The Use of Bulk-Fill Flow in the Customization of Glass Fiber Post

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Abstract

Objectives The aim of this study is to evaluate the influence of different composite resin in the customization of glass fiber posts (GFPs) on bond strength and failure mode.
Materials and Methods Thirty bovine roots were selected. The wall roots were reduced so that each wall had a minimum dentin thickness of 1 mm. Thirty GFPs were divided into three groups ($n = 10$), which received different types of customization. The first had the GFP relined by bulk-fill flowable composite resin (BF), the second group had the GFP customized by conventional regular composite resin (CR), and the third group was cemented with dual resin cements (DRC), without relining. The root were sectioned, resulting in two 1.0-mm thick slices from cervical root regions only and push-out bond strength test was performed (EMIC, Universal testing machine). To determine failure mode, a stereomicroscope was used at ×40 magnification, with a 2.5D analysis.
Statistical Analysis Data were analyzed using two-way ANOVA ($\alpha = 0.05$) and Tukey's test.
Results BF (9.08 ± 1.9) and CR (9.17 ± 3.00) did not show a statistically significant difference ($p = 0.961$), regarding the bond strength test values. However, there was a statistically significant difference between DRC (5.44 ± 1.89) and the others ($p < 0.05$). BF (66.66%) and the CR group (47.61%) presented a predominantly failure mode type 6: mixed between resin cement and composite. While the highest failure index of the DRC group was type 2: adhesive between resin cement and dentin (47.61%).
Conclusion BF can be an alternative for the customization of fiber posts, since it presented a similar behavior to the established technique with conventional composites.

Keywords
- dental bonding
- glass fiber posts
- resins
- resin cements
- composite resin

Introduction

The rehabilitation of endodontically treated teeth is a challenge for restorative dentistry, and therefore, several studies evaluate the presence of a high rate of biomechanical failure.[1-4] Failures can occur due to factors such as excessive loss of tooth structure related to extensive caries, occlusal imbalance, endodontic treatment, preparation for intraradicular retainers, fractures, trauma, and previous restorations.[5,6]

For a long time for the rehabilitation of endodontically treated teeth, molten metal posts were used. Among its advantages, the good adaptation to the root canal and resistance to significant fracture stand out.[3,7] However, this material has a high modulus of elasticity that increases the possibility of catastrophic fractures that often result in the need to extract the dental element.[1,3] Recently, glass fiber posts (GFP) have been used in an attempt to improve the longevity of endodontically treated teeth, as they have an

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elasticity module similar to that of dentin, which reduces the risk of dental fractures[8] and still have better characteristics aesthetics greater practice in clinical application.[9] Although the systematic review does not show a statistical difference in the risk of dental fracture between the techniques, GFPs have been more indicated.[10]

The use of GFP in weakened roots or with wide channels is a challenge, since the fiber post has a standardized size, and often there is no size that allows its complete adaptation to the root canal walls, especially in the cervical third, requiring a thick layer of resin cement that increases the risk of failure.[11,12] Studies show that roots with customized GFP using composite resin have greater resistance to fracture, and when these occur, the teeth become more viable to be kept in the oral cavity.[1,3,13] The relining provides greater interaction between the post and the root dentin, and improves the performance of the resin cement, since the decrease in the thickness of the cement influences positively its adhesive strength.[2]

Bulk-fill composite resins were developed to simplify the restorative process, and consequently, promise lower levels of polymerization shrinkage stress.[14,15] In addition, they have properties that allow greater light transmission[16] and can be used in a single increment of up to 5 mm according to the manufacturer's recommendations. The volume of these composites correlates with the material's properties, such as flexural strength,[17] Vickers microhardness,[18] and elastic modulus.[19] The higher viscosity of bulk-fill flowable resins facilitates adaptation in less accessible areas.[20] Bulk-fill resins are indicated for cementation, restorations in class I or II cavities, and reconstitution of structural losses in single incremental layers, filling cavities with depths of approximately 5 mm and making the GFP-cementation filling core.[21]

There is no consensus on the customization of GFP using bulk-fill composite resin; therefore, the objective of the present study was to evaluate the influence of different resin-based materials in the customization of GFP and to analyze the failure mode of these materials. The null hypothesis of this study was that there will be no difference between the groups.

