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# Influence of different adhesive agents on the bond strength of universal fiberglass posts

Influência de diferentes protocolos adesivos na resistência de união de pinos de fibra de vidro universal

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## ABSTRACT

**Objective:** This study analyzed the bond strength of universal glass fiber posts under different adhesive protocols for surface treatment prior to cementation. **Material and Methods:** 50 bovine incisor roots were randomly divided into five experimental groups: Group 1 (control): no treatment; Group 2: surface treatment with a 3-step adhesive system (phosphoric acid + Optibond FL etch-and-rinse - KERR); Group 3: conventional 2-step adhesive system (phosphoric acid + Single Bond Universal - 3M); Group 4: 2- step self-etch adhesive system (Clearfil SE Bond); Group 5: 1-step self-etch universal adhesive system (Single Bond Universal - 3M). A single prefabricated fiberglass post (Splendor - Angelus) and self-adhesive resin cement (RelyX U200 ESPE- 3M) were used for all groups. After cementation, the roots were sectioned into 3 thirds (cervical, middle and apical) and subjected to the push-out test at 0.5 mm/mim. The data collected was analyzed, where descriptive statistics, homogeneity test, two-way ANOVA and post hoc Tukey test were presented at a 5% significance level. **Results:** The mean bond strength by the push-out test was highest in Group 1 (control), with no statistical difference in Groups 2 and 3, followed by the worst result in Group 5, with no statistical difference in Group 4. The worst behavior was shown by Groups 4 and 5 where the load values for fracture were low . **Conclusion:** The adhesion protocol prior to cementation drastically affects the bond strength.

## KEYWORDS

Adhesiveness; Cementation; Dentin adhesives; Dental materials; Post and core technique.

## RESUMO

**Objetivo:** O presente estudo analisou a resistência de união de pino de fibra de vidro universal, sob diferentes protocolos adesivos para tratamento de superfície antes da cimentação. **Material e Métodos:** Utilizou-se 50 raízes de incisivos bovinos divididos aleatoriamente entre cinco grupos experimentais: Grupo 1 (controle): sem tratamento; Grupo 2: tratamento de superfície com sistema adesivo de 3 passos (ácido fosfórico + Optibond FL - etch-and-rinse- KERR); Grupo 3: sistema adesivo convencional 2 passos (ácido fosfórico + Single Bond Universal - 3M); Grupo 4: sistema adesivo autocondicionante (Clearfil SE Bond); Grupo 5: sistema adesivo autocondicionante de 1 passo com adesivo universal (Single Bond Universal - 3M). Um único retentor pré-fabricado (Splendor - Angelus) e cimento resinoso autoadesivo (RelyX U200 ESPE- 3M) foram utilizados para todos os grupos. Após a cimentação, as raízes foram seccionadas em 3 terços (cervical, médio e apical) e submetidas ao teste de push-out a 0.5 mm/min. Os dados foram analisados por estatística descritiva, teste de homogeneidade, ANOVA a dois fatores e teste de Tukey, com um nível de significância de 5%. **Resultados:** A média da força de união pelo teste de push-out foi maior no Grupo 1 (controle), sem diferença estatística dos grupos 2 e 3, seguidos pelo pior resultado do grupo 5, sem diferença estatística do grupo 4. O pior comportamento foi apresentado pelos Grupos 4 e 5 onde os valores de carga para fratura foram baixos. **Conclusão:** O protocolo de adesão antes da cimentação afeta drasticamente a resistência da união.

## PALAVRAS-CHAVE

Adesividade; Cimentação; Adesivos dentinários; Materiais dentários; Técnica para retentor intrarradicular.

## INTRODUCTION

Endodontically treated teeth with coronal wall loss represent the worst clinical scenario for oral rehabilitation, requiring the use of intraradicular posts [1-3]. Prefabricated posts (fiberglass posts) are currently the most widely used, as they have a modulus of elasticity similar to dentin, flexural resistance, simplicity of technique, shorter clinical time and are highly aesthetic, with a reported 5-year survival rate of approximately 93% [4,5]. Despite their qualities, unique fiberglass posts alone cannot adapt to anatomically wider or narrow canals [6]. Thus, the chances of cementation failure increase, compromising the longevity of restorations and even endodontic treatment [7]. The successful retention of these posts within the root canal relies on various factors, particularly surface treatment [8,9], as post decementation is one of the primary modes of failure [10].

