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Effect of resin cements on the bond strength of three types of glass fiber post systems to intraradicular dentin

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ABSTRACT

Rehabilitating teeth after root canal treatment often requires the use of glass fiber posts (GFPs) to retain the final restorations, so the choice of resin cement is critical for bond strength (BS) and treatment success. ***Aim:*** *The aim of this study was to evaluate the effect of different GFP systems on BS to intraradicular dentin using two dual-curing resin cement types.* ***Materials and Method:*** *Thirty bovine incisors with wide canals were filled endodontically with gutta-percha and epoxy resin sealer. Initially, the canal filling was removed, and 4 mm of the apical seal was left intact. The teeth were divided into three groups according to the GFPs used: AP (anatomical posts – prefabricated GFP (Reforpost #2, Angelus®) relined with composite resin (Filtek Z350, 3M ESPE); SPLENDOR (Splendor SAP, Angelus®), and milled CAD/CAM (FiberCAD, Angelus®). Posts were fixed with conventional (RelyX Ultimate, 3M ESPE) or self-adhesive resin cement (RC) (RelyX U200, 3M ESPE), following the manufacturer's instructions. After 48 h, the roots were sectioned into thirds and subjected to push-out BS testing using a universal testing machine. BS data were analyzed using Wilcoxon and Mann-Whitney U tests. Failure modes were assessed with Fisher's Exact test (α=0.05).* ***Results:*** *In the apical and middle root sections, BS was similar in the AP and Splendor groups, both of which performed better than the milled CAD/CAM group (p≤0.05). In the cervical section, BS was significantly higher for the anatomical posts than for Splendor and milled CAD/CAM posts. Self-adhesive RC promoted statistically lower BS compared to conventional RC for the milled CAD/CAM post in the cervical and middle thirds (p≤0.05). Self-adhesive RC provided statistically higher bond strength than conventional RC for the anatomical post in the apical third (p≤0.05). No significant difference in failure modes was observed between resin cements and different root sections (p>0.05).* ***Conclusion:*** *The BS of the GFP system was affected by resin cement type and root section, with composite resin-relined anatomically shaped posts generally performing better.*

Keywords: *dental cements - dental posts - shear strength - intraradicular retainer*

Efeito de cimentos resinosos na resistencia de união de três tipos de pinos de fibra de vidro à dentina intrarradicular

RESUMO

A reabilitação de dentes tratados endodónticamente geralmente requer o uso de pinos de fibra de vidro (PFV) para retenção da restauração final, e, portanto, a escolha do cimento resinoso é crítica para adequada resistencia de união (RU) e sucesso do tratamento. ***Objetivo:*** *O objetivo deste estudo foi avaliar o efeito de diferentes sistemas de PFV na RU a dentina intrarradicular utilizando dois tipos de cimentos resinosos duais.* ***Materiais e Método:*** *Trinta incisivos bovinos com condutos amplos foram tratados endodónticamente com guta-percha e cimento a base de resina epóxica. A obturação do conduto foi removida, e 4 mm de material na porção apical foi mantido intacto. Os dentes foram dividiso em três grupos de acorco com o pFV utilizado: PA (pino anatômico – PFV pre-fabricado (Reforpost #2, Angelus®) reembasado com resina composta (Filtek Z350, 3M ESPE); SPLENDOR (Splendor SAP, Angelus®), e PFV fresados em CAD/CAM (FiberCAD, Angelus®). Os PFVs foram fixados com cimento resinoso (CR) convencional (RelyX Ultimate, 3M ESPE) ou autoadesivo (RelyX U200, 3M ESPE), seguindo-se as intruções do fabricante. Após 48 horas, as raízes foram seccionadas em terços e submetidas ao teste de RU por push-out em máquina universal de ensaios. A RU foi na analisada pelo teste de Wilcoxon e Mann-Whitney U. O modo de falha foi avaliado pelo teste Exato de Fisher (α=0.05).* ***Resultados:*** *Nos terços radiculares apical e médio, a RU foi semelhante entre os grupos PA e SPLENDOR, e ambos tiveram RU superior do que o grupo de PFV fresado em CAD/CAM (p≤0.05). Na região cervical, a RU foi significantemente superior para PA do que SPLENDOR e PFV fresado. O CR autoadesivo promoveu RU estatisticamente inferior comparado ao CR convencional para o PFV fresado em CAD/CAM nos terços cervical e médio (p≤0.05). O CR autodesivo promoveu RU estatisticamente superior do que o CR convencional para PA, no terço apical (p≤0.05). Não houve diferença significativa no modo de falhas, considereando-se os diferentes CRs e terços radiculares (p>0.05).* ***Conclusão:*** *A RU de sistemas de PFV foi afetada pelo tipo de cimento resinoso e região radicular, sendo que de forma geral os pinos anatômicos, reembasados com resina composta, tiveram desempenho superior.*