Materials and Methods

Root Selection

Thirty bovine incisors of similar size and shape were selected and extracted from adult animals with health evaluation by the Ministry of Health and consent of the responsible veterinarian. They were stored in a buffered 0.2% aqueous solution of thymol. Then, they were cleaned with periodontal curettes (Duflex, Juiz de Fora, MG, Brazil), submitted to prophylaxis with pumice paste and water, and stored in distilled water under refrigeration at 4°C. The teeth were sectioned with diamond disc (7020-KG Sorensen, Cotia, SP, Brazil) under constant water jet, the crown was removed, and leaving 15 mm of remaining root. The selected root was randomly divided into three different groups (n = 10) for the micro push-out test and failure pattern analysis.

Root Preparation

To prepare the root canal, gates glidden 2, 3, and 4 were used sequentially (Malleifer, Dentsply, Petrópolis, RJ). For irrigation, 1% sodium hypochlorite solution and saline solution were used and the final irrigation was performed with 17% EDTA. The roots were widened with a cylindrical diamond drill (3215–KG Sorensen; Cotia, SP, Brazil) so that each wall had a minimum thickness of 1 mm of dentin.

Glass Fiber Post Selection

Thirty GFP (Whitepost nº 2, FGM; Joinville, SC, Brazil) were selected with a coronal third diameter of 2.0 mm, a middle third portion of with 1.8 mm, and an apical third with 1.05 mm. The width of GFP was 20 mm, but only 10 mm were inserted into the root.

The GFP were divided in three groups, which received different types of customization. The first group had the postcustomized with bulk-fill flowable composite resin (BF-Opus bulk-fill flowable; FGM, Joinville, SC, Brazil). The second group had the postcustomized with conventional regular composite resin (CR-Opallis; FGM, Joinville, SC, Brazil). The third group was just cemented with conventional dual resin cement (DRC), without postcustomization as a negative group (Allcem Dual; FGM, Joinville, SC, Brazil). The group BF and CR were also cemented with conventional DRC after customization (Allcem Dual, FGM, Joinville, SC, Brazil).

Surface Treatment of Glass Fiber Post and Root Cleaning

Posts were treated with 35% hydrogen peroxide (Whiteness HP Maxx; FGM, Joinville, SC, Brazil), frictioned for 1 minute, washed with water for the same time, and dried with air jets. Then, silane (Prosil; FGM Produtos Odontológicas, Joinville, SC, Brazil) was applied for 1 minute. A universal adhesive system (AMBAR Universal; FGM, Brazil) was applied after the silane time.[22] The cleaning of the root canal was performed by irrigation with distilled water and humidity control with tips of absorbent paper (Tanari; Manacapuru, AM, Brazil).

Customization of Glass Fiber Post

The roots were sealed with water-soluble gel and then the roots were filled with the experimental material. The GFP were inserted within the roots and them the composite material covered the post. The light cure unit (±1,200 mW/cm^2–Radii Plus, SDI, Austrália) was performed for 5 seconds only on top surface. The post customized were removed and light cured for 40 seconds on each surface (buccal, lingual, medial, distal, and occlusal). The water-soluble gel was rinsed with water for 10 seconds and dried with air jet.

Root Treatment

Afterward, all the root canals were treated with phosphoric acid 37% (Condac 37%, FGM, Brazil) for 15 seconds and cleaned with water for 30 seconds. The adhesive system (AMBAR Universal, FGM, Brazil) were rubbed on the walls and then light cured for 20 seconds. The roots were covered with impression material to avoid the light through and not influence the photoactivation.

Cementation Technique

The cement was handled according to manufacturer's instructions, inserted into the canal with a Centrix syringe with a needle tip, and also on the surface of the GFP. Total 5 minutes were expected for the chemical cure of the cement with a constant load of 500 g on the posts and light cured for 20 seconds each face of the root.

Micro Push-Out Test

The samples were fixed to an acrylic plate (4.0 × 3.0 × 0.4 cm) with heated Godiva (Godiva Exata, DFL, Jacarepaguá, RJ, Brazil) and sectioned transversely into three slices in the region cervical for each root with diamond disc (4 × 0.12 × 0.12, Extec, Enfield, Connecticut, United States) assembled on a precision-cutter machine (Isomet 1000, Buehler, Lake Bluff, Illinois, United States) cooled in water, resulting in 1.0 mm thick slices for the cervical third of the root.

For testing on the cervical third, a 2.5-mm base and a 1.3-mm tip were used. The diameters of the tips and bases were used to introduce shear stress along the bonding interface according to the conical shape. This set was assembled in a mechanical test machine (EMIC DL 2000, São José dos Pinhais, Brazil) containing a load cell of 50 KgF. The slices were positioned on the hole of the metal base and the applicator tip at the center of the post, and subjected to compression loading at a constant speed of 0.5 mm/minute in the apex/crown direction, avoiding any mechanical obstacle due to the conical shape of the GFP until the debonding of the GFP occurred.

