study Limitations and Future Directions

The studys scope was restricted by its lab-based setup that might not completely mirror real world scenarios. Moreover, they only assessed one type of post. Subsequent studies ought to include cycling, extended aging periods and examination of different post materials, like zirconia.

DECLARATIONS

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