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Can the size and the luting material influence in the bond strength of the fiberglass post to dentin?

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Aim: To evaluate the influence of lengths and different luting agents on the bond strength of fiberglass posts' adhesion to dentin.

Methods: Sixty single-root bovine teeth were endodontically treated and included in polyether and acrilyc resin to simulate a periodontal ligament. These were divided into 6 groups according to the post lengths (6, 10 or 14 mm) and luting agents (self-adhesive dual resin cement – U; or etch-and-rinse dual resin cement – A): U6, U10, U14, A6, A19, and A14. All fiberglass posts were cemented according to manufacturer instructions. After this, mechanical aging was performed (1.2×10^6 cycles; 4 Hz, 90 N). The push-out specimens were then conducted (2.0 ± 0.1 mm), with the test executed in a universal machine (10 kgf at 0.5 mm/min). Data obtained were submitted to the Kruskal-Wallis and Dunn's test.

Results: No statistically significant difference was observed in bond strength between the groups due to the type of luting agent ($p > 0.05$). However, the isolated post-length factor showed significantly different results for the U groups ($p < 0.05$). The U10 group showed similar union values to U6 but statistically inferior to U14.

Conclusion: bond strength of fiberglass posts of the same length as the dentin presented no differences according to the luting agent, but the post-length property influenced the bond strength when self-adhesive resin cement was used.

Uniterms: Fiber post, push out, resin cement.

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INTRODUCTION

Endodontic treatment helps to preserve teeth and, associated with coronary reconstruction, allows for their functional rehabilitation[1]. Several situations call for the use of intraradicular retainers to enable such rehabilitation, and fiberglass posts are a feasible esthetic option, as they are biocompatible and non-corrosive, and require a relatively simple technique, which reduces the clinical time when compared to indirect metal posts[2,3]. When cemented with resinous agents, they promote adhesion to the tooth, greater resilience, and an elasticity modulus similar to dentin[3,4].

However, their correct cementation on the root canal is a challenge for restorative dentistry. In this light, self-adhesive resin cements were developed to minimize the technical sensitivity of this procedure[5,9]. These consist of acid and hydrophilic monomers, which simultaneously demineralize and infiltrate the enamel and the dentin, resulting in an effective bonding[6], eliminating the need for pretreatment on both the dentin and the post[6,10,11]. Its use, in addition

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to mechanical retention, allows for a chemical adhesion to the dentin[12].

Even with the evolution of these materials, failures still occur in the adhesive cementation process, especially inside the root canal. The deboding has been pinpointed as the main cause of fiberglass posts failures[2,7,8,11,13-16]. Several studies have investigated the effectiveness of this adhesion. Some authors state that the posts' failures may well occur due to problems in the chemical interaction between the adhesive system and the resin cement on the interface of luting material and dentin[17,18]. They also said that failures might occur due to the use of harmful irrigating substances[19], anatomical differences between the posts and the third of root canals[14,17], as well as the shape and composition of the fiberglass post[5]. However, the influence of fiberglass post length on bond strength to self-adhesive systems is still poorly debated in the literature.

Therefore, the present study evaluated the influence of different fiberglass post lengths and luting agents on the strength of the bond to the dentin after aging. The null hypotheses were: (1) no significant difference would be observed in bonding strength regardless of the type of luting agent used and (2) no significant difference would be found in bonding strength regardless of the post length.

MATERIALS AND METHODS

TEETH SELECTION AND PREPARATION OF THE SPECIMENS

A total of 60 single-root bovine teeth were selected, and their crowns were removed with a carborundum disc (Dentorium, São Paulo, São Paulo, Brazil) under constant water cooling, obtaining roots with 18 mm in length. The diameter of the root canal was measured in the vestibular/lingual and mesio/distal dimensions with a digital caliper (Absolute Digimatic, Mitutoyo, Tokyo, Japan) in order to make sure the root canal had a bigger diameter than the posts used (ø = 2.0 mm, White Post DC # 2, FGM, Joinvile, Santa Catarina, Brazil).

The roots were endodontically treated with Gates-Gliden drills and manual files (Dentsply/Maillefer, Petrópolis, Rio de Janeiro Brazil), using 2.5% NaCl solution to irrigate the canals between the instrumentations and 17% EDTA (ethylenediamine tetraacetic acid) for the final irrigation. Then they were dried with absorbent paper tips (Maillefer, Dentisply, Petrópolis, RJ, Brazil). These root canals were filled with gutta percha (Dentisply, Petrópolis, Rio de Janeiro, Brazil) and endodontic resin cement (AH Plus, Dentisply, Petrópolis, Rio de Janeiro, Brazil), by the lateral condensation technique, considering the foramen as the apical limit.

