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Nogueira Moreira, Allyson; Silami Magalhães, Cláudia
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Original Article

Comparison of Resin Cement Insertion Techniques for Luting Fiberglass Posts

Emerson Hamilton da Silva¹, Carolina Nemesio de Barros Pereira², Bruno Daleprane³, Allyson Nogueira Moreira¹, Cláudia Silami Magalhães¹

¹Department of Restorative Dentistry, Faculty of Dentistry, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil.

²Department of Dentistry, Faculdade de Estudos Administrativos, Belo Horizonte, MG, Brazil.

³Private Practice, Vila Velha, ES, Brazil.

Author to whom correspondence should be addressed: Cláudia Silami Magalhães. Department of Restorative Dentistry, Faculty of Dentistry, UFMG. Avenida Antônio Carlos, 6627. Pampulha, Belo Horizonte, MG, Brazil. 31270-010. Phone: +55 (31) 3409-2456. E-mail: silamics@yahoo.com.

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Abstract

Objective: To evaluate the effect of two insertion techniques of self-adhesive dual resin cement on the bond strength of fiberglass posts in different portions of the root. The homogeneity of the cement layer along the root canal was also evaluated. **Material and Methods:** The root canals of 28 bovine teeth were instrumented, filled, and 14mm-space was prepared for luting fiberglass posts (Reforpost #3, Angelus), maintaining 4mm of apical sealing. The roots were randomly allocated into two groups according to the cement insertion technique (n=14): Lentulo Drill (Dentsply/Maillefer) or Centrix syringe (Dentsply). The posts were fixed with self-adhesive resin cement (RelyX U200, 3M ESPE). After 7 days, the roots were cross-sectioned to obtain three 1.0-mm-thick samples of each third of the space prepared for the post. Two samples of each third were subjected to push-out test (0.5 mm/min; 200N) and the third specimen was used for the analysis of cementation layer homogeneity. Images of specimens (40x magnification) were assessed and classified by two calibrated examiners (Kappa = 0.87) according to the presence or absence of voids and misfit. Data were analyzed by two-way ANOVA and Pearson Chi-Square test. **Results:** There was no statistically significant effect of insertion technique (p=0.278) or post-space thirds (p = 0.521) on bond strength of fiberglass posts. Chi-Square test showed that cement insertion with the Lentulo drill produced more cement voids than Centrix syringe (p = 0.023). **Conclusion:** The cement insertion technique did not influence bond strength of fiberglass posts in bovine root dentin. The use of Centrix syringe for cement insertion is preferred since it produced more homogenous cement layer.

Keywords: Resin Cements; Post and Core Technique; Dentin-Bonding Agents.

Introduction

Luting of fiberglass posts with resin cement into the root canal supports the rehabilitation of endodontically treated teeth as it promotes and retains union between the prosthetic crown and the rest of the dental structure [1]. Conventional resin cements, in association with etch-and-rinse or self-etch adhesive systems, are typically used for luting posts. However, multiple steps application techniques are complex and sensitive, and can compromise the quality of the union, especially in the deeper areas of the root canal [2-4].

Self-adhesive resin cements have been marketed to simplify clinical procedures and overcome the technique sensitivity of multistep systems. They do not require etching of the post space dentine or the use of adhesive systems [2-4]. The bond strength of self-adhesive cements appears to be superior to that of conventional cements, and does not vary according to the depth of the canal [5]. Root canal depth can prevent access for operatory instruments and reduce light transmission through the canal [6,7]. Substrate condition, difficulty of access for the instrumentation, light activation, and also the technique sensitivity of adhesive systems application have been shown to be associated with lower bond strength in the canal apical third in some studies [8-10], but not in others [4,11,12].

In addition, the bond strength of the dentin/cement/post system is influenced by polymerization shrinkage flow and the quality of cementation line. Besides, the homogeneity of resin cement layer can be influenced by the presence of remains of filling materials on the canal walls, smear layer, formation of voids within the cement and adhesive interfaces. Poor cement layer homogeneity can also reduce bond durability [2,9,13].

The insertion technique used to place the cement into the post space seemed to be important factor that may affect the complete setting of fiber posts and, consequently, influence the occurrence of post debonding and increase the possibility of failure of restorative procedure. The most common application methods are syringe needle tips, a lentulo-type drill, a straight-edge explorer, and the insertion of the cement with the post itself [14]. According to some manufacturer's instructions, self-adhesive dual-cure resin cement should be taken into the root canal by applying a thin layer of cement over the post before setting it in position or alternatively by using syringe needle tips. The findings of a systematic review show that applying the cement into the root canal increased post retention when compared with the technique where the cement is also applied around the post. In addition, as cement application around the post is usually carried out with a spatula, this may not be a reliable procedure to prevent incorporation of voids [15]. The use of lentulo drills or syringes for cement insertion could reduce the presence of voids and bubbles that could affect correct cementation of fiberglass posts [16-19]. In fact, when using the lentulo drill, caution is advised to avoid premature cement polymerization that compromises the proper insertion of the post [14,16].

