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Effect of periodontal disease on the bond strength of fiber post cemented with different adhesive systems and resin luting agents

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Abstract

The objective of the present study was to determine the effect periodontal disease on the bond strength of fiberglass posts, different adhesive systems and resin cements. Ninety human maxillary central incisors roots extracted due to periodontal disease or prosthetic reasons were endodontically treated and divided into six experimental groups: NPD-ARC – no periodontal disease/RelyX ARC and Adper Single Bond 2; NPD-PF – no periodontal disease/Panavia F and ED Primer; NPD-U – no periodontal disease/RelyX U100; PD-ARC – periodontal disease/RelyX ARC and Adper Single Bond 2; PD-PF – periodontal disease/Panavia F and ED Primer; and PD-U – periodontal disease/RelyX U100. Specimens were subjected to push-out test and data were analyzed by two-way ANOVA and Tukey's test ($p = 0.05$). The periodontal disease groups showed that the Panavia F/ED Primer group presented no significantly higher mean values compared with RelyX U100, and that both presented significantly higher mean values when compared with RelyX ARC/Single Bond 2 group. These results were also observed in roots with no periodontal disease. There were no differences in bond strength mean values of roots related or not to periodontal disease.

Keywords: Resin cements; Primers and coupling agents; Periodontitis; Post and core technique; Tooth root

Background

A persistent problem in clinical dentistry is associated with fractures occurring in endodontically treated teeth [1]. Restoration of these teeth, in some cases, can be a complicated process because of extensive structural defects resulting from caries, cavity access and the excessive removal of radicular dentin during endodontic treatment [2-4]. The Restoration must restore the form and function of the tooth, create resources for restorative material anchorage to prevent it from being displaced and provide adequate distribution of forces [2,5].

Numerous restoration techniques for endodontically treated teeth have been advocated with criteria for success dependent upon variations in length, diameter, shape and surface configuration, quantity of dentinal structure, and materials and techniques used in reconstruction [6-8]. Teeth with a minimal or moderate degree of destruction can be restored conservatively with bonded direct composite restorations [9,10]. In cases where most of the coronal portion is lost, a common method to restore such teeth is the use of a post, onto which a full crown is cemented [5,6,10]. The post functions primarily to aid the retention of the restoration and to protect the tooth by dissipating or distributing forces along the tooth [11].

Posts can be divided into two categories: (1) custom/cast post-and-core and (2) prefabricated posts, primarily with composite core. Metal alloys are generally used to fabricate post-and-core [3,6]. Prefabricated posts are divided into two groups: (1) metallic, such as titanium, palladium, gold and stainless steel alloy posts, and (2) non-metallic, such as carbon fiber, glass fiber and yttrium-stabilized zirconia-based ceramic posts [3,6,12,13].

Various luting agents and the corresponding adhesive systems have been proposed for bonding non-metallic posts to root canal dentin. These materials can be divided into etch-and-rinse adhesives, self-etching adhesives and self-adhesive resin cements, which does not require any pre-treatment of dentin [2,14-16]. The etch-and-rinse system involves the use of an acid, which removes the smear layer and demineralizes the dentine to a depth of several microns. The acid is rinsed off using water and then a primer and an adhesive resin are applied [17,18]. Self-etch adhesives however, use a self-etching primer to promote condition and prime the dentine. This is followed by the application of an adhesive resin [17,18]. Simplified versions of both adhesives have made bonding simpler, faster, and more user-friendly [18,19]. In an attempt to simplify procedures, a new group of resin cements have been introduced. These products are self-adhesive, including acidic and hydrophilic monomers in their composition, which simultaneously demineralize and infiltrate in the dentin. Therefore, they require no conditioning or priming pretreatments of the substrate [2,16,18,20].