Failure Mode Classification

The specimens were analyzed using the ×40 magnification stereomicroscope (Mitutoyo, Tokyo, Japan), with 2.5D analysis. The failure mode were determined in a stereomicroscope magnifier (Leica) and classified into six different types[1]: adhesive between GFP and composite resin; 2 adhesive between resin cement and dentin; 3 adhesive between resin cement and composite; 4 cohesive failure within the post; 5 cohesive failure within the dentin; 6 and mixed between resin cement and composite.

Statistical Analysis of the Data

The data were initially analyzed for detection of normal distribution and homogeneity using the Kolmogorov–Smirnov test. The values presented requirements for the use of parametric analysis; analysis of variance was performed at a 5% probability level. The Tukey test was performed to determine significant differences occurred between which groups at the level of probability ($p < 0.05$). The analyses were performed using Sigma Plot 12 (Systat Software Inc., California, United States).

Results

Regarding the bond strength to the micro push-out, bulk fill flowable composite and nanohybrid composite did not show a statistically significant difference ($p = 0.961$). However, there was a statistically significant difference between DRC group and the other two groups ($p < 0.05$; ►**Fig. 1**).

The failure mode of the bulk fill group (66.66%) and the nanohybrid composite group (47.61%) was predominantly type 6: mixed, between resin cement and composite. While the highest failure index of the resin cement group was type 2: adhesive between resin cement and dentin (47.61%; ►**Table 1**).

Discussion

The null hypothesis of this study was rejected; there were no significant differences between the groups of nanohybrid composite and bulk fill flowable. However, significant differences were identified when the group with no customization was compared with the groups that had a customization with both resins.

The similar results between nanohybrid composite and bulk fill flowable can be explained by the thickness cement line found in these groups. Restored roots with customized posts have greater fracture resistance.[1,13] It also improves root canal adaptation and reduces the resin cement layer.[11] Thus, the amount of bubbles and other defects are smaller when compared with the thick cementation line. In addition, the thicker resin cement can provide bubbles that promote cracking and consequently decrease the retention of the posts,[10,11] which explains the low adhesive strength of the no customization group.

The thickness of resin cement substantially interferes in the bond strength of GFPs to root dentin, a layer of cement that is too thick or too thin significantly decrease the

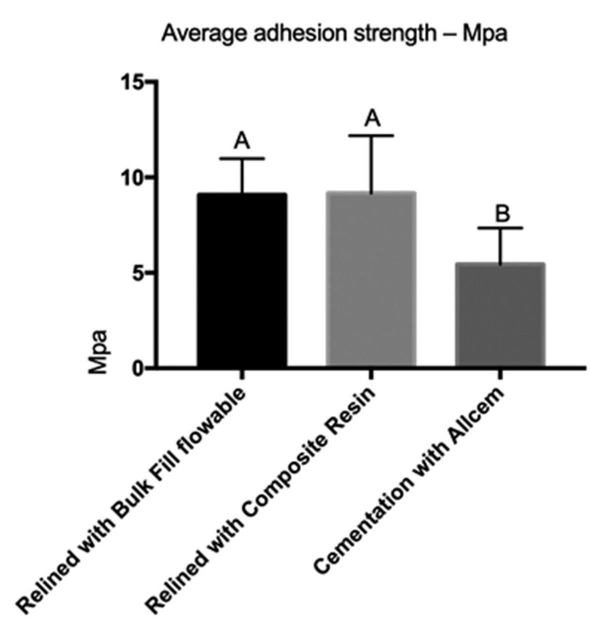

Fig. 1 Bond strength of glass fiber posts relined with bulk-fill flowable, glass fiber posts relined with conventional resin, and glass fiber post without customization cemented with resin cement determined by push-out tests. The mean values followed by the same uppercase letter in each row and the same lowercase letter in each column are not significantly different according to the results of two-way ANOVA ($p < 0.05$).

