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ORIGINAL ARTICLE

Influence of the type of post and the cementation line on the adhesive union of fiberglass posts within the root canal

Gabriela Carvalho da Rosa[1]

Gabriella Gulden Lobo[1]

Vicente Castelo Branco Leitune[2]

Tiago André Fontoura de Melo[3*]

[1]Dentistry College, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil.

[2]Dental Materials Division, Department of Conservative Dentistry, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil.

[3]Endodontic Division, Department of Conservative Dentistry, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil.

ABSTRACT

Aim: *To evaluate the adhesive strength of fiberglass posts cemented in the root canal, according to the type of post and the thickness of the cement line.*

Methodology: *Forty primary bovine incisors, 17 mm long, were endodontically treated. After seven days, the teeth were unfilled and prepared to receive the 13 mm posts. The roots were randomly divided into four groups according to the type of post (Reforpost® cylindrical post and Exacto® conical post) and the thickness of the cementation line. The posts were cemented with RelyX U200® within the root canal. The roots were sectioned, thus obtaining specimens with an average thickness of 1.92 mm in each of the root thirds (cervical and middle). The specimens were submitted to the push-out test. After performing the test, the fractured samples were analyzed under a stereomicroscope to determine the fracture pattern. The data obtained were treated by the one-way ANOVA test, followed by the Tukey test, and the non-parametric t test (α=0.05).*

Results: *There was a statistical difference between the groups regarding the different root positions analyzed (P<0.05). The Exacto® conical post demonstrated the best results when used with a diameter matching that of the prepared root canal. Conversely, the least favorable outcome was observed when the Reforpost® cylindrical post was employed within a root canal prepared with a diameter larger than that of the post.*

Conclusions: *The type of post and the thickness of the cementation line influence the displacement resistance of intraradicular cemented fiberglass posts. The smooth conical post with a small cement line showed greater adhesive bond strength.*

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Corresponding Author
Tiago André Fontoura de Melo | Universidade Federal do Rio Grande do Sul, Faculty of Odontology
Dept. of Conservative Odontology, Porto Alegre, RS | Brazil
E-mail: tiago.melo@ufrgs.br Phone: +55 (51) 3308-5430

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Introduction

In certain clinical cases, restoring endodontically treated teeth poses a significant challenge in clinical practice due to extensive tissue loss. In situations where the crown structure is insufficient, the placement of an intraradical post becomes necessary to enhance the retention of the restorative material (1).

In this context, the use of fiberglass-based retainers has gained widespread acceptance (2) due to their advantages over cast metal cores. These advantages include improved aesthetics, elimination of labor-intensive laboratory steps, reduced number and duration of clinical sessions, as well as mechanical properties that closely resemble dentin. This similarity promotes a biomechanical behavior akin to natural teeth, thereby reducing the risk of coronal fractures (3, 4). However, a limitation associated with fiberglass posts is that their shape may sometimes fail to adapt to the root canal's morphology, resulting in a thick and irregular cementation line (5).

The most common issues encountered with prefabricated posts involve loss of retention and subsequent detachment from the root canal (6). During the adhesive cementation of intraradical posts, the greater the discrepancy between the canal diameter and the post diameter, the higher the levels of residual stresses due to the increased volume of cement (7-9). According to D'Arcangelo et al (10), the ideal thickness of the cement line between root dentin and post should fall within the range of 0.1 to 0.3 mm, a finding supported by Grandini et al (11). A narrower cementation line not only enhances the stability of the intraradical post within the root canal (12) but also reduces the concentration of polymerization stress on the cement layer (13), thereby increasing bond strength (14).

Consequently, this study aims to assess whether the type of post and the thickness of the cementation line have an impact on the resistance to displacement of fiberglass posts cemented intraradicularly. The null hypothesis posits that neither the type of post nor the thickness of the cementation line influence the bond strength of fiberglass posts with intraradicular dentin.