After the endodontic treatment, the roots were fixed to a dental parallelometer. In a metal container, plastic wax for immersion (PW 1 Plastic - Kota Import's, São Paulo, São Paulo, Brazil) was plastified to 70°C, and the roots were inserted into this container, up to 3 mm from the cervical portion. After this step, the specimens were placed inside metal cylinders (h = 20 mm and ø = 15 mm) up to the height of the wax coating, and chemically activated acrylic resin (Dencrilay®, Dencril, Caieiras, São Paulo, Brazil) was prepared and poured inside the structures. After polymerization of the acrylic resin, the specimens were removed from inside the cylinder and the coating wax was removed from the root surface and the cylinder. Polyether (Impregum Soft, 3M-Espe, Seefeld, Germany) was then injected into the space created inside the acrylic resin cylinder to simulate the periodontal ligament[20,21]. Soon after, the roots were repositioned inside the cylinder, and the excess material was removed.

After the preparation the roots were randomly divided into 6 groups (n = 10) (Table 1). The canals had the obturation removed with the tip recommended by the fiberglass post manufacturer (WHITE POST DC # 2, FGM) until reaching a dimension of 14, 10, or 6 mm in length. The root canals were then cleaned with distilled water and dried with absorbent paper tips (Maillefer, Dentisply, Petrópolis, Rio de Janeiro, Brazil).

Table 1 - Distribution of the research groups according to the cement and length of the glass fiber post used

Group	Post-length	Cement type
A14	**14 mm**	**AllCem -** indicated to core construction, cementing pins and crowns
A10	**10 mm**	
A6	**06 mm**	
U14	**14 mm**	**U200** - indicated for final cementation of partial restorations in ceramic, metal and indirect composite resin; metallic cores and posts (fiberglass, carbon fiber, and zirconia); and crowns.
U10	**10 mm**	
U6	**06 mm**	

POST CEMENTATION AND CORONARY RECONSTRUCTION

The glass fiber posts had their surface treated by 37% phosphoric acid for 15 s, washed with water for 60 s and air dried for 15 s. A silane coupling agent (Prosil, FGM, Joinville, Santa Catarina, Brazil) was then applied for 15 s over the entire surface of the post with a microbrush application device (FGM, Joinville, Santa Catarina, Brazil). This procedure was performed for all posts.

After removing the moisture with absorbent paper tips, the luting procedure was performed. In A14, A10, and A6 groups, the conventional dual resin cement (etch-and-rinse) AllCem Core (FGM, Joinville, Santa Catarina, Brazil) and dental adhesive (Ambar, FGM, Joinville, Santa Catarina, Brazil) were used, while in U14, U10, and U6, the self-adhesive dual resin cement RelyX U200 Automix (3M ESPE, Saint Paul, Minnesota, USA) was used following manufacturer recommendations. The luting material was taken to the root canal with the aid of the mixing tip of the respective cement and the glass fiber post was placed in the root with the aid of a clinical tweezer. The excess luting material was removed, and the specimens were cured for 60 s with a 1200 mW/cm^2 LED curing light (Radii Cal, SDI, São Paulo, São Paulo, Brazil). No inclination was performed during the cure, so the device's distance from the top of the post was correspondent to the length of that post. The coronary reconstruction was made with a standardized polyacetate matrix, obtained from a superior canine. This matrix was filled with micro-hybrid composite resin (Opallis, FGM, Joinville, Santa Catarina, Brazil), positioned on the post coronary surface, and the light curing was performed for 20 s on each surface of the tooth[22].

MECHANICAL CYCLING

Specimens were placed at 45º in a mechanical cycling machine (ER 11000, Erios, São Paulo, Brazil). A 90 N load was applied with a piston (ø = 1.6 mm), 2 mm below the incisal edge on the palatal face of the specimen, for 1.2x10^6 cycles, under a frequency of 4 Hz in a humid environment.

