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Evaluation of the bond strength of different intraradicular posts in endodontically treated teeth

Evaluación de la fuerza de unión de diferentes postes intrarradiculares en dientes tratados endodónticamente

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ABSTRACT

Objectives: The reconstruction of endodontically treated teeth with significant coronal destruction often requires the use of posts. This study evaluated the bond strength of four intraradicular post systems in different root regions using a push-out test: conventional fiberglass, CAD/CAM fiberglass, Splendor SAP, and anatomical posts. **Materials and Methods:** Nineteen single-rooted premolars were treated endodontically and divided into four groups. The posts were cemented with dual self-adhesive resin cement and then sectioned into 1 mm slices for push-out testing. **Results:** The cervical region had a higher bond strength than middle and apical thirds. Conventional fiberglass posts presented higher resistance than anatomical posts (p=0.048). **Conclusions:** These results confirm that cervical thirds present the best bonding conditions and that conventional fiberglass posts outperform the anatomical ones.

Keywords: Dental Pins; Resin Cements; Post and Core Technique; CAD/CAM; Endodontics. (Source: MeSH NLM)

RESUMEN

Objetivos: La reconstrucción de dientes endodónticos con destrucción coronal significativa a menudo requiere el uso de postes. Este estudio evaluó la resistencia de adhesión de cuatro sistemas de postes intrarradiculares en diferentes regiones radiculares mediante una prueba de expulsión: fibra de vidrio convencional, fibra de vidrio CAD/CAM, Splendor SAP y postes anatómicos. **Materiales y Métodos:** Diecinueve premolares unirradiculares fueron endodónticamente tratados y divididos en cuatro grupos. Los postes se cementaron con cemento de resina autoadhesivo dual y luego se seccionaron en rebanadas de 1 mm para la prueba de expulsión. **Resultados:** La región cervical tuvo una mayor resistencia de adhesión que los tercios medio y apical. Los postes convencionales de fibra de vidrio presentaron mayor resistencia que los postes anatómicos (p=0,048). **Conclusiones:** Estos resultados confirman que los tercios cervicales presentan las mejores condiciones de adhesión y que los postes convencionales de fibra de vidrio superan a los anatómicos.

Palabras clave: Pins Dentales; Cementos de Resina; Técnica de Perno Muñón; CAD-CAM; Endodoncia. (Fuente: DeCS BIREME)

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INTRODUCTION

Endodontically treated teeth with extensive coronal damage need intraradicular posts for adequate retention of restorative materials. In such cases, the posts will help in the stabilization of restorations and distribute functional forces along the tooth structure, hence minimizing the possibility of fractures [(1)]. The development of post materials and designs has been continuously improving clinical outcomes and makes available options that can balance mechanical strength, esthetics, and compatibility with dentin [(2)].

Fiberglass posts are used based on their modulus of elasticity being closer to dentin and reducing further the possibility of root fractures. They are also more esthetic and do not raise concerns of corrosion compared to metallic posts [(3)]. Technological advancements have led to the emergence of CAD/CAM posts, which offer individualized adaptation to specific root canal morphologies, and Splendor SAP posts with sleeves for better adaptation in wide canals. Another option for improving adaptation in teeth with irregular canal geometries is the use of customized anatomical posts made from composite resins [(4)].

Despite these advancements, the clinical performance of these systems remains a matter of interest. Optimizing post selection and cementation protocols requires understanding bond strength in different regions of the root, such as the cervical, middle, and apical thirds. The purpose of this study was to test and compare the bond strength of four different post systems regarding their efficacy in retaining restorative materials and their interaction with root dentin.

MATERIALS AND METHODS

This *in vitro* experimental study was conducted at the Mechanical Testing Laboratory of the Federal University of Alfenas, Brazil and approved by the Research Ethics Committee (CAAE: 36146720.5.0000.5.5142).