Methodology

Sample selection and preparation

Forty primary bovine incisors were selected and standardized to the initial apical diameter of the root canal, equivalent to a K-type #20 endodontic instrument (Dentsply/Maillefer Instruments S.A., Ballaigues, Switzerland). The root canals had circular sections. After cleaning, the dental crowns were sectioned at the cementoenamel junction with the aid of a low-speed silicone carbide disc. The length of the root remnant was standardized to 17 mm and the working length (WL) was 1 mm below this standardized measurement (WL=16 mm).

Endodontic preparation of samples

All samples were prepared manually with first and second series K-type stainless steel endodontic instruments (Dentsply/ Maillefer Instruments S.A., Ballaigues, Switzerland). Chemomechanical preparation was carried out in the following sequence of K-type instruments: #20, #25, #30, #35, #40, and #45 (Dentsply/Maillefer Instruments S.A., Ballaigues, Switzerland). All instruments were used along the WL.

At each instrument change, the canals were irrigated with the aid of a plastic syringe (BD Solumed, Sao Paulo, SP, Brazil) and 25 mm 30-gauge NaviTip needles (Ultradent, Indaiatuba, SP, Brazil), containing 2.5% sodium hypochlorite (Iodontec Industria e Comercio de Produtos Odontologicas Ltda., Porto Alegre, RS, Brazil) in a standard amount of 2 mL. After the preparation, the final toilet was made with 17% trisodium EDTA (Biodinamica, Ibipora, PR, Brazil) for three minutes and with agitation of #45 instrument. The canals were then washed with distilled water (Iodontosul, Industrial Odontologica do Sul LTDA, Porto Alegre, RS, Brazil) and dried with absorbent paper points (Tanari Industria Ltda., Manaus, AM, Brazil).

For the endodontic filling, the canals were filled with gutta-percha cones and AH Plus® epoxy resin-based cement (Dentsply/ Maillefer Instruments SA, Ballaigues, Switzerland), using Tagger's hybrid technique and #60 McSpadden® compactor (Dentsply/Maillefer Instruments SA, Ballaigues, Switzerland).

After filling, all samples were provisionally restored with Cimpat® restorative material (Septodont, Saint Maur des Fosses, France) and immersed for two days in a flask containing distilled water, at 37 °C and 100% relative humidity, for complete setting of the endodontic sealer.

Division of experimental groups

The teeth were divided into four experimental groups (Table 1) by the simple random sampling using Excel (Microsoft Excel, Microsoft, USA).

Post cementation and specimen preparation

The canals were cleared to prepare the space needed for the post to be cemented. The root canal filling was removed along 13 mm, leaving 3 mm of apical sealing.

In the canals of the GR and GE groups, drills from the kit with a diameter equivalent to the post to be cemented in the root canal were used. In the teeth of the GRM and GEM groups, drills from the kit with a larger number than the post to be cemented were used, thus providing a greater cementation line. The choice of the diameter of the posts was made according to the conditions of the treated canal, based on the guide ruler for selecting the posts provided by the manufacturer.

After performing the unobturation of the canals, the posts underwent the cementation protocol, following the manufacturer's recommendations. The posts were disinfected with 70% alcohol (Icarai, Sao Paulo, SP, Brazil) prior to use and subsequently dried. Single Bond Universal® adhesive was applied for 20 seconds and then dried with air jets for 5 seconds.

The posts were luted with self-adhesive cement (RelyX U200R, 3M ESPE, St. Paul, MN, USA). The resin cement was applied to the root canal with the aid of a centrix syringe (DFL, Rio de Janeiro, RJ, Brazil) with a fine metal tip. The post was inserted into the root canal and filled with cement to the most coronal portion to hermetically seal the entrance and photoactivated with the aid of an EC450 device (ECEL, Ribeirao Preto, SP, Brazil), with light intensity greater than 400 mW/cm^2, for 20 seconds, and chemical polymerization for 6 minutes.

After 15 days of cementation and storage in distilled water, the roots were sectioned perpendicularly to the long axis, and two thick slices (1.92 mm±0.32 mm) were obtained with the aid of a cutting machine (Labcut 1010, Extec Corp., Enfield, CT, USA). The slices were obtained in a standardized manner at 5 mm (cervical third), and 10 mm (middle third) away from the cervical edge of the root (Figure 1), identified, and stored in an oven at 37°C and 100% relative humidity for 7 days.