Adhesive resin cements are widely used for cementing endodontic posts, with different systems available. Research shows that resin cements combined with fiber posts result in higher success rates. However, several aspects influence this adhesion, including the anatomy and preparation of the canal, the hydration of the dentin, the type of cement and sealer used, the orientation of the dentinal tubules, contamination control, limited visibility within the canals, the polymerization contraction of the cement, the thickness of the cementing layer, cyclic masticatory forces, including the type of adhesive system chosen [11].

To prevent post detachment, it is essential to ensure efficient adhesion between the post, cement and dentin, based on chemical and micromechanical interactions. Methods such as abrasive blasting, silanization and acid etching are used to improve this bond, but the process still presents technical challenges. Factors such as chemical incompatibility, residues in the root canal, incorrect handling of the adhesive, polymerization shrinkage, decreased conversion rate of the cement and adhesive system in the apical region and air bubbles can compromise the quality of cementation [12].

Among the various surface treatments, the main one is the application of silane [13] because it is a simple and widely used technique [14], although scientific evidence shows both successful adhesion between the post and cement, as well as failure in the technique where there was no increase in bond strength [7,11,15-17].

The bond strength between the fiberglass post, resin cement and dentin promotes the formation of a monoblock which guarantees the longevity of the restoration [18,19]. Fiberglass posts can be cemented with conventional dual cements in combination with adhesive systems, or with self-etching cements that allow simultaneous bonding between the intraradicular dentin and the post [20]. Therefore, adhesion between resin/cement-dentin and resin/cement-post is crucial for long-term restorative success [21,22].

The scientific evidence regarding dentin surface treatment for cement application is already well-established, but there is still no consensus regarding post treatment. Therefore, the aim of this study was to analyze the influence of different adhesive agents on the bond strength of universal glass fiber posts, considering different adhesive protocols for surface treatment prior to post cementation.The study's null hypothesis is that there is no difference between the different adhesive protocols in the bond strength of fiberglass posts.

## METHODS AND MATERIAL

Fifty bovine incisors from Nelores animals, recently slaughtered in meatpacking plants, were selected at adult age, with similar dimensions, without structural defects and treated according to the recommendations of the Ministry of Agriculture (SIF 1758). The sample calculation was carried out through the pilot study.

The crowns of the roots were separated at the cement-enamel junction using carburundum disks attached to a straight piece at low speed. The crowns were discarded and the roots underwent endodontic treatment involving biomechanical preparation up to a #40 K-file (Dentsply Sirona, Switzerland). The canals were subsequently filled utilizing a calibrated gutta-percha cone (AllPrime, São José, Santa Catarina, Brazil) and AH Plus cement (Dentsply Sirona, Ballaigues, Switzerland) via lateral condensation, ensuring complete filling of the canal space, as confirmed by radiographic assessment. Excess gutta-percha was then removed using endodontic pluggers. Afterwards the roots were prepared for 2/3 of the canal using the drill indicated for each fiberglass post.

The roots were separated into 5 groups (n=10) according to the adhesive protocol used: Group 1 (Control): no treatment; Group 2: surface treatment with a 3-step adhesive system (phosphoric acid + Optibond FL - three-step etch-and-rinse - KERR); Group 3: conventional 2-step adhesive system (phosphoric acid + Single Bond Universal - 3M); Group 4: self-etch adhesive system (Clearfil SE Bond) and Group 5: 1-step self-etch universal adhesive system (Single Bond Universal - 3M). The same prefabricated post (Splendor - Angelus - Londrina/PR - Brazil) and self-adhesive resin cement (RelyX U200 ESPE- 3M) were consistently employed in all experimental groups (Figure 1).