Specimen selection

Nineteen single-rooted premolars (1st or 2nd lower premolars) were obtained from the university's tooth bank. Teeth were selected based on similarity in size, shape, and root morphology. The absence of caries, cracks, or fractures was confirmed using magnification. All teeth were cleaned with ultrasonic instruments and stored in saline solution at room temperature until use.

Endodontic treatment

The crowns were sectioned to standardize the root length at 15 mm. Root canals were prepared using the Reciproc R40 system with a #40 tip and 0.06 taper (Dentsply, Brazil) (Figure 1). Irrigation was performed alternately with 2.5% sodium hypochlorite and 17% EDTA. Canals were obturated with gutta-percha and Sealer 26 using lateral condensation. The root canal orifices were sealed with glass ionomer cement (Ketac Cem, 3M ESPE, Germany). and the samples were stored in distilled water at 37 °C for seven days.

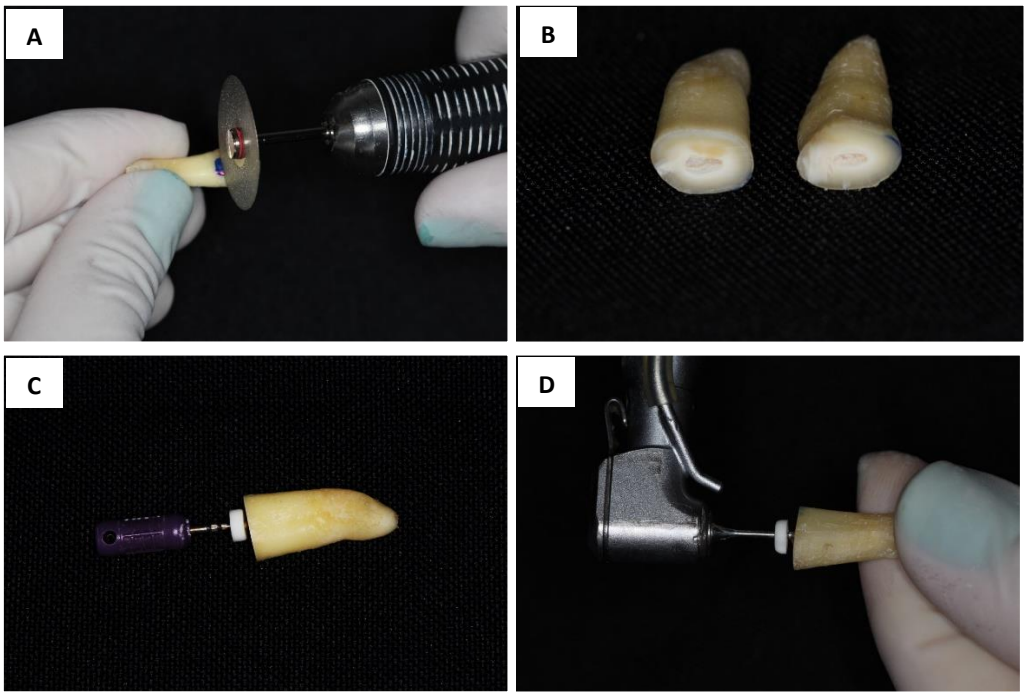

Figure 1. Tooth preparation and treatment. **A.** Tooth being sectioned. **B.** Sectioned tooth. **C.** File positioned for odontometry. **D.** Endodontic treatment being carried out with a reciprocating system

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Group allocation
Teeth were randomly divided into four groups according to the type of post used (Table 1). All the posts were subjected to the same cementation technique with self-adhesive resin cement.

Table 1. Distribution of groups according to the post used

Group	N	Post type	Cement
I	4	Conventional fiberglass posts (Exacto N.2, Angelus, Brazil).	**SET PP**
II	6	CAD/CAM fiberglass posts (Fiber CAD Post, Angelus, Brazil).	**SET PP**
III	3	Splendor SAP posts (Angelus, Brazil)	**SET PP**
IV	6	Anatomical posts (customized fiberglass posts)	**SET PP**

Post preparation
Conventional Fiberglass Posts: Posts were selected based on canal diameter and cleaned with 37% phosphoric acid, silanized for 60 seconds, and dried. They were ready for immediate insertion following cement application.