Push-out test

The specimens were placed on a stainless steel metal support with a 2 mm central hole. Given the conical shape of the posts, the load was applied in the apical-cervical direction from the apical surface, so that the post could be pushed towards the widest portion of the root canal.

The load was applied only on the post surface with a tip of approximately 1 mm in diameter coupled to the EZ-SX (Shimadzu Corp., Kyoto, Kyoto, Japan) universal testing machine. The selected load cell was 500 kg (50 N) and the loading speed was 0.5 mm/min. The values were recorded in N and displacement resistance in MPa.

To measure the area of the canal and calculate resistance, the diameter of the upper and lower circle of the canal and the thickness of the section (area of a cone trunk) were measured (15). After the push-out test, the fractured specimens were analyzed under an X20 stereomicroscope (Stemi 2000, Karl Zeiss, Germany) to determine the adhesive, cohesive, or mixed failure pattern.

Statistical analysis

The Shapiro-Wilk test was used to assess the normality of the data. One-way ANOVA test, followed by the Tukey test, and the non-parametric t-test were used to assess bond strength. The level of significance was set at 5% ($P \leq 0.05$). Statistical analysis was performed using GraphPad Prism 7 (GraphPad Software Inc., San Diego, CA, USA).

Table 1
Experimental groups

Group	n	Intraradicular post type	Drill diameter in relation to the post
GR	10	Pino Reforpost®	Equal
GRM	10	Pino Reforpost®	Bigger
GE	10	Pino Exacto®	Equal
GEM	10	Pino Exacto®	Bigger

Results

Mean values of displacement resistance (MPa) for the different experimental groups in different regions of the canal are shown in Table 2. There was a statistical difference between the groups regarding the different root positions analyzed ($P<0.05$). Among the different groups, the GE group, which employed a conical post with a diameter matching that of the prepared root canal, exhibited the most favorable outcomes compared to the other groups. It is worth noting that there was no discernible distinction between the GEM and GR groups in terms of their results. The least favorable outcome was observed in the GRM group, which utilized a cylindrical post within a root canal that had been prepared with a diameter larger than that of the post.

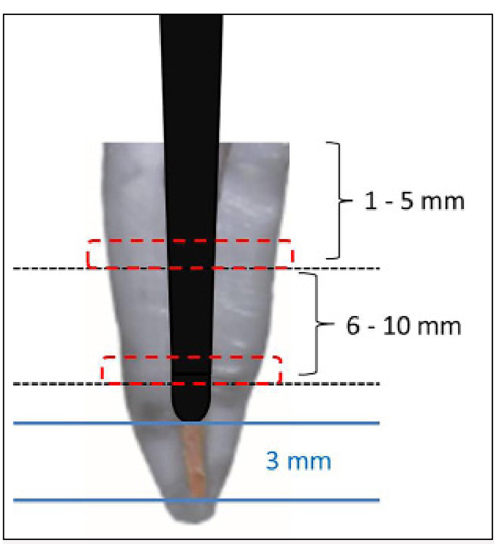

Figure 1
Schematic diagram of root slices.

The most notable findings regarding resistance to displacement were observed in the cervical third of the canal, in comparison to the middle third, when examining each group individually. However, it's worth noting that an exception was identified in the GE group, where no significant difference was observed between the two root thirds.
Graph in figure 2 show the percentage of failures in the samples in the cervical and middle thirds of the root. There was an increase in adhesive failures in the GRM and GEM groups compared to the other tested groups. Cohesive failures predominated in the GR, GE and GEM groups