Further experiments are needed to disclose which technique should be more suitable for the insertion of a particular self-adhesive resin cement into the post space preparation. The aim of this study was to evaluate two insertion techniques of self-adhesive dual resin cement for luting

fiberglass posts. The primary null hypothesis is that the insertion cement technique does not influence bond strength of fiberglass post to different portions of the root canal; and the secondary null hypothesis that the homogeneity of cement layer along the root canal is not influenced by the insertion technique.

Material and Methods

Study Design

This in vitro study was designed in accordance with a randomized complete block model. The factors investigated were the resin cement insertion techniques (Lentulo drill and Centrix syringe) and the portions of the post space preparation (coronal, middle, and apical). The experimental units comprised 28 bovine teeth roots divided into two randomized complete blocks with seven repetition of each experimental condition ($n=14$). The dependent variable was the bond strength (MPa) of posts cemented to the root canal, which was measured in the coronal, middle, and apical thirds. The cement layer was observed in 40x magnification images to check for the presence of voids and misfit.

Sampling

The total sample size ($n=28$) was determined using an estimated effect size of 0.25, a type I error of 0.05, and a power of 0.80 (GPower 3.1.7, Franz Faul, University Kiel, Germany). Twenty-eight extracted lower anterior bovine teeth with similar dimensions were selected, cleaned, and stored in a 0.9% saline solution for up to 3 months. The crown of each tooth was sectioned at the cement-enamel junction with a diamond disk (KG Sorensen, Cotia, SP, Brazil) using a low-speed hand piece under air/water irrigation; the root length was standardized at 18.0 mm.

Root Canal Treatment and Preparation

Root canal treatment was performed by a single operator using rotary instruments (Xmart, Dentsply, Petrópolis, RJ, Brazil) with Easy Pro-design files (Easy, Belo Horizonte, MG, Brazil) and irrigation with a 2.5% sodium hypochlorite solution. The canals were then irrigated with EDTA solution (Biodinâmica, Ibioporã, PR, Brazil) followed by thermoplastic obturation using Thermo Pack WL (Easy, Belo Horizonte, MG, Brazil), gutta-percha cones, and the epoxy-based resin cement AH Plus (Dentsply, Petrópolis, RJ, Brazil). The roots were stored in distilled water at 37°C for 7 days. The post space preparation was performed using Largo burs #2 to #5, as recommended by the post manufacturer (Reforpost #3, Angelus Ind., Londrina, PR, Brazil). The post-space length was 14 mm, leaving 4 mm of apical gutta-percha filling material.

Random Group Assignment

The roots were randomly divided into two groups ($n=14$). In Group L, Lentulo drill was used to insert the resin cement into the canal, while in Group C, Centrix syringe was used. The self-

adhesive resin cement Rely X U200 (3M ESPE, St Paul, MN, USA) was used in both groups (Table 1).

Table 1. Resin cement used in the study: composition, lot and manufacturer.

Resin Cement	Composition	Manufacturer
RelyX™ U200 (U200)	BASE: fiberglass, phosphoric acid esters, methacrylate, triethylene glycol dimethacrylate, silane-treated silica, sodium persulfate CATALYST: fiberglass, replacement dimethacrylate, silica treated with silane, ptoluenesulfonate, sodium calcium hydroxide Lot: 492217	3M ESPE

Cementation of Posts

The roots were positioned with their long axis perpendicular to the ground on a base of composite resin (Z100, 3M ESPE, St Paul, MN, USA) in order to provide support. Root surfaces were covered with black adhesive tape to protect them from external light interference. Each post was cleaned with 37% phosphoric acid (37 Condac, FGM, Joiville, SC, Brazil) for 30 seconds, followed by rinsing with water for 60 seconds and drying under compressed air. Any other surface treatment was performed on the posts.