Palavras-chaves: *cimentos de resina - pinos dentários - resistência ao cisalhamento - técnica para retentor intrarradicular*

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INTRODUCTION

Teeth that have undergone endodontic treatment and lost a significant amount of their structure are more susceptible to biomechanical failures and fractures. Roots and crowns must be effectively and promptly restored to prevent further complications[1-3].

Rehabilitation protocols to restore the function and appearance of these teeth often involve intraradicular retainers[4,5]. These retainers should ideally mimic the physical properties of natural dentin to ensure seamless integration. The materials should ensure a range of properties, such as biocompatibility, ability to preserve the integrity of the root dentin, good adherence to the existing tooth structure, resistance to corrosion, minimization of stress to the remaining tooth, natural appearance, and affordability[3]. For many years, dental professionals have favored cast metal posts for reconstructing teeth after root canal treatment because of their durability and success rate[5]. However, some drawbacks have limited their popularity, including their less appealing look, lengthy time required for placement, higher cost, need to remove more of the tooth root and crown structure, and greater risk of causing tooth fractures due to stiffness[6].

In recent years, glass fiber posts (GFPs) have become a popular alternative. Their physical properties are similar to those of natural tooth dentin, and they help distribute chewing forces more evenly, thus reducing the risk of root fractures. However, they also involve challenges. They can be difficult to bond securely to the inner tooth dentin, and the bonding process is sensitive to the technique and resin cement employed[7]. Moreover, GFPs do not always fit perfectly in certain types of root canals, particularly those that are oval-shaped or unusually wide, in which case a thick layer of resin cement may form, leading to more shrinkage and bond weakening, and possibly causing the post to become loose over time[8].

Flared root canals clearly require better-fitting retainer posts that will stay in place as a result of increased friction, thereby reducing the need for thick layers of resin cement[8]. The anatomical post technique was developed to address these issues. It involves using composite resin to strengthen fiber posts, thereby enhancing their adaptation and bond strength[8-10]. More recently, CAD/CAM technology has been developed to create customized one-piece fiberglass resin retainers which have better fit and only require a thin layer of cement[9,11].

Recognizing the importance of a precise fit for retainers in root canals, the dental industry has introduced new post systems designed to reduce failures in retention and shorten dental procedure time. One such innovation is the Splendor SAP system, which comprises a GFP and universal sleeve for better adaptation to the canal, thus eliminating the steps of relining the GFP with composite resin[12]. Although it has been demonstrated that bond strength to root dentin is not influenced by the GFP system[13], there is still no consensus in literature about which resin cement strategy performs better in terms of bond strength, especially regarding the Splendor SAP system, on which there are few studies. Lopes et al.[12] observed that the use of either self-adhesive or conventional resin cement did not influence the bond strength of the Splendor SAP system to a flared root canal, while systematic reviews suggest that self-adhesive cements are less sensitive and can improve the bond strength of glass fiber-based posts to root canals[14]. Based on this development, the purpose of this study was to examine the bond strength and failure mode of three types of intraradicular retainers (anatomical, milled CAD/CAM and Splendor SAP posts) cemented into wide root canals using either self-adhesive or conventional resin cements, considering different thirds of the root.

MATERIALS AND METHOD

Ethical Aspects

This in vitro study was approved by the Ethics Committee on Animal Research of the São Leopoldo Mandic School of Dentistry (protocol number 2024/18) because of the use of bovine incisor teeth.

Selection and Preparation of Teeth

Thirty bovine incisors were selected, cleaned of adherent tissue, and sectioned horizontally using a double-sided diamond disc (Microdont, São Paulo, SP, Brazil) under constant cooling with water and air, to achieve a root length of 17 mm from the root apex, as measured by a digital caliper (Mitutoyo Sul Americana, Suzano, SP, Brazil). The crowns were discarded, and the standardized roots were fixed in a 21 x 34 mm acrylic resin matrix filled with condensation silicone (Speedex; Coltene, Altstätten, Switzerland).

