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Influence of post pattern and resin cement curing mode on the retention of glass fibre posts

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Abstract

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Aim To evaluate the influence of post design and roughness and cement system (dual- or self-cured) on the retention of glass fibre posts.

Methodology Two tapered and smooth posts (Exacto Cônico No. 2 and White Post No. 1) and two parallel-sided and serrated posts (Fibrekor 1.25 mm and Reforpost No. 2) were adhesively luted with two different resin cements – a dual-cured (Rely-X ARC) and a self-cured (Cement Post) – in 40 single-rooted teeth. The teeth were divided into eight experimental groups (n = 5): PFD – Parallel-serrated-Fibrekor/dual-cured; PRD – Parallel-serrated-Reforpost/dual-cured; TED – Tapered-smooth-Exacto Cônico/dual-cured; TWD – Tapered-smooth-White Post/dual-cured; PFS – Parallel-serrated-Fibrekor/self-cured; PRS – Parallel-serrated-Reforpost/self-cured; TES – Tapered-smooth-Exacto Cônico/self-cured; TWS – Tapered-smooth-White Post/self-cured. The specimens were submitted to a pull-out test at a crosshead speed of 0.5 mm min^{-1}. Data were analysed using analysis of variance and Bonferroni's multiple comparison test (α = 0.05).

Results Pull-out results (MPa) were: PFD = 8.13 (±1.71); PRD = 8.30 (±0.46); TED = 8.68 (±1.71); TWD = 9.35 (±1.99); PFS = 8.54 (±2.23); PRS = 7.09 (±1.96); TES = 8.27 (±3.92); TWS = 7.57 (±2.35). No statistical significant difference was detected for posts and cement factors and their interaction.

Conclusions The retention of glass fibre posts was not affected by post design or surface roughness nor by resin cement-curing mode. These results imply that the choice for serrated posts and self-cured cements is not related to an improvement in retention.

Keywords: cements, design, posts, retention, roughness.

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Introduction

Carbon fibre posts were introduced in the early 1990s (Duret *et al.*1990), making the substitution of the traditional cast post and core and the pre-fabricated metallic posts possible. Fibre posts have several advantages, such as ease of placement, adhesion to the resin cement and to the composite core, and an elastic modulus similar to the tooth structure, which may reduce stress concentration along the root canals (Asmussen *et al.* 1999, Christensen 2004). For an aesthetic reason, a new generation of posts such as zirconia and glass fibre posts are an alternative to carbon fibre posts, with excellent clinical performance (Grandini *et al.* 2005a).

Some studies have shown that the major cause of failure with fibre posts is loss of retention (Ferrari *et al.* 2000, Cagidiaco *et al.* 2008, Signore *et al.* 2009). Post retention can be affected by several factors such as the adhesive system, the resin cement and the post patterns. The literature presents conflicting results concerning which adhesive system would be best (light-cured or self-cured) to hybridize the root canal

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dentine before post cementation (Mallmann *et al.* 2005, Valandro *et al.* 2005). In any case, bonding to root canal dentine seems to be a critical and case-sensitive event (Lopes *et al.* 2004).

It has been demonstrated that the light exposure demanded to start the polymerization reaction on dual-cured cements increases the velocity of the polymerization, leading to higher stresses along the cavity walls, when compared to self-cured cements (Kinomoto *et al.* 1999). With regard to the type of resin cement employed on post cementation, Bouillaguet *et al.* (2003) showed higher values of bond strength for self-cured resin cements compared to the dual-cured ones. This result is not in accordance with Bitter *et al.* (2006), whose results indicated higher bond strengths for dual-cured cements. Besides, the high cavity configuration factor calculated for root canal dentine (Tay *et al.* 2005) could contribute to gap formation along the cement–dentine interface, because there is almost no free area to compensate the polymerization shrinkage. Therefore, it is also important that the post fits well to the prepared root canal to achieve thin layers of cement and consequently to avoid higher polymerization stress as well as voids and bubbles (Grandini *et al.* 2005b).

It has also been reported that the post design could influence its retentive capability, at least when metallic and zirconia posts are used (Torbjörner *et al.* 1995, Sahafi *et al.* 2004). In spite of the smaller compromising of the healthy tooth structure for tapered posts, those previous studies revealed that parallel-sided posts have superior retention when compared to tapered ones. Emphasizing this, in a retrospective clinical study (Signore *et al.* 2009), tapered posts had a higher failure rate than parallel posts, although there was no statistically significant difference between them. In contrast, Naumann *et al.* (2005) reported a failure rate for parallel posts three times higher than for tapered posts.