Table 1 Relining failure pattern

Relining failure pattern						
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Bulk-fill flow	0 (0%)	3 (14. 28%)	3 (14. 28%)	2 (9. 52%)	0 (0%)	14 (66. 66%)
Nanohybrid composite	0 (0%)	0 (0%)	2 (9. 52%)	4 (19. 04%)	0 (0%)	10 (47. 61%)
Allcem	0 (0%)	10 (47. 61%)	1 (4. 76%)	1 (4. 76%)	0 (0%)	7 (33. 33%)

Push-out test failure mode distribution for each root third in the bulk-fill resin group. The failure modulus were determined in a stereomicroscope magnifier (Leica) and classified into six different types: (1) adhesive between glass fiber post and composite resin; (2) adhesive between resin cement and dentin; (3) adhesive between resin cement and composite; (4) cohesive failure within the post; (5) cohesive failure within the dentin; (6) mixed between resin cement and composite.

retention of GFPs.[12] Different bonding protocols substantially influence the bond strength to root dentin,[23] which justifies the best results for the groups with the lowest cementation thickness in the present study. That findings might be influenced through the use of simplified adhesive associated with dual cement that is not indicated by some studies.[24]

Like shown in previous studies[11,12,25] on the cervical third can occur some alterations and failure. On a study,[25] flared root canals restored with GFP alone showed inferior adhesion at the resin–dentin interface, especially in the cervical. That's the reason that only the cervical third was analyzed.

In conventional resin composites based on bisphenol A-glycidyl methacrylate (Bis-GMA) progress has been made by adding new monomers such as urethane dimethacrylate (UDMA), ethoxylated bisphenol-A dimethacrylate combined with higher fillers. UDMA helps to reduce the amount of contraction and stress that occurs during polymerization without degrading the mechanical properties.[26] Although there have been advances in the resinous composites, the reduction of its volume related to the polymerization process can generate contraction stress, compromise mechanical, and chemical stability and may decrease marginal adaptation.[27]

The bulk-fill composite has a high polymerization degree with curing depth of up to 8 mm[28] and low contraction stress due to its flexural properties, contraction kinetics, and improved initiation systems.[14,15] The manufacturers explain that the greater depth of conversion of these composites is due to the more potent initiator system and higher translucency,[16,29] which allows collimation of the photoinitiator light beam to reach the deeper layers of the resin composite. Due to its properties and lower viscosity can be indicated for the cementation of GFPs.[30]

The treatment of the GFP aims to allow chemical–mechanical bonding between the material and the surface of the post. Some studies have demonstrated that the use of hydrogen peroxide (H_2O_2) as a surface treatment of the post allows the chemical–mechanical bonding of resin composites to the post.[22,30] The use of H_2O_2 in high concentration on the GFP showed greater exposure of the post fibers and consequently improved the bond strength of the resin composite to the surface of the post.[31]

The difficulty of adequate adhesion to root dentin is the main cause of failure in endodontically treated teeth receiving GFP restorations (GFPs).[32] GFPs are commonly cemented with DRC for chemical polymerization to occur in deeper areas, where the photoinitiators have reduced irradiance; 3[3] however, polymerization in the most apical portions remains a critical factor.[34] In addition, factors such as dentine morphology along the root canals may influence the bond strength.[35,36]

The non customization group had its predominantly adhesive failure pattern between resin cement and dentin. This can be explained by the greater cementation line in this group, which reduces the bond strength between GFPs and dentin.[12] In addition, some studies show that the use of simplified adhesive with dual cement does not show bond strength,[24] although the manufacture recommend the use and some studies shows the chemical incompatibility between the evaluated simplified adhesives and the dual-cured resin cement was not significant[37]).

The groups of nanohybrid composite and bulk-fill flow presented a predominantly mixed failure pattern between resin cement and composite, which is justified due to the lower cementation line in these groups. Relining improves the adaptation,[11] the frictional retention of GFPs in the root canal,[38,39] and potentiates the performance of the resin cement, since it influences the bond strength between the resin cement and composite.[2,38] The customization of GFPs reduces the tension generated by the shrinkage of the polymerization and presents greater adhesive resistance to the dentin.[40] The thin cementation line reduces the defects observed in the thicker resin cement layers.

This study has some limitations that shows the lack of information and more studies. The adhesive used is not appropriated with dual cement like showed in some studies. Although the cervical third is the most unsuitable when it comes to weakened roots, it is important to carry out studies evaluating the adhesive strength of all thirds. Another limitation is the need for analysis of the entire restorative complex using fracture resistance tests, finite elements analyses, and other methodologies.

Thus, bulk fill composite presents itself as an alternative in the customization of GFPs, since it presented a similar behavior to the already established technique with conventional composites. The reline with bulk fill composite may facilitate the technique because it will fit better on the root, but still need further studies regarding the behavior of this material in the studied condition.

Conclusion

The results are preliminary and have a methodological bias, so they should not be extrapolated for clinical application.

It is suggested to conclude only what the analysis allows: GFP customized with bulk-fill resins and regular composite resin have superior bond strength than conventional cementation without customization in weakened roots.

Conflict of Interest

None declared.

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