A single calibrated operator performed the endodontic procedures, standardizing the working length at 17 mm. The root canals were prepared using a crown-down technique with a K80 file (Dentsply/Maillefer, Ballaigues, Switzerland) as the primary file. The root canals were irrigated with 1% sodium hypochlorite (Biodinâmica Produtos Químicos, São Paulo, SP, Brazil) at each file change, and 17 % EDTA solution (Maquira, Maringá, PR, Brazil), followed by distilled water.

The root canal was dried with suction tips and absorbent paper, and filled by lateral condensation with gutta-percha cones (Dentsply, Petrópolis, RJ, Brazil) and an epoxy resin-based cement (Sealer 26; Dentsply, Petrópolis, RJ, Brazil). The root canal was sealed temporarily, and the specimens were stored at 37 °C and 100% humidity for 72 hours. After this period, the intraradicular retainer was installed.

The root canals were further prepared under copious irrigation using a Largo #2 drill (Angelus®, Londrina, PR, Brazil), followed by enlargement of the root canal with a conical diamond tip (4137) (Kavo, Joinville, SC, Brazil). A 4 mm thick layer of gutta-percha was used for apical sealing. The canals were irrigated with 16% EDTA (Maquira, Maringá, PR, Brazil), washed abundantly with distilled water, and dried.

Fabrication of the Intraradicular Retainers

The roots were randomly allocated to three different experimental groups: the anatomical post group (AP); the SPLENDOR group, which employed Splendor SAP GFPs; and the CAD/CAM group, which used Fiber CAD System posts.

The anatomical posts for the AP group were fabricated by coating GFPs with composite resin. Initially, the root canals were isolated with a water-soluble gel (KY, Johnson & Johnson, São Paulo, SP, Brazil), using disposable micro-applicators (AllPrime, São José, SC, Brazil). A prefabricated GFP (Reforpost #2, Angelus, Londrina, PR, Brazil) was used. After cleaning and disinfecting the GFP with 70% alcohol, a silane-based bonding agent (Angelus, Londrina, PR, Brazil) was applied using disposable micro-applicators (All Prime, São José, SC, Brazil) for one minute, followed by air drying. Next, the Single Bond Universal adhesive system (3M ESPE, São Paulo, SP, Brazil) was applied, followed by adhesive evaporation with an air jet and light-curing for 10 seconds using a LED light-curing unit (Valo, Ultradent Products, St. Jordan, USA), operating in standard mode with an irradiance of 1000 mW/cm². Subsequently, a small amount of composite resin (Filtek Z350 XT, 3M ESPE, St. Paul, USA) in shade A1 was placed on the apical portion of the post, and the assembly (post and resin) was inserted in the root canal to be molded and made anatomically compatible with the root, followed by initial light-curing for 10 seconds. The post was removed, and light-curing was completed for another 40 seconds (Valo, Ultradent Products, St. Jordan, USA). The water-soluble gel was removed by irrigation with distilled water and suction using a metal cannula, followed by absorbent paper points (Dentsply Maillefer, Catanduva, SP, Brazil).

In the SPLENDOR group, Splendor SAP GFPs (Angelus, Londrina, PR, Brazil) were used, consisting of a post and a sleeve also made of fiberglass, designed to fit into the root canals regardless of their diameter.

In the experimental CAD/CAM group, Fiber CAD system GFPs were fabricated. The root was modeled using Duralay red acrylic resin (Reliance Dental Manufacturing, Worth, USA) and the Pinjet acrylic resin pin for modeling (Angelus, Londrina, PR, Brazil). After lubricating the root with lubricating gel (KY, Johnson & Johnson, São Paulo, SP, Brazil), the acrylic resin (powder and liquid) was manipulated and inserted into the root with a Lentulo drill. Then, the modeling pin was placed, removed, and reinserted several times to eliminate any bubbles and prevent the resin from getting stuck in the root canal until polymerization was complete. After the final polymerization, the Duralay patterns were stored in water and sent to the prosthetic laboratory. In the prosthetic laboratory, the Fiber CAD system fiberglass cores were manufactured using the CAD/CAM system (computer-aided design/computer-aided manufacturing). The process began by scanning the molded pattern in the root canal originally produced with Duralay acrylic resin, using an extraoral scanner (model inEos X, Sirona, Barueri, SP, Brazil). Subsequently, the milling process was conducted with a CEREC MC XL milling unit (Sirona, Barueri, SP, Brazil), using a specific block of the Fiber CAD System – Post and Core (Angelus, Londrina, PR, Brazil).