Another aspect that could influence post retention is its superficial roughness, which could be characterized by micro or macroretention. Regarding superficial macroretention of the serrated posts, some authors (Peters *et al.* 2007) reported that their presence can lead to an improvement in retention. Whereas micro retention can be achieved using superficial treatment of the posts, such as airborne-particle abrasion. However, this procedure did not seem to increase the bond strength values (Soares *et al.* 2008).

Recently, several types of resin cements and glass fibre posts have been developed, with varied form-congruence and surface roughness. Because there are few studies and no consensus about the influence of the post design and its surface roughness and of the resin cement's curing mode on the retentive capability of glass fibre posts, additional studies should be developed.

The null hypotheses tested in this study were (i) retention of glass fibre posts is not influenced by the cure mode of the resin cement; (ii) there are no differences between parallel-sided and tapered-luted glass fibre posts with regard to retention; (iii) post retention is not influenced by its surface roughness – serrated or smooth.

Materials and methods

Forty sound single-rooted human teeth (maxillary incisors and mandibular premolars) recently extracted for periodontal or orthodontics reasons were selected. After cleaning and storing them in an aqueous solution of 1% chloramine, the teeth were washed and sectioned below the buccal cementoenamel junction with a low speed diamond disc (KG Sorensen, São Paulo, SP, Brazil). The apical region was also removed to standardize the root length at 12 mm. Teeth with coronal canal diameter larger than 1.5 mm were discarded and replaced. A digital caliper (Mitutoyo, São Paulo, SP, Brazil) was used to measure the canal diameter and tooth length.

The roots canals were enlarged under irrigation with 2.5% sodium hypochlorite, at a working length of 2 mm from the apex, using Largo drills No. 1 and No. 2 (Dentsply Maillefer, Ballaigues, Switzerland). The root apices were sealed externally with a composite resin (Z100; 3M ESPE, St. Paul, MN, USA) and horizontal grooves were prepared in the external root surfaces with a No. 2200 diamond bur (KG Sorensen). The roots were then coated with black cosmetic varnish to avoid the propagation of light through the external roots surfaces.

To create the post space and standardize the root canal diameter, the roots canals were prepared with the appropriate drill supplied by the manufacturer using a slow speed handpiece and following the manufacturer's instructions a 10-mm-deep preparation was created. Two different resin cements were used: a dual-cured (Rely-X ARC/3M ESPE) and a self-cured (Cement Post/Angelus, Londrina, PR, Brazil). The glass fibre posts tested in the present study, with their specifications, are described in Table 1 and the experimental groups (n = 5) are described in Table 2.

Table 1 Glass fibre posts investigated

Glass fibre posts	Diameter (mm)	Design	Surface roughness
Fibrekor (Jeneric Pentron, Wallingford, CT, USA)	1.25	Parallel	Serrated
Reforpost No. 2 (Angelus)	1.30		
Exacto Cônico No. 2 (Angelus)	1.40[a]	Tapered	Smooth
White Post DC No. 1 (FGM)	1.23[b]		

[a]Post medial portion diameter (coronal diameter = 1.4 mm; apex diameter = 0.9 mm).
[b]Post medial portion diameter (coronal diameter = 1.6 mm; apex diameter = 0.85 mm).

Table 2 Experimental groups

Group	Glass fibre post	Resin cement
PFD	Parallel-serrated (Fibrekor)	Dual-cured (Rely-X ARC)
PRD	Parallel-serrated (Reforpost)	
TED	Tapered-smooth (Exacto Cônico)	
TWD	Tapered-smooth (White Post DC)	
PFS	Parallel-serrated (Fibrekor)	Self-cured (Cement Post)
PRS	Parallel-serrated (Reforpost)	
TES	Tapered-smooth (Exacto Cônico)	
TWS	Tapered-smooth (White Post DC)	

Prior to cementation, all posts were silanized (Soares *et al.* 2008) with two coats of Ceramic Primer (3M ESPE). The roots canals walls were acid-etched for 15 s with 37% phosphoric acid (Condac 37; FGM, Joinville, SC, Brazil), rinsed with distilled water for 30 s and blot dried with paper points (Dentsply Maillefer, Petrópolis, RJ, Brazil). Adper Single Bond adhesive system (3M ESPE) was applied with a microbrush (Cavibrush #1; FGM) following the manufacturer's instructions and light-cured [800 mW cm^{-2} (20 $s)^{-1}$] using a halogen unit (Optilux 501; SDS Kerr Corp., Orange, CA, USA). The irradiance was monitored using a radiometer (model 100; Demetron Inc., Danbury, CT, USA).