The canals were washed with water and dried using absorbent paper points. RelyX U200 self-adhesive resin cement was hand mixed and inserted into the canal using either the Lentulo drill # 30 (Dentsply/Maillefer) with a micro motor at low-speed, or the Centrix syringe with a needle tip (Dentsply). The posts were then inserted and held in position using an adapted parallelometer with a static load of 10N while photoactivation with a light emitting diode (Bluephase, Ivoclar Vivadent, Liechtensten, 1340mW/cm²) for 40 seconds. After cementation, specimens were stored in humid environment at 37°C for 7 days before preparation for mechanical testing.

Preparation for the Push-out Test

The roots were sectioned perpendicular to the long axis using a precision saw (Isomet 1000; Buehler, Lake Bluff, IL, USA) to obtain three 1.0-mm-thick samples of each third of the space prepared for the post. The coronal, medium and apical thirds were defined respectively 2.0mm, 6.0mm and 10.0mm from the enamel-dentine-junction. The thickness of two specimens was checked using a digital caliper (Mitutoyo Series 500, Mitutoyo Sul Americana, Suzano, SP, Brazil) and then, the specimens were positioned on a metal base with a central hole of 2.0 mm in diameter. The third specimen was used for the analysis of cementation layer homogeneity. The push-out test was performed in a universal testing machine (EMIC DL 3000; EMIC, São José dos Pinhais, PR, Brazil) with a 200N load cell (CCE200N, EMIC) at a speed of 0.5 mm/min. A plunger with a 1.0-mm diameter tip was attached to the top crosshead of testing machine and positioned on specimen, touching the post. The load was applied from the most apical surface, in coronal direction. The maximum extrusion load for displacing the post within the canal was recorded in N (Tesc version 3.05, EMIC).

To express the bond strength, in MPa, the load obtained in N was divided by the area (A) of the bonded interface, calculated by following equation:

$$A = 2\pi rh$$

Where π is a constant, 3.14, r is the radius of the post (0.75 mm), and h is the slice thickness (in mm).

Analysis of Cementation Layer

The third specimen obtained by sectioning each root third was observed and photographed using a stereomicroscope (Zeiss, Jena, Oberkochen, Germany) at 40x magnification. Two calibrated examiners ($\kappa = 0.87$) independently evaluated the cement layer in each specimen by checking for presence or absence of voids and misfit. Disagreements between the examiners were solved by consensus.

Statistical Analysis

The homogeneity of variances was evaluated using Levene's test ($p = 0.994$) and the data normal distribution was analyzed by Kolmogorov-Smirnov test ($p = 0.200$). Two-way ANOVA verified the effect of study factors (cement insertion technique and post space third) on bond strength. Pearson Chi-Square test was used for analysis of the presence of voids and misfit of cement layer. The statistical software SPSS 17.1 (SPSS Inc., Chicago, IL, USA) was used for all tests. The level of significance was set at 5%.

Results

The mean bond strength in each root region for Lentulo drill and Centrix syringe insertion techniques is presented in Table 2. Insertion technique had no statistically significant effect on push-out bond strength ($p = 0.278$), and there were no statistically significant differences among the post space portions ($p = 0.521$).

Table 2. Means (Standard Deviations) of push-out bond strength according to insertion techniques and root regions (MPa) (n=14).

Post Space Third	Insertion Techniques	
	Lentulo Drill	Centrix Syringe
Coronal	10.57 (3.11) ^{Aa}	10.30 (3.21) ^{Aa}
Middle	9.35 (3.53) ^{Aa}	9.84 (3.75) ^{Aa}
Apical	9.44 (3.43) ^{Aa}	11.61 (2.93) ^{Aa}

Values followed by the same capital letters in columns and the same superscripted lower case letters in rows did not differ statistically ($p > 0.05$).

Results of Pearson Chi-Square test that analyzed the cement layer for the presence of voids and misfit are presented in Figures 1 and 2, respectively. Group L had more voids than Group C ($p = 0.016$). In both groups, the presence of misfit was only observed in the apical thirds. There was a statistically significant difference in the presence of misfit in the apical thirds between groups C and L ($p = 0.031$). In Group C, there was no statistically significant difference along the canal for both the

presence of misfit ($p=0.359$) and presence of voids ($p=0.235$). In Group L, there was no difference in the presence of voids ($p=0.311$) but there was a statistically significant difference in the presence of misfit ($p=0.012$). Posts were absent in the apical thirds of four specimens in Group L and two specimens in Group C, that were not considered in the statistical analysis for voids and misfit. Figure 3 shows representative images of the parameters evaluated in resin cement layer.