Cementation of Intraradicular Retainers

The GFPs were fixed using RelyX U200 (3M ESPE, St. Paul, MN, USA) (15 teeth) or RelyX Ultimate

(3M ESPE, St. Paul, MN, USA) resin cements. Initially, the root canals were irrigated with distilled water, and then dried using absorbent paper points (Dentsply Maillefer, Catanduva, SP, Brazil).

In the AP group, the GFPs were cleaned with 70% alcohol. The resin cement was mixed in a mixing block according to the manufacturer's instructions, and inserted into the root canals using the applicator tip of a Centrix syringe (Maquira, Maringá, PR, Brazil), followed by insertion of the GFP. Any excess resin cement was removed with a disposable micro-applicator (All Prime, São José, SC, Brazil). After all the GFPs had been inserted, each was light-cured for 40 seconds, with the tip of the device positioned as closely as possible to the cervical region.

In the CAD/CAM group, adjustments were made to ensure proper fit before cementing the GFPs. This involved liquid carbon Super Film (Kota, São Paulo, SP, Brazil) and a Sof Lex sanding disc (3M ESPE, St. Paul, MN, USA). After the adjustments were made, the GFPs were cleaned with 70% alcohol. A silane-based bonding agent (Angelus, Londrina, PR, Brazil) was then applied with a disposable micro-applicator (All Prime, São José, SC, Brazil), followed by drying with compressed air and waiting one minute. Subsequently, the Single Bond Universal adhesive system (3M ESPE, St. Paul, MN, USA) was applied, followed by adhesive evaporation with compressed air, and light-curing for 10 seconds. The resin cement was then manipulated and inserted into the root canals using a Centrix syringe applicator tip (Maquira, Maringá, PR, Brazil). The GFPs were positioned, and any excess was removed, followed by light-curing for another 40 seconds.

The Splendor SAP GFPs were fixed following a process similar to that of the Fiber CAD GFPs. An additional step involved the surface treatment of the accompanying sleeve. The GFPs were inserted into the canals in two stages: first, the post was positioned, and then the sleeve was carefully accommodated around the post with tweezers. After cementation, the specimens were placed in a humid environment at 37 °C for storage.

Sample Preparation

Forty-eight hours after cementation of the GFPs, the roots were fixed individually in an acrylic resin plate using modeling wax and aligned parallel to one another. They were then sectioned transversely using a double-sided diamond disc (Buehler, IL, USA), attached to a metallographic cutter (Isomet 1000, Buehler, OL, USA), operating at a speed of 300 rpm with constant cooling. This process resulted in a 1 mm thick slice from each root third (apical, middle, and cervical). The slices were mounted on a universal testing machine (EMIC DL2000, São José dos Pinhais, SP, Brazil) to conduct the push-out test at a speed of 0.5 mm/min and a load of 50 Kgf.

After completing the push-out test, the specimens were examined under a stereoscopic microscope to analyze the failure type. Failures were classified as adhesive between the resin cement (RC) and the dentin, adhesive between the resin cement and the GFP, cohesive in GFP, cohesive in RC, cohesive in dentin, or a combination, indicating the presence of two types of failures simultaneously.

Push-out Bond Strength Test

The push-out bond strength test was conducted on the prepared root slices using a universal testing machine (EMIC DL 2000; EMIC, São José dos Pinhais, Paraná, Brazil), using. Each slice was placed in a push-out device consisting of a steel base with an active tip 1 mm in diameter. The test was performed at a speed of 0.5 mm/min and a load cell with a capacity of 500 N. The force data obtained in Kgf were expressed in MPa (MPa = KgF*9.8/area). The area of each section was calculated using the following formula: $\pi * R^2 * h$, where π is the constant 3.1416, R represents the diameter of the pin, and h, the height of the section in mm.

Failure Mode Evaluation

The push-out specimens were observed under a stereomicroscope (Eikonal Equip. Ópticos e Analíticos, model EK3ST, São Paulo, SP, Brazil) at a magnification of 40x. Failures were classified as adhesive failure between RC and fiber post, adhesive failure between RC and dentin; dentin cohesive failure; RC cohesive failure; fiber post cohesive failure, or mixed failure.