The cements were manipulated according to the manufacturer's instructions, and a syringe (Centrix Incorp, Shelton, CT, USA) was used to fill the post space cement. Finally, the posts were inserted into the canals and the cement excesses removed. Rely-X ARC was then light-cured for 40 s (800 mW cm^{-2}).

The specimens were embedded with epoxy resin in PVC cylinders, with the long axes parallel to the cylinder walls. To release bond stresses, the specimens were stored in distilled water for 24 h, prior to the experimental test. The pull-out test (Prisco *et al.* 2003, Le Bell *et al.* 2004, Sahafi *et al.* 2004, Valandro *et al.* 2005) was performed in a universal test machine (Versat 500; Panambra, São Paulo, Brazil) at a crosshead speed of 0.5 mm min^{-1}. The schematic set-up of the test is presented in Fig. 1. Specimens were analysed by an optical microscope (magnification ×45; Coleman Santo André, SP, Brazil) to verify the type of failures. Data were subjected to two-way ANOVA and

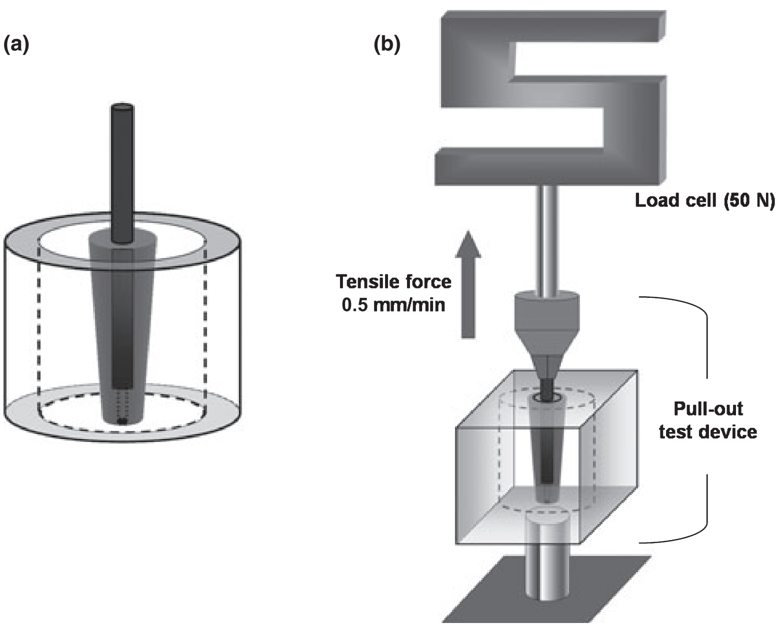

Figure 1 Schematic set-up of the test. (a) An embedded specimen; (b) the specimen positioned in the pull-out test device.

Table 3 Pull-out results for the dual cement's groups

Groups	Mean ± SD (MPa)
PFD	8.13 ± 1.71
PRD	8.30 ± 0.46
TED	8.68 ± 1.71
TWD	9.35 ± 1.99

PFD, Parallel-serrated-Fibrekor/dual-cured; PRD, Parallel-serrated-Reforpost/dual-cured; TED, Tapered-smooth-Exacto Cônico/dual-cured; TWD, Tapered-smooth-White Post/dual-cured.

Table 4 Pull-out results for the self-cured cement's groups

Groups	Mean ± SD (MPa)
PFS	8.54 ± 2.23
PRS	7.09 ± 1.96
TES	8.27 ± 3.92
TWS	7.57 ± 2.35

PFS, Parallel-serrated-Fibrekor/self-cured; PRS, Parallel-serrated-Reforpost/self-cured; TES, Tapered-smooth-Exacto Cônico/self-cured; TWS, Tapered-smooth-White Post/self-cured.

Bonferroni's multiple comparison test ($\alpha = 0.05$) using a statistical software (Statgraphics Plus 5.1; Manugistic Inc., Rockville, MD, USA).

Results

There was no significant difference, neither for the independent factors, fibre post ($P = 0.84$) and resin cement ($P = 0.30$), nor for their interaction ($P = 0.71$). The pull-out means and standard deviations (MPa) are described in Tables 3 and 4. Analysis of the specimens under an optical microscope revealed that some areas of the posts showed failures between the post and the resin cement, whilst others showed failures between the resin cement and the dentine surface. For serrated posts, a continuous cement layer was frequently found; whilst for smooth posts, an irregular cement layer was shown, with some free superficial areas.