PUSH-OUT TEST

The teeth were sectioned perpendicular to their long axis into slices of 2.0 ± 0.1 mm with a diamond disc (Buehler, Lake Bluff, EUA) in a cutting machine (Isomet 1000, Buehler, Lake Bluff, EUA) under constant distilled water irrigation to obtain samples of the coronal, middle, and apical sections of the roots. The thickness of the slices was measured with a digital caliper (Absolute Digimatic, Mitutoyo, Tokyo, Japan). The resin crown and root apex of the teeth were discarded[22].

Push-out test was performed in a universal machine (EMIC, São José dos Pinhais, Paraná, Brazil). A 10 kgf load was applied in the middle of the post (cross-head speed 0.5 mm/min until failure), which resulted in shear stresses along the cement/dentin and cement/post interfaces.

Since the posts were parallel in the middle third of the roots, the exact adhesive surface could be calculated with the equation: $A = 2\pi rh$; where $\pi = 3.14$, A = surface area (mm), r = radius (mm) of the post, and h = thickness (mm) of each section. The diameters of the post and the thickness of the slice were individually measured using a digital caliper with 0.01 mm accuracy (Absolute Digimatic, Mitutoyo, Tokyo, Japan).

The load (N) required to remove the fiber post from each section was recorded. The results were then calculated in an MPa by dividing the resultant load in Newton by the adhesive area of the specimen.

Failure mode was determined in a stereomicroscope with 50x magnification (Vanox, Olympus, Tokyo, Japan) and classified as an adhesive between post/luting material or luting material/dentin, cohesive within post, and mixed.

STATISTICAL ANALYSIS

Data obtained by the push-out test were submitted to descriptive statistical analysis (mean, standard deviation, median, minimum, and maximum) to the non-parametric Kruskal-Wallis and Dunn's multiple comparisons test ($\alpha = 0.05$), in which the data revealed no normal distribution.