CAD/CAM Posts: Custom posts were designed using Duralay resin molds (Reliance Dental Mfg. Co., USA) of the root canals. The resin patterns were scanned using the Ceramill CAD/CAM system (Amann Girrbach, Austria) to fabricate fiberglass posts precisely matching canal morphology. Posts were cleaned and prepared with acid etching and silanization prior to cementation.

Splendor SAP Posts: These posts were combined with prefabricated fiberglass sleeves to adapt better to canal walls. The sleeves were manually adjusted to minimize cement layer thickness and enhance fit. Both components were etched, silanized, and bonded as a single unit.

Anatomical Posts: Conventional fiberglass posts were customized by layering composite resin (Filtek Z350 XT, 3M ESPE, USA) to match canal anatomy. After applying 37% phosphoric acid and silane, the resin was incrementally added and light-cured inside the canal. Once removed, the post was fully cured outside the root, finished, and polished before final cementation.

Post cementation
All posts were treated with 37% phosphoric acid for one minute, silanized for one minute, and bonded with a dual self-adhesive resin cement (RelyX U200, 3M ESPE, Germany). Cement was applied into the canal using mixing tips, and posts were inserted with slight pressure. Excess cement was removed, and polymerization was performed for 60 seconds using a light-curing device (Valo Cordless, Ultradent, USA).

Sample sectioning
After cementation, roots were embedded in silicone molds and sectioned perpendicular to their long axis into 1-mm slices using a precision metallographic cutter (Isomet 1000, Buehler, USA). Three slices were obtained from each root: cervical, middle, and apical thirds.

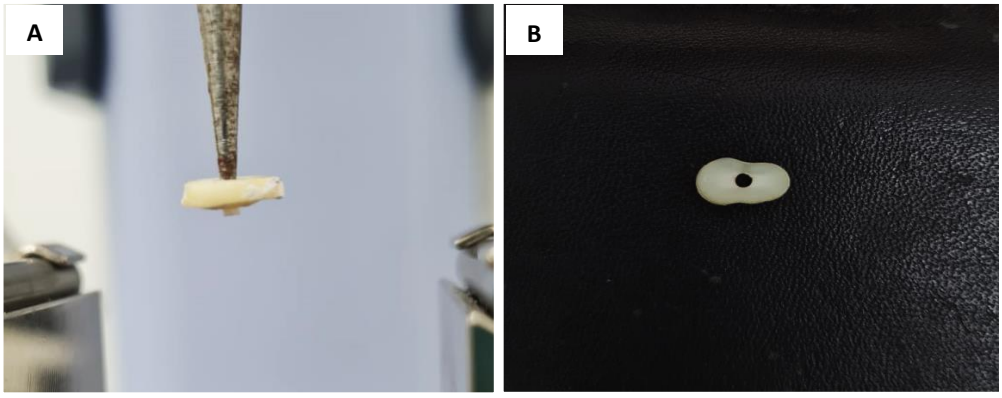

Figure 2 - Displacement of intraradicular posts during the push-out bond strength test. **A.** Post displacement. **B.** Slice after total post displacement

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Push-out test
Each slice was positioned in a stainless-steel support device with an opening slightly smaller than the post diameter, ensuring that the applied force would only displace the post without deforming the root slice. A custom cylindrical plunger with a diameter slightly smaller than the post was attached to a universal testing machine (EMIC DL2000, Brazil). Force was applied at a crosshead speed of 0.5 mm/min in an apical-to-coronal direction until the post was completely dislodged (Figure 2). The force at dislodgement was recorded in Newtons (N) where and are the apical and coronal radii of the slice and is its thickness (1 mm). Measurements of radii were performed using a digital caliper to ensure accuracy. The bond strength was calculated by dividing the force (N) by the bonded area (mm²), and results were expressed in MPa. The force at dislodgement was recorded in Newtons (N). The bonded area of each slice was calculated using the following formula: A= π (R1+R2)[h2+(R2-R1)2]0.5 (π =3,14; R1= apical radius of the post fragment; R2= coronal radius of the post fragment; H= slice thickness).