Discussion

Even though the concept that endodontic posts could reinforce the tooth structure, their main objective is to provide retention to the core material without inducing internal root stresses (Prisco *et al.* 2003). Although fibre posts are widely used in restorative dentistry, clinical studies demonstrate that the most common failure of fibre post is debonding (Ferrari *et al.* 2000, Cagidiaco *et al.* 2008, Signore *et al.* 2009), confirming that bonding to intraradicular dentine seems to be more critical than to external superficial dentine (Lopes *et al.* 2004). The adhesive clinical protocol for the post luting procedure is not agreed, probably because of the different types of variables involved in adhesion to root canal such as surface treatments of the dentine and the post, and different materials (adhesive systems, posts and cements), which could be used for that procedure (Monticelli *et al.* 2008a,b). In addition, different methodologies can lead to different results (Goracci *et al.* 2007).

It should be explained that, in contrast to the clinical situation, in the present study, the root canals were not filled with sealer and gutta-percha (Valandro *et al.* 2005, Kremeier *et al.* 2008), avoiding a confounding factor, as speculated by others authors (Kremeier *et al.* 2008).

With regard to resin cements tested, it could be expected that the higher velocity of polymerization of dual-cured materials, when compared to chemically cured, could prejudice the bond strength to the dentine, because the material could not flow to relieve polymerization stress (Feilzer *et al.* 1993). Emphasizing this, higher values of bond strength were reached by self-cured cements when compared to dual-cured cements (Bouillaguet *et al.* 2003, Huber *et al.* 2007). However, in the present study, the results did not differ for both cements tested, self and dual-cured. In contrast, Bitter *et al.* (2006) found higher bond strengths for dual-cured cements. These authors also questioned the clinical relevance of the differences between the dual- and self-cured cements, as they did not exceeded 1.5 MPa.

It should be considered that the adhesion between resin cements and glass fibre posts is very difficult to achieve because not only the monomers of the composite resin luting cements cannot penetrate into the highly cross-linked polymer matrix of the fibre post, but also there is not enough free monomers in the polymer matrix of the posts to establish adhesion between posts and cements (Vallittu *et al.* 1997, Le Bell *et al.* 2004). It could be hypothesized that other factors, such as the mechanical interlocking between the surface of the post and the resin cement (i.e. the superficial characteristics of the posts – serrated or smooth and/or surface treatments of the posts), are important for the resistance to dislodgment of the glass fibre posts (Le Bell *et al.* 2004, Balbosh & Kern 2006, Peters *et al.* 2007). In the present investigation, the surface treatments of the posts were not tested. With regard to posts macroretentions, the glass fibre posts with the serrated surface did not lead to a superior retention when compared with those that present a smooth surface without any superficial macroretention. An interesting aspect could be observed on the surface of the posts: a continuous cement layer was found for both serrated posts, whilst an irregular cement layer was shown for the smooth ones, with some free superficial areas (Fig. 1). This fact could be explained by the superficial macroretentions of the serrated posts investigated, indicating a higher mechanical interlocking between cement and these types of posts.

Some authors also suggested that parallel-sided posts demonstrated superior retention when compared to tapered ones (Torbjörner *et al.* 1995, Sahafi *et al.* 2004). In retrospective clinical studies (Naumann *et al.* 2005, Signore *et al.* 2009), no significant difference between parallel and tapered posts has been found. In fact, sometimes these studies show better results with parallel posts (Naumann *et al.* 2005) or with tapered ones (Signore *et al.* 2009), although without any statistical significance. In the present study, no significant difference between those designs for the glass fibre posts tested was found. It seems that some superficial treatment carried out by posts manufactures' could improve the interaction between the posts and the cement, so that the design and roughness became secondary for the retention.

It is important to comment that the different adhesion areas determined by the different diameters and shapes of the teeth canals and posts used in this study could influence the results. However, the canals were prepared with the bur indicated by each post manufacturer, whose diameter is quite similar to the post diameter, leading to a thin cement layer. This procedure not only made it possible to establish the adhesion area (fundamental for expressing the stress values) but also permitted a similar cement layer thickness for all groups. Although the cement layer thickness was not measured in this study, it could be speculated that these small differences did not interfere with the bond strength results, as there was no significant difference between the groups.

Taking into account the limitations of this laboratory study, it can be hypothesized that the retention of glass fibre posts might not be influenced by post patterns (design and roughness) or by resin cements with different curing modes.

Conclusion

All null hypotheses were accepted. So, the following can be concluded: (i) the cure mode of the cements did not increase the values of the bond strength; (ii) nor the post design, neither the surface roughness were determinant factors for the retention.

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