After fitting the fiberglass posts, they were cleaned with 70% alcohol for one minute and submitted to the cementation protocol in which a layer of silane was applied, and after one minute it was volatilized with an air jet, allowing the corresponding resin cement for each group to be applied. The remaining teeth wSere irrigated with sodium chloride and distilled water and dried with a paper cone.

The group without surface treatment (Group 1) was cemented using only dual self-adhesive resin cement (RelyX U200 ESPE - 3M), followed by light-curing for 20 seconds (VALO; Ultradent Products, Inc., South Jordan, Utah, United States of America).

For Group 2, the remaining teeth were acid etched with 37% phosphoric acid, irrigated with distilled water and dried with a paper cone after 30 seconds; primer and polymerization were applied; the 3-step adhesive system was applied (phosphoric acid + Optibond FL - three-step etch-and-rinse - KERR), air jet and polymerization for 20 seconds (VALO; Ultradent Products, Inc., South Jordan, Utah, United States of America).

Group 3 was acid etched with 37% phosphoric acid, washed with distilled water and dried with a paper cone after 30 seconds; application of the conventional 2-step adhesive system (phosphoric acid + Single Bond Universal - 3M), air jet and light-curing for 20 seconds (VALO; Ultradent Products, Inc., South Jordan, Utah, United States of America).