Discussion

The use of fiberglass posts in weakened roots or in large root canals is a challenge, since the prefabricated post has a standardized size, and many times there is no size that allows its complete adaptation to the root canal walls, requiring thus a thick layer of cement in some regions of the canal that can cause failures in the cementation process.
Fiberglass posts are composed of longitudinal fibers surrounded by a resin-based matrix (16), which in a way favors the adhesive cementation process. Thus, resin cements with chemical, photopolymerizable, or dual polymerization mechanisms are routinely used for cementation of this type of post (17).
Shear strength depends on the degree and stability of micromechanical locking and chemical adhesion between root canal dentin, bonding agent and fiberglass post. The push-out test is based on the shear stress at the interface between the dentin and the cement, as well as between the post and the cement (18). The main advantage of push-out testing over other bonding testing methods is the ability to test a material within a dentin-surrounded canal, thus reproducing the clinical use of the material (19).
In the analysis of the adhesive union between the tested experimental groups, better results can be observed with the use of conical posts in relation to the cylindrical ones, as well as the influence of the thickness of the cementation line. In the groups in which the cementation line was less thick, there was a greater adhesive bond strength between the post and the

Table 2
Bond strength in root segments in the push-out test

Experimental Group	Root thirds		P
	Cervical	Middle	
	MPa (±SD)	MPa (±SD)	
GR	11.69Ba±(2.07)	9.17BCb±(2.27)	P<0.05
GRM	9.56Ca±(1.74)	7.02Cb±(2.28)	P<0.05
GE	16.92^{Aa}±(4.82)	12.92^{Aa}±(4.19)	P=0.062
GEM	13.58^{Ba}±(1.40)	10.53^{ABb}±(2.40)	P<0.05
P	P<0.05	P<0.05	

Means followed by different uppercase letters in the column differ significantly in the analysis of variance and means followed by different lowercase letters in the row differ significantly in the non-parametric t-tests, at a significance level of 5%.