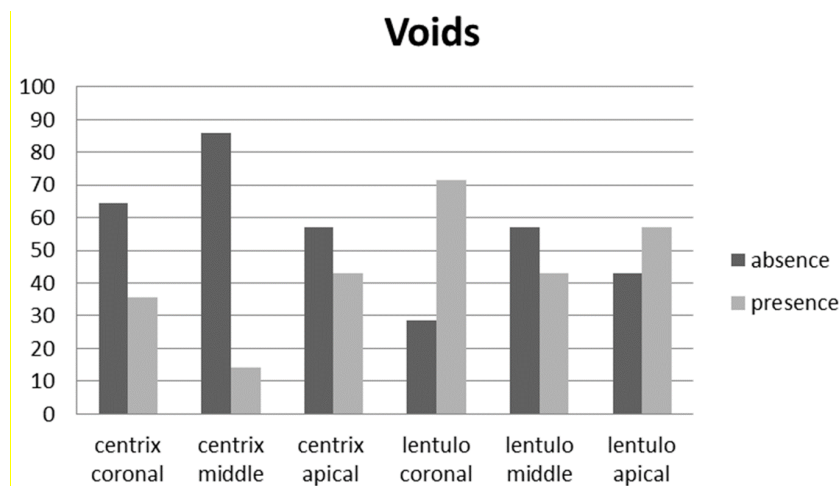


Figure 1. Results of cement layer evaluation for the presence of voids.

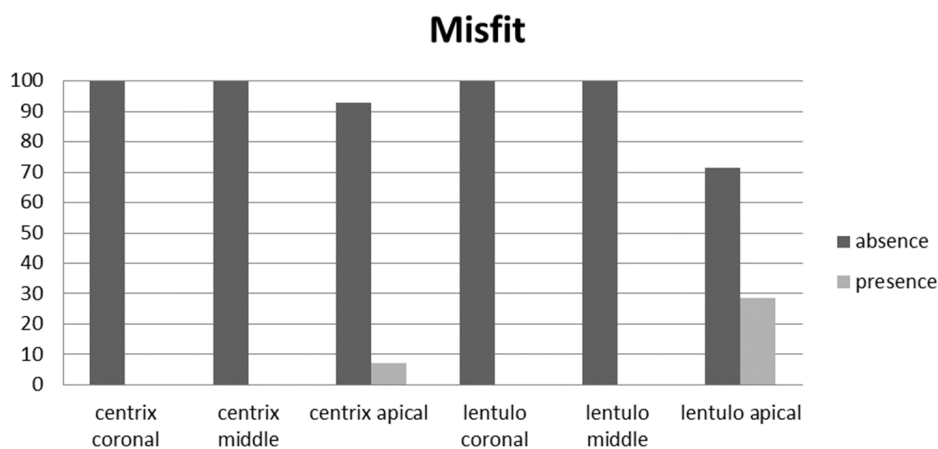


Figure 2. Results of cement layer evaluation for the presence of misfit.

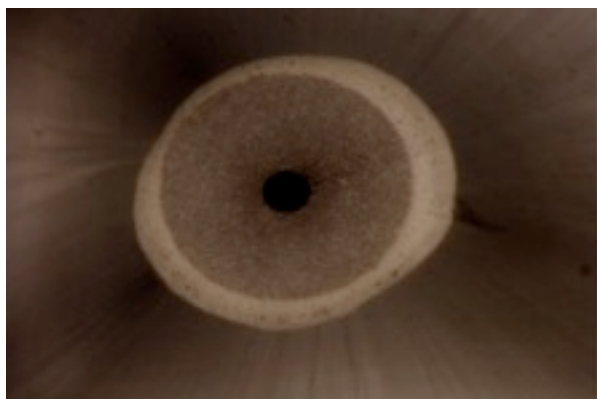


Figure 3A. Homogeneous cement layer.



Figure 3B. Presence of void.

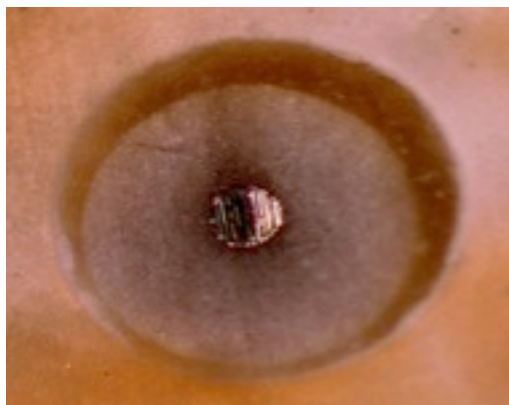


Figure 3C. Presence of misfit.