Periodontal disease is a heterogeneous group of disorders affecting the periodontium, the most common are gingivitis and chronic periodontitis. Substantial evidence indicates that susceptibility to periodontal disease varies among patients and is a function of both acquired and intrinsic risk factors [21-23]. Periodontitis is an irreversible periodontal attachment loss – destruction of periodontal ligament and/or alveolar bone – in some patients [24]. The causal agents of periodontal disease may be appointed as local and systemic factors. Local factors typically include, but are not limited to, dental plaque, gingival inflammation, prior attachment loss, furcations, pocket formation, occlusal trauma and defective restorations. Systemic factors include conditions that result in suppression of the immune system, alterations in endocrine status, and certain medications that specifically affect the gingiva. In addition, specific genetic markers have been linked to susceptibility to periodontitis [21,24-26].

It is supposed that loss of cementum and dentine structure may increase root permeability to periodontum space components [27], what should compromise the bond strength of the luting agents proposed for bonding posts to root canal dentin. The aim of the present study was to evaluate the influence of periodontal disease on the bond strength of a fiberglass post cemented with different adhesive systems and resin luting agents. The null hypothesis tested was that periodontitis has no influence on bond strength of fiber post and resin cements.

Table 1 Materials tested – Commercial brand names, manufacturer and composition*

Commercial brand name	Composition	Manufacturer
RelyX ARC	Silane treated ceramic. Silane treated silica. TEGDMA. BISGMA. Functionalized dimethacrylate polymer. Triphenylantimony.	3 M/ESPE – St.Paul, Mn, USA
Adper Single Bond 2	Silane treated silica (nanofiller). Bis-GMA. HEMA. Dimethacrylate. Methacrylate functional copolymer of polyacrylic and polytaconic acid. Water. Ethyl alcohol.	3 M/ESPE – St.Paul, Mn, USA
Adper Scotchbond – Etching	35% - phosphoric acid. Thickener (pyrogenic silica). Water-soluble surfactant, (pH 0.6).	3 M/ESPE – St.Paul, Mn, USA
Panavia F 2.0	Paste A: 10-Methacryloyloxydecyl dihydrogen phosphate. Hydrophobic aromatic dimethacrylate. Hydrophobic aliphatic methacrylate. Hydrophilic aliphatic dimethacrylate. Silanated silica filler. Silanated colloidal sílica. dl-Camphorquinone. Catalysts. Initiators.	Kuraray Medical/Okayama-Japan
	Paste B: Hydrophobic aromatic dimethacrylate. Hydrophobic aliphatic methacrylate. Hydrophilic aliphatic dimethacrylate. Silanated barium glass filler. Catalysts. Accelerators. Pigments.	
ED Primer	Liquid A: 10-Methacryloyloxydecyl dihydrogen phosphate. N-Methacryloyl-5-aminosalicylic acid. Water. Accelerators.	Kuraray Medical/Okayama-Japan,
	Liquid B: N-Methacryloyl-5-aminosalicylic acid. Water. Catalysts. Accelerators.	
RelyX U100	Base paste: glass powder. TEGDMA. Silane treatead silica. Sodium persulfate.	3 M ESPE/Seefeld-Germany
	Catalyst paste: glass powder. Substituted dimethacrylate. Silane treatead silica. Sodium P-toluenesulfinate. Calcium hydroxide.	
Reforpost	Epoxi resin. Initiators. Stabilizers. Glass fibers.	Ângelus – Londrina, PR, Brazil
Silano	90%-Ethyl alcohol. 10%-3-Methacryloxypropyltrimethoxysilane. Water.	Ângelus – Londrina, PR, Brazil

*According to manufacturer's information.

Methods

Commercial brand names, chemical composition and material manufacturers are presented in Table 1. The push-out bond strength test was carried out and the experimental design of the study is showed in Figure 1.