Statistical Analysis

Descriptive data analyses were conducted initially. Subsequently, the bond strength variable was examined using a generalized linear model, following a split-plot design. This implies that different thirds were evaluated in the same specimens of the model, while the systems were assessed in different specimens. The analysis of the failure mode was

Table 1. Descriptive analysis and bond strength results for push-out tests (MPa) according to resin cement type, type of retainer and root third

Post	Rely X U 200			Rely X Ultimate		
	Cervical	Middle	Apical	Cervical	Middle	Apical
Milled	2.17 ± 1.09Ba*	0.77 ± 0.30Bb*	0.89 ± 0.92Bb	5.45 ± 2.64Ba#	3.64 ± 2.44Ba#	4.84 ± 5.45ABa
Anatomical	11.08 ± 6.30Aa	14.93 ± 6.47Aa	10.74 ± 5.39Aa*	14.64 ± 3.12Aa	15.66 ± 6.02Aa	1.41 ± 0.46Bb#
Splendor SAP	3.40 ± 4.01Ba	6.38 ± 5.10Aa	10.37 ± 9.60Aa	7.47 ± 8.30AABa	19.98 ± 27.95ABa	9.22 ± 6.65Aa

Means followed by different letters (uppercase in the columns, comparing the GFPs within each third, and lowercase in the rows, comparing the thirds within each type of GFP) indicate significant differences ($p \leq 0.05$). Means followed by different symbols indicate a statistical difference between RelyX U200 and Rely X Ultimate resin cements, within the same root third and type of GFP.

conducted using Fisher's Exact Test. All analyses were performed in R software, with a significance level set at 5%.

RESULTS

The results of the bond strength evaluation are presented in Table 1. A comparison of different types of GFPs (milled vs. anatomical post vs. Splendor) showed that the anatomical post and Splendor groups had statistically similar average bond strengths ($p > 0.05$) and were superior to the milled group ($p \leq 0.05$) when the RelyX U200 resin cement was used in the apical and middle thirds. In the cervical third, the anatomical post provided statistically superior bond strength compared to the milled and Splendor GFPs ($p \leq 0.05$). The latter two were statistically similar to each other ($p > 0.05$).

When RelyX Ultimate cement was used in the cervical and middle thirds, the anatomical post group had a statistically higher average bond strength value than the milled GFP group ($p \leq 0.05$). Splendor showed intermediate results that were statistically similar to those of the other groups ($p > 0.05$). In the apical third, average bond strength was statistically higher in the Splendor GFP group than in the AP group, but both were statistically similar to the milled group.

Regarding resin cements, RelyX U200 had statistically lower bond strength than RelyX Ultimate for the milled post in the cervical and middle thirds ($p \leq 0.05$). RelyX U200 resin cement provided statistically higher bond strength than Ultimate ($p \leq 0.05$) for the anatomical post in the apical third. In the other comparisons between the two resin cements, considering the same GFP and root third, the means did not differ statistically.

Comparison of root thirds showed that the milled GFP cemented with RelyX U200 self-adhesive resin had statistically lower bond strength in the apical and middle thirds than in the cervical third ($p \leq 0.05$), with no statistical difference between apical and middle thirds ($p > 0.05$). However, the averages for the milled pin cemented with RelyX Ultimate conventional resin showed no significant difference among the apical, middle and cervical thirds ($p > 0.05$).

Regarding the anatomical post cemented with RelyX U200 self-adhesive resin, no statistically significant difference was observed between the average bond strengths across the apical, middle and cervical thirds ($p > 0.05$). However, for the same post cemented with RelyX Ultimate conventional resin, the middle and cervical thirds had statistically higher bond strength than the apical third ($p \leq 0.05$), with no significant difference between middle and cervical thirds ($p > 0.05$). Finally, there was no statistically significant difference in bond strength for the Splendor post in the apical, middle or cervical thirds, regardless of the resin agent used ($p > 0.05$).

The results of the failure mode analysis for the RelyX U200 and RelyX Ultimate 3M cementation systems, stratified by cervical, middle and apical thirds, are presented in Fig. 1. There was no significant difference between the resin cements or among the thirds in terms of failure modes ($p > 0.05$ in all cases), suggesting a similar distribution of failure modes among the evaluated groups.