Discussion

This study compared the effect of two cement insertion techniques on the push-out bond strength and the homogeneity of a self-adhesive dual cure cement layer along the post space preparation. The primary null hypothesis tested was accepted, as there was no significant effect of the cement insertion technique on the bond strength of fiberglass posts along the root canal. However, the secondary null hypothesis was rejected since the Lentulo drill technique resulted in the formation of a cement layer with more voids and misfit.

The bond strength of cement/post/dentin interface can be influenced by resin cement flowability, cement distribution in coronal, middle, and apical thirds of the root, the anatomy of the canal, and the orientation of the dentinal tubules [5,13,20-23]. In the present study, there was no significant difference in the bond strength between the Centrix syringe or Lentulo drill technique, corroborating the findings of previous studies [14,17-19]. The use of a Lentulo drill improved the distribution of resin cement along the root canal, with a more uniform layer and that the greater the level of cement homogeneity, the more retention of the intraradicular post [17]. It was suggested that where the cement layer is more homogeneous, an increase in the cement's degree of conversion would occur in the long term. In fact, the degree of conversion of the resin cement can increase after several months in the root canal environment [13,24]. However, if a dual-cure resin was the selected cementing material, the major recommendation is to avoid partial polymerisation before the adequate post seat [18]. Lentulo drill and Centrix syringe are convenient to use, as they are relatively inexpensive and ordinary techniques for the clinician. Moreover, the use of an application aid needs some training [16].

An innovative delivery automix system, claimed to provide better manipulative results, produced similar results in terms of bond strength and bubbles in comparison with that of hand mixing. In addition, the bond strength of posts to root canal cemented with self-adhesive resin cements was improved when applied with a Centrix syringe, compared to manufacturer's instructions, irrespective of the root third [9]. Despite improved delivery systems have recently been developed in order to mix and provide, according to the manufacturers, a consistent bubble-free paste-paste mixture, the use of an auto mixture syringe have not been shown to differ significantly

from different applications and handling techniques (manual Lentulo drill, Centrix syringe and Automix) [19].

Resin cement insertion techniques can lead to the formation of voids within the cement [9,16,17]. These imperfections may reduce the cement ability to retain the fiberglass post in root canal, consequently influencing the longevity of the restoration [16]. In this study, analysis of cementation layer showed that cement insertion with the Lentulo drill produced significantly more voids and misfit than the Centrix syringe. These results suggest that the rotational movement of Lentulo drill caused air to become trapped in the cement, influencing the homogeneity of the cement layer [16]. The misfit of cement layer was only observed in the apical third for both insertion techniques but was greater for Lentulo drill. The frequency of post absence in the apical portion of the post space preparation was 7.14% in Lentulo drill group and 3.57% in Centrix group suggesting that the increase of internal energy promoted by the rotary motion of the drill may speed up polymerization and prevent the complete insertion of the post [16].

Although both cement insertion techniques were comparable in terms of bond strength, the incomplete post insertion could support the manufacturer's instruction to not use Lentulo drill for insertion of RelyX U200. Analysis of cement layer suggested that insertion with the Centrix syringe generates a more homogeneous cement layer when properly executed. Prior to insertion in the root canal, the syringe plunger must be pressed to remove the air contained in the end of the needle, at the applicator tip. It is necessary to ensure correct timing between the injection of the material and the withdrawal of the syringe out of the canal in order to prevent voids and cement misfit [14,17].

Bond strengths in the present study were not significantly affected by the post space portions. This result confirms previous studies [12,13,18,20] that observed no influence of root canal region on fibre post retention. Recording no significant differences in microtensile bond strength values between coronal, middle and apical portions of the post space suggests that retentive strength may be related more to the area of solid dentine than to the density of the dentinal tubules [18].

This *in vitro* analysis attempted simulates clinical situations but some procedural modifications were made to standardize study parameters. Thus, bovine teeth were used as alternative substrate for the tests and it has been reported in the literature [5,12,17,22,24].

Using human or bovine teeth in the studies seems not influence the results and this finding can be considered relevant because the use of extracted human teeth, particularly single-root anterior teeth, is increasingly difficult [15].

Although there was a low percentage of post absence and cement layer misfit in the apical portion of the post space preparation, it did not influence the bond strength of fiberglass posts to root dentin. However, this study was performed under dry conditions and further studies using thermal and mechanical aging could be useful to simulate the long-term influence of the insertion techniques on self-adhesive cement performance of fiber posts.

Conclusion

The insertion technique of a particular self-adhesive dual resin cement did not influence the bond strength of fiberglass posts to bovine root dentin. The use of commercial syringe needle tips to insert hand-mixed cement should be preferable as facilitates the formation of more homogeneous cement layer.

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