Data analysis
The bond strength values were statistically analyzed using two-way ANOVA to evaluate the influence of post type and root region on retention. Tukey's post hoc test was applied for pairwise comparisons, with a significance level set at 5%.

RESULTS
Cervical regions showed the highest bond strength across all groups (Tables 2-3). Conventional fiberglass posts demonstrated superior retention compared to anatomical posts (p=0.048). No significant differences were observed between other post types (Figure 3).

Table 2. Values in N of the force required to dislodge the post (first slices of each third)

Post Type	Tooth Area		
	Cervical Area 1 x̄ (sd)	**Middle Area 1 x̄ (sd)**	**Apical Area 1 x̄ (sd)**
Conventional fiberglass posts	117.3 (58.4)[a]	37.4 (26.9)[a]	11.4 (19.7)[a]
CAD/CAM fiberglass post	102.2 (62.2)[ab]	38.7 (25.3)[ab]	57.4 (70.5)[ab]
Splendor SAP post	75.2 (16.0)[abc]	53.1 (14.6)[abc]	30.7 (22.1)[abc]
Anatomical post	37.7 (13.0)[c]	44.4 (15.6)[abc]	27.5 (8.7)[abc]

Letters indicate statistical difference between study groups (p=0.05); x̄ = mean; sd = standart deviation.

Table 3. Values in N of the force required to dislodge the post (first slices of each third)

Post Type	Tooth Area		
	Cervical Area 2 x̄ (sd)	**Middle Area 2 x̄ (sd)**	**Apical Area 2 x̄ (sd)**
Conventional fiberglass posts	165.8 (62.9)	49.1 (43.4)[a]	-
CAD/CAM fiberglass post	60.4 (28.4)[a]	42.4 (19.7)[ab]	14.5 (16.7)[a]
Splendor SAP Ppost	72.3 (6.1)[ab]	36.1 (19.2)[abc]	23.7 (16.8)[ab]
Anatomical Post	43.4 (20.0)[ab]	46.0 (14.2)[abc]	28.0 (5.7)[ab]

Letters indicate statistical difference between study groups (p=0.05); x̄ = mean; sd = standart deviation.

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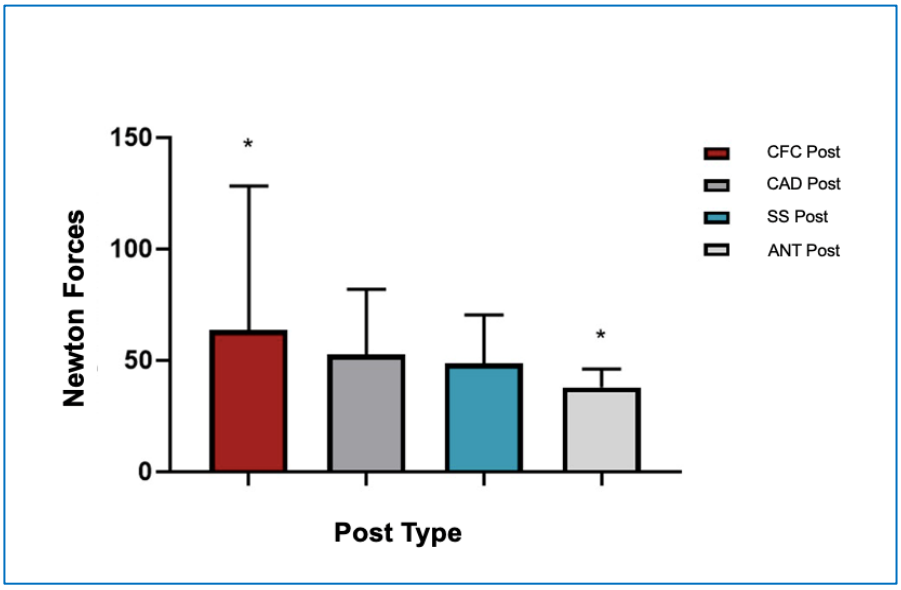