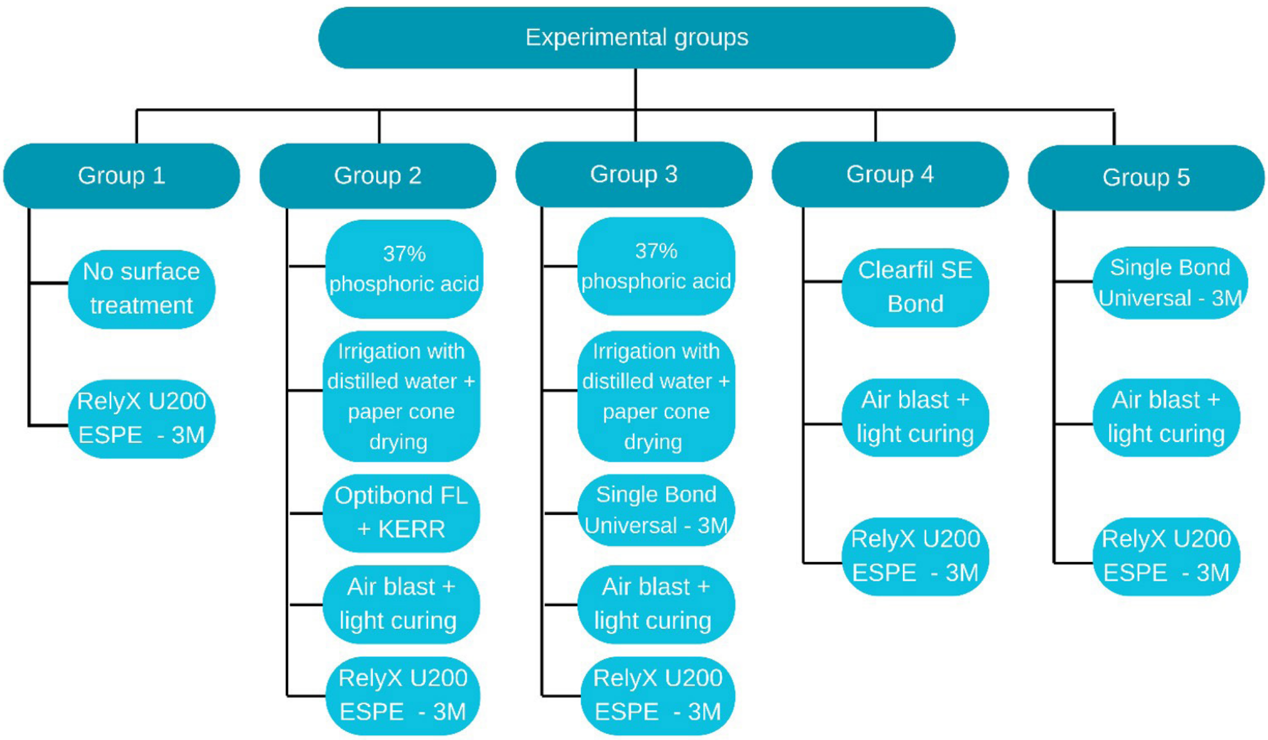


**Figure 1 -** Schematic drawing of the experimental groups.

For Group 4, the self-etching adhesive system (Clearfil SE Bond) was used. The primer was applied for 20 seconds, dried and light-cured for 20 seconds. Bond applied and light-cured for 20 seconds (VALO; Ultradent Products, Inc., South Jordan, Utah, United States of America).

In group 5, the 1-step self-etch adhesive system (Single Bond Universal - 3M) was applied, air-dried and polymerized for 20 seconds (VALO; Ultradent Products, Inc., South Jordan, Utah, United States of America).

The self-adhesive resin cement (RelyX U200 ESPE - 3M) was applied to the posts and inserted in circular movements into the respective conduits, after the excess resin cement was removed with a microbrush (AllPrime, São José, Santa Catarina, Brazil) light-curing was carried out for 40 seconds (VALO; Ultradent Products, Inc., South Jordan, Utah, United States of America), with digital pressure to hold the post in position. All the excess of the post was removed with a cooled diamond drill.

### Push Out bond strength test

In order to obtain specimens for the Push Out test, the roots were individually included in polyvinyl chloride (PVC) tubes with the base perpendicular to the ground and only the root apices were embedded in self-curing acrylic resin (VIPI Flash, VIPI) with the assistance of an delineator centered on the tube.

This allowed them to be fixed in the ISOMET® 1000 precision cutting machine (Buehler, Lake Bluff, USA) for sectioning the fragments. The sections were made perpendicular to the long axis of the root under constant water cooling, at a speed of 350 rpm, with a load of 200 mg. The cutting disc was a diamond blade with a thickness of 0.03 mm. The cuts started at the cervical portion towards the root portion, with the first cut and 1.5 mm from the root apex being discarded. Once these specimens were discarded, the others were cut to the same size, approximately 1.5 mm thick. Each root was sectioned into three segments: apical segment, middle segment and cervical segment.

After preparing the samples, they were taken to a bacteriological oven at 37°C to dry the cut surface for more than three hours. Each segment obtained was loaded in a universal testing machine (EMIC DL 1000) at a speed of 0.5 mm/min and a load cell of 100 Kgf. A tip with a diameter of 1 mm was used so that the load was applied to the central portion of the post/cement, with no load applied to the dentin.

The data collected from all the groups was analyzed using Jamov 2.0 software, where descriptive statistics, homogeneity test, two-factor ANOVA and post hoc Tukey test were presented at a 5% significance level.

## RESULTS

The mean push-out bond strength values in Newtons [N] are shown in Table I. The two-way

**Table I -** Fracture load [N], descriptive statistics and homogeneous groups

| Groups | Region | Mean[N] | Standard Deviation | Shapiro- Wilk | Overall average (MPa) | Homogeneous groups |
|---|---|---|---|---|---|---|
| | Apical | 12.2 | 3.61 | 0.961 | | |
| ***G1 Control*** | Middle | 11.9 | 2.81 | 0.933 | 11.7 | A |
| | Cervical | 11.0 | 4.4 | 0.960 | | |
| | Apical | 10.5 | 5.23 | 0.899 | | |
| ***G2*** | Middle | 12.7 | 8.59 | 0.847 | 11.0 | A |
| | Cervical | 9.8 | 4.34 | 0.835 | | |
| | Apical | 10.0 | 4.0 | 0.958 | | |
| ***G3*** | Middle | 14.2 | 6.44 | 0.871 | 11.83 | A |
| | Cervical | 11.3 | 5.17 | 0.913 | | |
| | Apical | 8.20 | 3.68 | 0.900 | | |
| ***G4*** | Middle | 7.5 | 6.5 | 0.889 | 7.87 | B |
| | Cervical | 7.9 | 4.86 | 0.869 | | |
| | Apical | 8.4 | 3.6 | 0.971 | | |
| ***G5*** | Middle | 7.1 | 4.48 | 0.864 | 7.50 | B |
| | Cervical | 7.0 | 3.74 | 0.908 | | |

ANOVA test showed that there were significant differences in the mean push-out bond strength values between the five experimental groups with $p < 0.05$ (Table II).