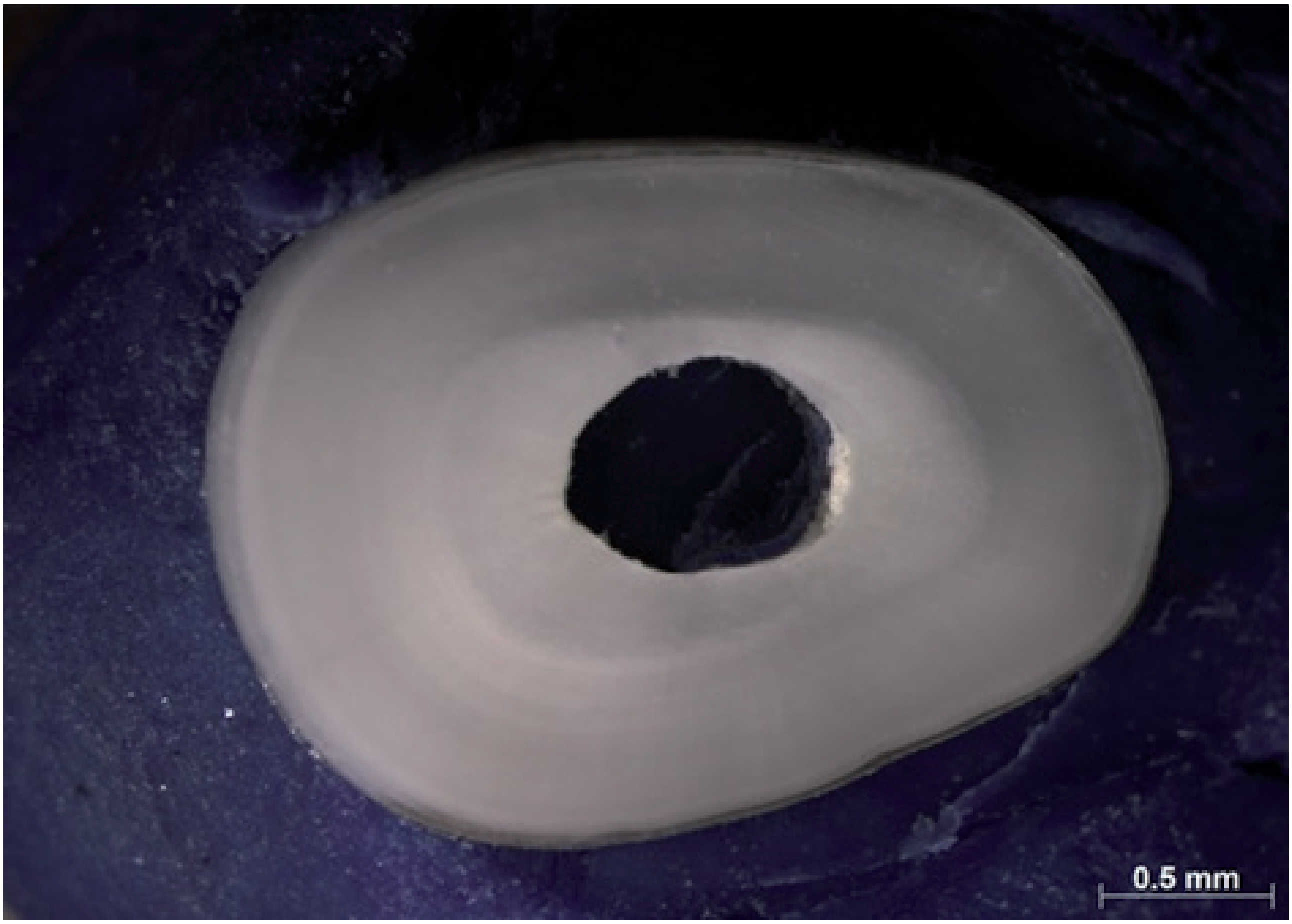
RESULTS

Data of the push-out bond strengths (MPa) are presented in Table 2. There was statistical difference only between the U groups with different lengths. Group A presented similar bond strength values, regardless of the length. The type of luting material did not influence the bond strength of the posts. Under stereomicroscope, it was observed that all failures were adhesive between the dentin and the luting material (Figure 1).

Table 2 - Mean values, standard deviations, median, minimum, and maximum for push-out bond strength. Different letters indicate statistically significant differences from groups (Dunn's test; $p < 0.05$). Capital letters are applied to indicate differences or similarity between the columns, as well as the lowercase letters for the lines

	U200				**AllCem**			
	N	Mean ± Standard Deviation (MPa)	Median (Minimum/Maximum)		N	Mean ± Standard Deviation (MPa)	Median (Minimum/Maximum)	
6mm	14	2.95 ± 1.90	2.31 (1.28 / 7.45)	ABa	15	2.34 ± 0.93	1.91 (1.03 / 3.75)	Aa
10mm	33	2.44 ± 1.03	2.61 (1.08 / 4.68)	Aa	31	2.37 ± 0.91	2.19 (1.13 / 4.42)	Aa
14mm	47	3.40 ± 1.64	3.22 (1.00 / 8.22)	Ba	45	3.26 ± 2.02	2.65 (1.16 / 9.42)	Aa

Figure 1 – Specimen showing an adhesive failure between luting material and dentin



DISCUSSION

Even with the evolution of the luting materials, debonding remains as the main cause of fiberglass post failure[2,7,8,11,13-15]. Therefore, to investigate the influence of post length and luting material on the bond strength to root dentin, the push-out test was performed in this study. This test is based on shear stress at the interface between dentin, luting material and posts[6,7,10]. It presents advantages when compared to other tests, such as the pull-out or the microsheartests[5,7,23]. Among

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these advantages, some can be highlighted: reduced amount of pre-test failures, lower standard deviations, lower execution complexity, and greater number of specimens from the same root[2,13,15,24].

In the present study, the thickness of the specimens obtained was 2 ± 0.1 mm, an easily measurable dimension[25], considered acceptable for the test[13,15] and pinpointed as an alternative to reduce the number of cohesive failures in the dentin[25]. Failure mode analysis indicated that the weakest cementation bond was between the dentin and the luting material. These results are in agreement with earlier studies[7,14,15,26] and may be justified by the fact that curing which occurs at the cement/dentin interface may be affected by root canal geometry, responsible for its high cavity configuration factor (C-Factor)[15].

In addition to the correct choice of the bond test, other factors were controlled: randomization of experimental units, use of dental materials according to manufacturer instructions, periodontal ligament simulation, standardization of endodontic treatment, preparation of root canals, and post-cementation performed by a single trained operator and mechanical aging performance[7,14].

Shear bond results depend on the interfacial micromechanical retention and the chemical bond between the dentin and the root canal, performed by the resinous luting material[10]. However, there is no consensus in the literature regarding the best luting material type. Some authors point out the etch-and-rinse cements as the best option[10,27], while others have obtained better results using auto-adhesive cements[5,13]. These conflicting results can be explained by the variability of the methodology and different materials used in different studies[5]. Nevertheless, the results of the present study showed no significant difference between the two, leading to the acceptance of the first null hypothesis and corroborating with some previous findings[2,14,22,28].