Figure 3. Push-out bond strength of different intraradicular posts across root thirds

DISCUSSION

The results of this study confirm that the cervical region consistently provides the best bonding conditions for intraradicular posts, primarily due to improved light penetration and hybrid layer formation in this region. This finding corroborates previous studies that highlight the importance of polymerization efficiency in achieving optimal adhesive properties [1,5].

Furthermore, the reduced bond strength observed in the apical third can be attributed to the challenges associated with limited light penetration and increased difficulty in cement placement in deeper regions. This underscores the necessity for clinicians to ensure meticulous cementation techniques, particularly in the apical region, to minimize voids and ensure uniform bonding [6].

Among the post systems evaluated, conventional fiberglass posts outperformed anatomical posts in terms of bond strength. This result can be explained by the better material homogeneity and reduced cement layer thickness of prefabricated posts, which contribute to enhanced mechanical retention[7]. On the other hand, anatomical posts, despite their superior adaptation to canal morphology, may introduce variability in the cement layer thickness, negatively impacting bond strength [8].

Although CAD/CAM posts show no statistically significant difference compared to conventional posts, their ability to accurately replicate root anatomy can represent a considerable clinical advantage, especially in cases of canals with irregular or dilated morphology. Recent studies highlight that this individualization can reduce adhesive failures and minimize internal tension during cementation [7,9].

Splendor SAP posts, on the other hand, showed intermediate performance. The combination of the expandable/adaptable sleeve with the prefabricated core may favor adaptation without compromising the thickness of the cement layer, showing a theoretical biomechanical advantage that requires further clinical validation [9].

In addition to laboratory results on adhesive strength, it is important to consider the clinical longevity of restorations with and without the use of intraradicular posts. A longitudinal study followed endodontic treatments with and without the use of posts for up to 18 years, demonstrating that the use of posts, especially fiber posts, contributes to greater restorative stability in teeth with significant structural loss. The authors emphasize that the appropriate choice of post system, combined with the correct adhesive technique, has a direct impact on the survival of the rehabilitation [10].

Finally, the findings highlight the role of regional root anatomy and its influence on bonding efficiency. Clinicians should prioritize proper adhesive protocols and post selection based on the anatomical challenges posed by different root regions. Future research should focus on larger sample sizes and the incorporation of advanced imaging techniques to further elucidate the factors affecting bond strength.

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Conventional fiberglass posts demonstrated superior bond strength compared to anatomical posts. The cervical third consistently exhibited the highest retention, highlighting its importance in clinical outcomes. Future studies should explore larger samples and diverse post systems.

Furthermore, based on the results, it is recommended that conventional fiber posts be used in the cervical regions of endodontically treated roots, where there is greater predictability of adhesion. CAD/CAM posts may be indicated in cases of canals with irregular anatomy, for greater adaptation and ease of cementation. However, although these findings reinforce practical clinical decisions, it is important to note that customized systems, such as CAD/CAM and those with expandable liners, still lack robust clinical evidence.

Contributor roles according to CRediT
Conceptualization: LSR, AAP. Methodology: LSR, AAP, BMSMM, GVLB, TSOC, FIDC. Investigation: AFMA, BMSMM, LSR. Writing – Original Draft Preparation: FIDC, GVLB, AFMA, BMSMM. Writing – Review & Editing: LSR, AAP, TSOC.

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