The mean bond strength using the push-out test was higher in group 1, with no statistical difference between groups 2 and 3, followed by groups 4 and 5.

There was a statistically significant difference between group 1 and 4, group 1 and 5, group 2 and 4, group 2 and 5, group 3 and 4 and group 3 and 5. The lowest value was observed for group 5, but there was no significant difference between groups 4 and 5.

The worst behavior was shown by groups 4 and 5 where the load values for fracture were low.

In Table III, the values presented by the post-hoc test show a comparison between the groups, where it can be confirmed that the behavior of the materials compared between the groups and between the regions was significantly relevant.

## DISCUSSION

This study rejected the null hypothesis, as it showed differences between the adhesive protocols applied.

The adhesion performance of resin cements depends on the quality of the hybrid layer [23,24]. There are factors such as cementation, dentin morphology, adhesive system and light-curing time that can interfere with the formation of the hybrid layer along the inner walls of the root canal, affecting the bond strength of the fiberglass post [25,26]. Thus, we know that the formation of the hybrid layer is critical in the apical third of the canal, which is why it is more difficult to establish a resistant bond in this area. In this study, it was observed that the apical group showed slightly lower results than the cervical and middle groups. These behaviors of lower fracture strength in the apical region were the same for all groups.

In addition to the formation of the hybrid layer, the photopolymerization of the adhesive agents must be taken into account [27]. Although some manufacturers defend the light transmission capacity of glass fiber posts, this may not be sufficient to determine the complete polymerization of the resin cement, especially in the deeper regions of the root canal, since light-curing cements determine less retention of the post when compared to chemically activated or dual-curing cements [28-31]. According to Braga, Cesar, Gonzaga, 2002, the amount of light

**Table II -** Two-way ANOVA

| | Sum of Squares | gl | Mean Square | F | p |
|---|---|---|---|---|---|
| **Region** | 50.8 | 2 | 25.4 | 1.059 | 0.350 |
| **Group** | 528.5 | 4 | 132.1 | 5.506 | <.001 |
| **Region * Group** | 130.0 | 8 | 16.2 | 0.677 | 0.711 |
| **Residues** | 3240.0 | 135 | 24.0 | | |

**Table III -** Post-Hoc Test

| Comparison | | | | | | |
|---|---|---|---|---|---|---|
| Groups | Groups | Mean difference | Standard error | gl | t | p tukey |
| **G1** | G2 | 0.933 | 1.26 | 135 | 0.947 | 0.947 |
| | G3 | -0.133 | 1.26 | 135 | 1.000 | 1.000 |
| | G4 | 3.833 | 1.26 | 135 | 0.024 | 0.024 |
| | G5 | 4.200 | 1.26 | 135 | 0.010 | 0.010 |
| **G2** | G3 | -1.067 | 1.26 | 135 | -0.843 | 0.917 |
| | G4 | 2.900 | 1.26 | 135 | 2.293 | 0.154 |
| | G5 | 3.267 | 1.26 | 135 | 2.583 | 0.079 |
| **G3** | G4 | 3.967 | 1.26 | 135 | 3.136 | 0.018 |
| | G5 | 4.333 | 1.26 | 135 | 3.426 | 0.007 |
| **G4** | G5 | 0.367 | 1.26 | 135 | 0.290 | 0.998 |

transmitted increases as the depth deepens [32], this study showed that even without the post, the light intensity inside the canal seems to decrease to levels that are insufficient for polymerization, especially in the apical third. This corroborates the present study.