For the RelyX U200 resin cement, most specimens exhibited adhesive RC/D failures (3 for AP, 4 for Splendor, and 3 for Fiber CAD) in the cervical third, followed by cohesive RC failures (1 for AP, 2 for Fiber CAD), and one mixed-type failure (1 for AP). In the middle third, most failures were also mixed type (2 for AP, 5 for Splendor, 2 for Fiber CAD),

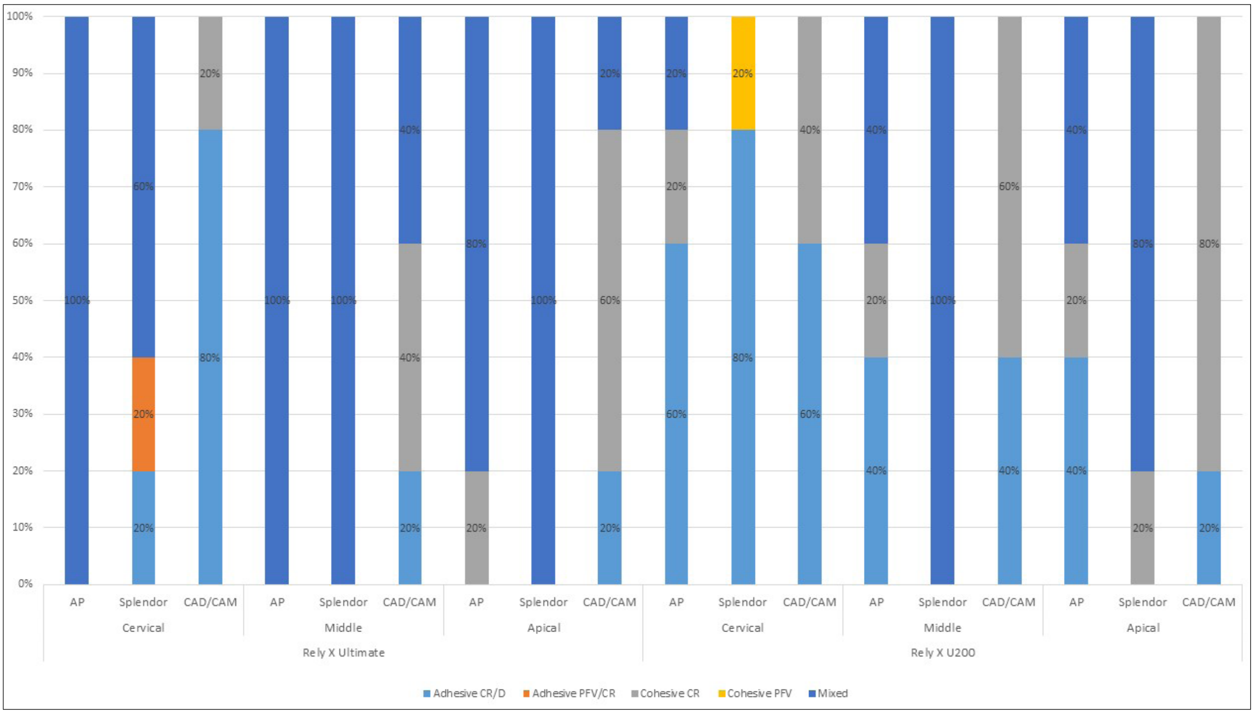

Fig. 1: Distribution of failure modes (%) relative to the experimental groups.

followed by cohesive GFP failures (1 for Splendor), cohesive RC failures (1 for AP, 3 for Fiber CAD), and adhesive RC/D failures (2 for Fiber CAD). In the apical third, mixed-type failures predominated (2 for AP, 4 for Splendor, 2 for Fiber CAD), followed by cohesive RC failures (1 for AP, 1 for Splendor) and adhesive RC/D failures (2 for AP, 1 for Fiber CAD).

Regarding RelyX Ultimate resin cement, a similar distribution of failures was observed in the cervical third, with a predominance of adhesive RC/D failures (4 for Fiber CAD), followed by mixed-type failures (5 for AP) and one cohesive RC failure (1 for Fiber CAD). In the middle third, again, most failures were mixed type (5 for AP and Splendor, 2 for Fiber CAD), followed by cohesive RC failures (2 for Fiber CAD) and one adhesive RC/D failure (1 for Splendor). In the apical third, mixed failures were the most common (4 for AP, 5 for Splendor, 1 for Fiber CAD), followed by adhesive RC/D failures (1 for AP, 1 for Splendor) and cohesive RC failures (3 for Fiber CAD).