Ninety intact human maxillary central incisors with similar root lengths (14 mm) were selected. Only teeth indicated to extraction due to periodontal disease and/or prosthetic purposes were collected. The specimens were refrigerated in a solution of

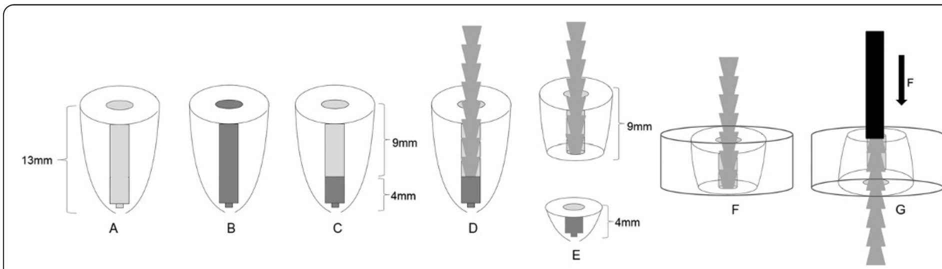

Figure 1 Experimental design of the study. (A) Removal of the tooth root - 13 mm length; **(B)** endodontic treatment executed; **(C)** preparation of the root canal for post insertion - 9 mm depth; **(D)** glass fiber post cementation using different adhesive systems and resin cements; **(E)** root section - 9 mm length; **(F)** root fragment embedded in acrylic resin; **(G)** push-out test.

0.9% sodium chloride and 0.1% thymol (LabSynth Produtos para Laboratórios Ltda., Diadema, SP, Brazil) for no longer than three months after extraction. They were cleaned of gross debris and placed in distilled water for twenty-four hours before beginning the experiment. The teeth used in this study were obtained under Protocol No. 83/06/07, which was analyzed and approved by the Research Ethics Committee, Health Sciences Center, Federal University of Paraiba.

All teeth were checked at 40× magnification and X-rays images. Those presenting caries, cracks, irregularities, anatomic abnormalities, internal or external reabsorptions, calcifications, incomplete formation, root curvature and previous endodontic treatment were eliminated. They were distributed into two groups considering the indication to extraction due to periodontal disease (45 teeth) and prosthetic purposes without periodontal disease (45 teeth).

The crown of each tooth was removed perpendicular to the long axis of the tooth using a flexible diamond disc at low speed (n.7020 – KG Sorensen, Barueri, SP, Brazil) and under water cooling. All roots were cut to a length of 13 mm (Figure 1A).

For endodontic treatment, a step-back preparation technique was used with stainless steel K-files and #2 and #3 Gates-Glidden burs (Dentsply Maillefer, York, PA, USA). All enlargement procedures were followed by irrigation with 2.5% sodium hypochlorite. Smear layer removal was done using 17% ethylenediaminetetraacetic acid (EDTA) (Biodinâmica, Ibiporã, PR, Brazil). Final irrigation was performed with distilled water. Prepared root canals were then filled with gutta-percha cones using the lateral condensation technique and Sealer 26 (calcium hydroxide-resin sealer – Dentsply, York, PA, USA) -Figure 1B. The canal access was sealed with a temporary restorative material and subsequently, the filled roots were stored in distilled water at 37°C for 48 h.

After storage, root canals were prepared to ensure a standardized space for post insertion. The canal space of each root was enlarged with a #4 Largo drill (Dentsply Maillefer, York, PA, USA), providing access for a #2 post, using a low-speed handpiece, to a depth of 9 mm. During preparation of the canal, 3 mm of the endodontic filling was left at the apex of each canal (Figure 1C). The roots were randomly divided into six experimental groups (n = 15). A fiberglass post (#2 Reforpost – Angelus, Londrina, PR, Brazil) and different resin cement systems were utilized in each group (Table 1):

- No periodontal disease/RelyX ARC and Adper Single Bond 2/post;
- No periodontal disease/Panavia F and ED Primer/post;
- No periodontal disease/RelyX U100/post;
- Periodontal disease/RelyX ARC and Adper Single Bond 2/post;
- Periodontal disease/Panavia F and ED Primer/post;
- Periodontal disease/RelyX U100/post.