When cementing a fiberglass post, the adhesive system used must be taken into account. In this study, we used the most common systems found on the market. To condition the root canal dentin, self-etching adhesive systems or phosphoric acid and rinse systems can be used [26,33,34]. However, new resin cement has been developed and improved. These materials are self-adhesive and their main advantage is that they do not require any dentin pre-treatment [35]. According to the results obtained in this laboratory study, the group in which Relyx self-adhesive resin cement was used performed better than the other adhesive system groups with more steps. This can be explained by the presence of tertiary amines in the dual resin cement, as they are consumed by any acid monomer residue present in the adhesive [35].

On the contrary, Calixto et al. 2012 [36], observed that the results for a self-adhesive cement were similar to other non-self-adhesive cements [36]. This result corroborates this study, as the Universal adhesive showed worse results compared to the other groups, but in general the group in which there was no surface treatment or use of adhesive systems behaved similarly to group 4. This can be explained by the chemical polymerization of Relyx, dual cement, which reduces shrinkage tension and consequently reduces defects in the adhesive layer [37].

According to the literature, two main factors are responsible for optimizing the adhesive resistance to microtensile bonding between fiber posts and composite resin - resin cement: (1) greater surface roughness, caused by hydrogen peroxide, potassium permanganate and sodium ethoxide [38], aluminum oxide blasting [39], or hydrofluoric acid; and (2) greater chemical reactivity of the surface, promoted by silicatization [38] and silanization [39].

Cementation of glass fiber posts in dentin root canals requires meticulous procedures due to the sensitivity of the technique [40]. The use of a correct surface treatment prior to the application of the adhesive system can result in better clinical performance and longevity of prostheses retained by composite resin cores associated with glass fiber posts [41]. Furthermore, Naeem et al. [42] demonstrated in a previous study that pre-etching the dentin walls with an adhesive system before cementing the glass fiber post with adhesive cement increased the bond strength [42].

Unlike the majority of studies which state that prior etching with 37% phosphoric acid interferes with bond strength [43], due to the high viscosity of these cements which prevents them from penetrating the collagen matrix, leading to the formation of a weak bond [44], this study found no interference ($p>0.05$). This can be explained by the application of pressure during cementation, as recommended by De Munck et al. [33]. According to Goracci [45], setting pressure during cementation has a positive influence on dentin.

Choosing the right adhesive protocol is essential to ensure the longevity of the retention of fiberglass posts in endodontic restorations and has a direct impact on the clinical success of the treatment. The study analyzed the influence of different adhesive protocols on the bond strength of fiberglass posts, showing that variations in adhesive strategy can significantly affect adhesion to intraradicular dentin. The findings reinforce the importance of selecting an effective adhesive system to minimize retention failures and provide longer-lasting prosthetic rehabilitation, reducing the need for retreatments. These results have direct implications for clinical practice, helping professionals make decisions to optimize the performance of glass fiber posts and improve restorative outcomes.

More studies are needed on the chemical properties of these resin and adhesive materials in order to obtain a single, effective protocol to be followed when cementing universal fiberglass posts.

## CONCLUSION

This study rejected the null hypothesis, since Group 1 (control): no treatment; Group 2: surface treatment with a 3-step adhesive system (phosphoric acid + Optibond FL etch-and-rinse - KERR) and Group 3: conventional 2-step adhesive system (phosphoric acid + Single Bond Universal - 3M), presented the best bond strength. Meanwhile, the groups that used self-conditioning adhesives: Group 4: 2-step self-etch adhesive system (Clearfil SE Bond); Group 5:

1-step universal self-etch adhesive system (Single Bond Universal - 3M) obtained the worst results.

## Author's Contributions

APAG: Resources, Data Curation, Writing – Review & Editing. CGCB: Resources, Data Curation, Writing – Review & Editing. RCM: Resources, Writing – Review & Editing. ALCOF: Methodology, Writing – Review & Editing. RPA: Methodology, Writing – Review & Editing. RCC: Writing – Review & Editing. ALSB: Writing – Review & Editing, Visualization, Supervision.

## Conflict of Interest

No conflicts of interest declared concerning the publication of this article.

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## Regulatory Statement

This study was conducted in accordance with ethical guidelines governing the use of animal materials in research. The research utilized animal teeth obtained as discarded materials.

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