DISCUSSION

The results of the present study demonstrated that there were significant differences in the bond strength of the GFP systems depending on the resin cement and the root third, so the null hypothesis was rejected.

Bond strength with RelyX U200 resin cement in the apical and middle root thirds was lower for CAD CAM posts than for anatomical or Splendor SAP posts, possibly due to the fit of CAD CAM posts. The first step in the CAD CAM process is to scan the acrylic resin pattern, which can introduce more variables in the digital process of a single-piece GFP[15]. The difficulty in fitting a post using the acrylic pattern to replicate the post space has been reported in a previous study[16]. Poor fit may have increased the thickness of resin cement in the middle and apical thirds, thereby affecting the degree of resin cement conversion. Indeed, it has been demonstrated that self-adhesive cements are viscous, which may affect the ability of radicals to migrate and complete the setting reaction, thereby decreasing the degree of conversion[17].

Comparisons of root thirds showed that the milled CAD CAM posts promoted lower bond strength in the apical and middle thirds than in the cervical third, when cemented with Rely X U200 resin agent. In this regard, it has been demonstrated that the self-polymerizing reaction of the dual-polymerized self-adhesive cement might not fully compensate for the inadequate light polymerization[18]. As mentioned before, the method for obtaining the replica of the post space by scanning an acrylic resin pattern may have led to more poorly fitting posts and the need for adjustments. Added to the low light transmission in middle and apical regions, this may have had an undesirable effect on the mechanical properties of the resin cement, especially if the cement was thicker due to poor post fit.

In contrast, bond strength in the CAD CAM posts cemented with Rely x Ultimate resin cement was statistically higher than in the group that received Rely X U200 resin cement, without differences among root thirds. The need for a universal adhesive system during the adhesive procedures of the conventional resin cement, Rely X Ultimate, may have compensated for any lack of fit promoted by the technique used to obtain the post space replica. The universal adhesive contains a functional monomer (10-MDP monomer), which establishes chemical bond to tooth structure[19], and silane, a coupling agent that strengthens the bond between the inorganic fillers in the post and the organic matrix in the resin[20]. This is especially important in the comparisons between resin cements, where it was found that in general, the cementation of milled CAD CAM posts with conventional resin cement promoted higher bond strength values, especially in the cervical and middle root thirds, compared to the self-adhesive resin cement, Rely X U200.

Comparison of the bond strength of different GFPs cemented with Rely X Ultimate cement showed greater strength for the anatomical post than for the CAD CAM milled post in the cervical and middle thirds. The anatomical post is used to enhance frictional retention between the GFP and the dentin walls, produce a more uniform resin cement layer, and reduce resin cement thickness, thereby enhancing the strength of the bond to root dentin[21]. However, specifically in the apical third, the bond strength was lower for the anatomical post than for the Splendor SAP post. This may be because the anatomical post is relined with composite resin, which may have acted as a barrier preventing adequate light transmission, thereby reducing resin cement polymerization[22].

For the self-adhesive cement, bond strength was also lower for all root thirds, though without statistical difference. The Splendor SAP post, which is prefabricated with a glass fiber sleeve, may have allowed more light transmission to the apical region and indeed, for this post system, there was no statistical difference in bond strength among root thirds.

This study presents promising solutions from a scientific perspective for daily clinical practice, highlighting the ease of fabrication of anatomical posts, the practicality of adaptation with Splendor SAP GFPs, and the use of advanced digital techniques such as CAD/CAM manufactured posts. The research aimed to identify a combination of simplicity and effectiveness among the rehabilitation techniques. Further studies are needed to confirm the stability of these findings, and gain further insights.

CONCLUSION

Based on these findings, it was concluded that:

- Bond strength to intraradicular dentin was influenced by the type of glass fiber post, resin cement and root third;
- In general, the anatomical post relined with composite resin performed better than the milled CAD/CAM post;
- The Splendor SAP post and the anatomical and milled CAD-CAM posts showed comparable results;
- The conventional resin cement (Rely X Ultimate, 3M ESPE) had similar or better bond strength than the self-adhesive resin cement (Rely X U200), except for the anatomical post in the apical third.

CONFLICT INTERESTS

The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

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