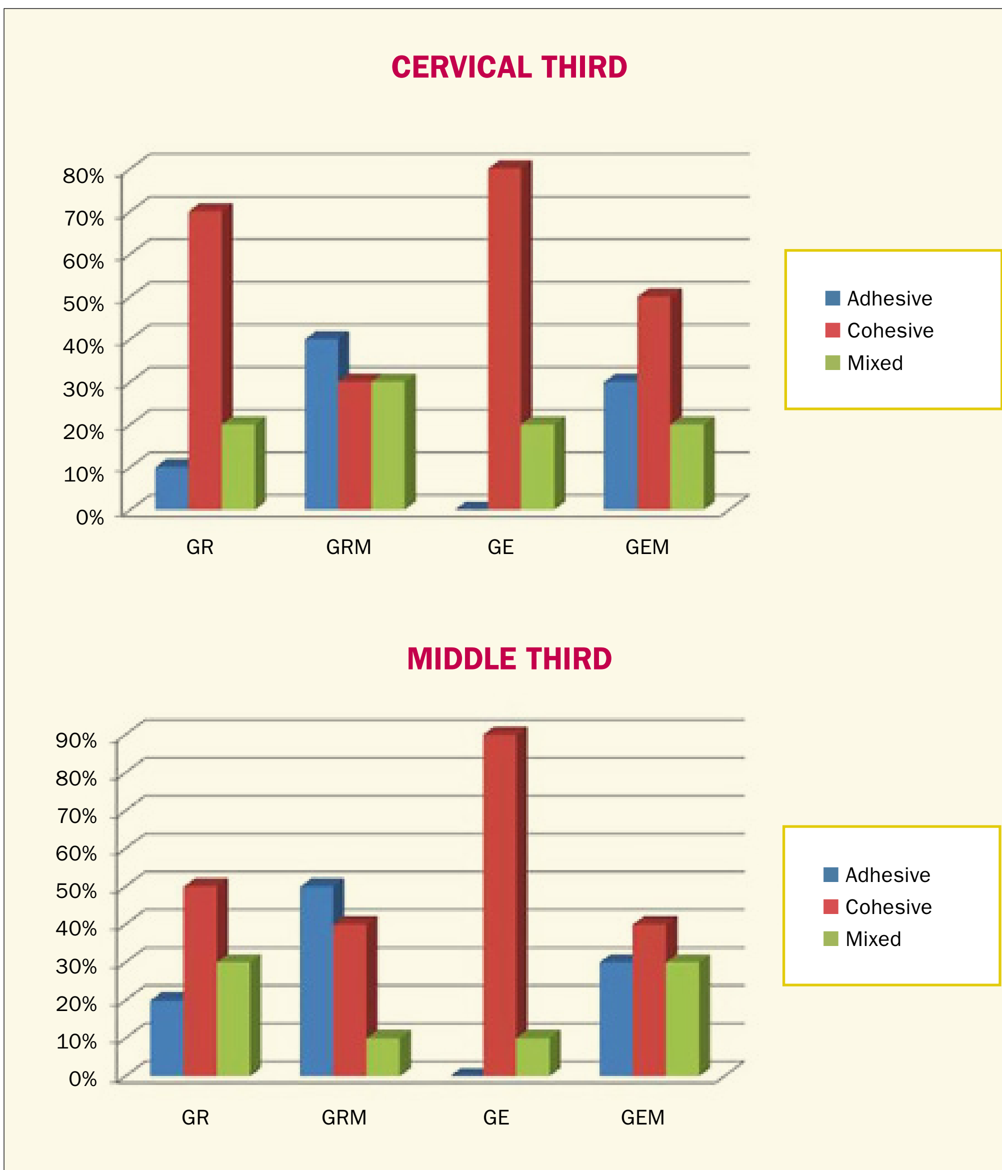

Figure 2
Failure patterns (%) after tested protocols.

dentin wall. This corroborates the statement that the bond strength of the fiberglass post to the dentin is significantly lower when the resin cement layer is thicker (20, 21). Thick layers of cement decrease bond strength, as a greater volume of cement leads to greater retraction, generating greater tension at the adhesive interface, which causes greater formation of cracks and bubbles within the root canal (22). Greater thickness, as a function of the C factor, maximizes polymerization contraction (23, 24) and results in empty spaces, and gaps (25). Well-fitting posts and thin layers of resin cement are essential to provide good adhesion to root dentin (26). However, several laboratory studies involving push-and-pull tests have reported divergent results regarding the impact of cement thickness on the bond strength to intraradicular surfaces (27-29).

In the study by Rengo et al (30), it can be observed that the volume of the post space and the volume of the post itself were considered smaller for oval posts when compared to circular posts. However, the cement volume was greater in oval posts, regardless of the level of the post space. Munhoz et al (31) also found no significant difference in the portion of the post space occupied by oval and circular posts. It is believed that selecting the type of post to be used according to the diameter of the root canal and the use of preparation drills, which are included in the manufacturer-recommended kits, may potentially provide greater control over the cement line around the post.

Analyzing the results of adhesive bonding between the thirds, a trend towards better bond strength results was observed in the cervical third compared to the middle third, which was also observed in the study by Borges et al (32). This observed difference may be due to factors such as dentin morphology and the diameter and number of dentinal tubules between the thirds. It is known that the number and diameter of dentinal tubules decreases in the cervico-apical direction. In addition to these factors, the adhesion process using resin cements depends on the formation of the hybrid layer. According to Calixto et al (33), this hybridization becomes more critical as it moves towards the apical third of the canal due to the difficulty in establishing adhesion in this region.

The resin-dentin interrelationship, an area called the hybrid layer, plays a fundamental role in micromechanical retention (34). The adhesive interface is expected to form a firm and permanent connection between the dentin and the resin cement (35). However, the formation of the hybrid layer consists of the infiltration of adhesive monomers into the collagen fiber network resulting from acid demineralization and subsequent polymerization, and is directly related to the treatment of the substrate surface (34). The hybrid layer is a highly organic interface, relatively hydrophobic and acid-fast. However, regardless of the system or material used, layer formation is not always homogeneous and stable (35).

The predominant type of failure observed in the study was cohesive, but with an increase in adhesive failures in the groups in which the root canal had a larger diameter in relation to the post. Aleisa et al (36) also found in their study more cohesive failures when the appropriate post space was created with the same drill size as the post size.

Conclusions

The adhesive bond strength of intraradicular fiberglass posts cemented was influenced by the type of post and the thickness of the cement line. The smooth conical post with a small cement line showed greater adhesive bond strength.

Clinical Relevance

The type of post and the cementation line influence intraradicular adhesion.

Conflict of Interest

The authors declares that there is no conflict of interest.

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