Due to the similarity in the bond strength between the different cements, some advantages of self-adhesive resin cements may be taken into account when choosing the luting material. These need less clinical steps, presenting less technical sensitivity and shorter clinical time when compared to the conventional procedures[6,8,18,27]. The low initial pH of the U-200 (3M ESPE, Saint Paul, Minnesota, USA) allows the hydrophilic part to act first, demineralizing and obtaining an intimate contact with dentin. Afterwards, the methacrylate acid monomers of this luting material and the hydroxyapatite of the tooth create a chemical bonding reaction[13,8]. However, there is no effective removal of the smear-layer and a good hybridization[5,11,13]. Therefore, Durski et al.[5] stated that the chemical interactions between self-adhesive cement and hydroxyapatite might be more important for root dentin bonding than the hybridization process.

Unlike the cement type, post-length showed influence in the bond strength only for the self-adhesive cement, thus leading to the negation of the second null hypothesis. The 14 mm posts had significantly greater bond strength than the 10 mm. However, the bond values were similar to those of the 6 mm. It is possible to suggest that, due to the shorter length, the results obtained in the U6 group can be attributed to a better light cure effectiveness in the cervical part of the root[29].

In the groups cemented with conventional luting agent, a different behavior was observed. The post length did not influence the adhesive strength. This fact can be justified by the dentine acid etching performed prior to cementation, generating a deep demineralization pattern and removing the smear layer more homogeneously[30,31].

It is noteworthy that deeper root preparations increase the risk of fracture and perforation, in addition to the difficulty of controlling the thickness of the adhesive and cement polymerization in the deepest regions of the root canal. It is important to emphasize the importance of preserving as much dental structure as possible when restoring these teeth, because the greater the amount of healthy tissue remaining, the greater the mechanical strength of the tooth[22].

Although bovine root dentin has been shown to have lower microhardness than its human counterpart, as well as a different radiographic density[32,33], it seems to be a suitable substitute for human root dentin for shear tests, since the de-remineralization intraoral caries model of those substrates did not differ from human dentin in terms of mineral loss and lesion depth. Therefore, it is necessary to conduct clinical studies that evaluate the behavior of different fiberglass post lengths cemented with different resin cements.

CONCLUSION

The bond strength of fiberglass posts of the same length showed no differences between the dual resin cements used in this study. However, the post-length did influence the bonding between the dentin and the luting material when auto-adhesive luting material was used.

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O comprimento e o tipo de cimento podem influenciar na adesão do pino de fibra de vidro a dentina?

Objetivo: avaliar a influência dos agentes cimentantes e dos diferentes comprimentos de pinos na resistência de união de pinos de fibra de vidro a dentina.

Métodos: Sessenta dentes bovinos uniradiculares tiveram a raiz endodonticamente tratada, e foram incluídos em poliéter e resina acrílica para simular o ligamento periodontal. Os espécimes foram divididos em seis grupos de acordo com o comprimento dos pinos (6, 10 ou 14mm) e dos agentes de cimentantes (cimento resinoso dual autoadesivo (RelyX U200, 3M ESPE) - U; ou cimento resinoso dual convencional (AllCem Core, FGM) - A: U6, U10, U14, A6, A19 e A14. Todos os pinos de fibra de vidro foram cimentados conforme as recomendações do fabricante. Após, o envelhecimento mecânico ($1,2x10^6$ ciclos; 4 Hz, 90 N) as amostras foram fatiadas para o teste de *push-out* (2,0 ± 0,1 mm) executado em uma máquina de ensaio universal (10 kgf a 0,5 mm/min). Os dados foram submetidos ao teste de Kruskal-Wallis e Dunn.

Resultados: não houve diferença estatística na resistência de união entre os grupos devido ao tipo de agente cimentante ($p > 0,05$), mas houve para o comprimento dos pinos dos grupos U ($p < 0,05$). O grupo U10 apresentou valores de união semelhantes a U6, mas estatisticamente inferiores ao U14.

Conclusão: a resistência de união dos pinos de fibra de vidro de um mesmo comprimento não apresentou diferenças mesmo quando cimentados com cimentos diferentes, mas o comprimento dos pinos isoladamente influenciou quando o cimento resinoso autoadesivo foi utilizado.

Descritores: Pinos de fibra. *Push-out.* Cimentação resinosa.

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