The post was tried-in to the prepared post-space. Before post insertion, each post was cleaned with ethanol (70% vol.) for 30 s, thoroughly air-dried and coated with a silane coupling agent (Silano - Angelus, Londrina, PR, Brazil). Posts were not manipulated until the luting procedure to avoid contamination of the post surface. In order to ensure the parallelism of the post during the lutting process it was used a metallic matrix.

For the RelyX ARC cement groups, the roots were etched with 37% phosphoric acid (Adper Scotchbond Etching – 3 M/ESPE – St. Paul, Mn, USA) for 15 s and water-rinsed. Then the excess water was removed using absorbent paper, leaving a moist dentin surface. The adhesive system, Adper Single Bond 2 (3 M/ESPE – St. Paul, Mn, USA), was applied using two consecutive coats, gentle air-dried for 5 s, and light cured for 10 s with a halogen light (Optilux – Kerr Dental, Orange, CA, USA), with an intensity of 600 mW/cm^2, measured with the SDS radiometer (Kerr Dental, Orange, CA, USA). The RelyX ARC (3 M /ESPE) base and catalyst paste were hand-mixed for 10 s and then inserted into the post space. The post was immediately inserted into the post space. Excess cement was removed and light-cured for 80 s.

For the Panavia F groups, self-etching and self-curing Primers A and B (ED Primer – Kuraray Medical, Okayama, Japan) were mixed and applied into the root canal for 60 s and dried with absorbent paper. The base and the catalyst pastes of the cement (Panavia F 2.0 – Kuraray Medical, Okayama, Japan) were then mixed in a 1:1 volume ratio during 10 s, and the same cementation procedure was performed.

For the RelyX U100 cement groups, dentin pretreatment was not necessary. The RelyX U100 cement (3 M/ESPE, Seefeld, Germany) base paste and the catalyst paste were hand-mixed during 10 s, and the same cementation procedure was performed.

Once the luting procedure was finished, specimens were stored in distilled water for 24 h at 37°C (Figure 1D). After the storage period, specimens were sectioned using a flexible diamond disc at low speed (n.7020 – KG Sorensen, Barueri, SP, Brazil) under water cooling. All roots were cut to a length of 9 mm (Figure 1E) and embedded in acrylic resin (Vipi, Pirassununga, SP, Brazil) - Figure 1F. Each specimen was marked with a dot on its coronal side and with the sample number on its apical side.

Push-out tests (Figure 1G) were performed with a universal testing machine (model AG-IC, Shimadzu, Kyoto, Japan) at a crosshead speed of 0.5 mm/min. All test specimens were loaded until fracture. To express bond strength in MPA (BS), the load value recorded (F) in Newton was divided by the area of the bonded interface:

$$\mathrm{BS} = \mathrm{F}/2\pi\mathrm{rh}$$

Where π is the constant 3.14, r is the post radius, and h is the specimen thickness in millimeters.

Bond strength data were submitted to statistical analysis. Two-way Analysis of Variance and Tukey's Test ($p = 0.05$) were used to analyze data of different cements whether or not related to periodontal disease. t-Student's Test were used to determine differences related or not to periodontal disease of one single cement ($p = 0.05$).

Results

Table 2 shows the mean push-out bond strengths and standard deviations for the experimental groups. Two-way ANOVA revealed significant difference ($p < 0{,}001$) of the

Table 2 Mean bond strength values in MPa (± standard deviation) and Tukey Post-hoc*

	RelyX ARC	Panavia	RelyX U100
No periodontal disease	10.42^{B} (±3,50)	21.01^{A} (±4,90)	17.04^{A} (±6,12)
Periodontal disease	11.55^{B} (±5,52)	20.66^{A} (±3,89)	16.90^{A} (±5,31)

* Different superscript capital letters indicate statistically significant differences – Tukey Post-Hoc test (p<0.05).

cements used on roots associated with periodontal disease or not. The mean values of the periodontal disease groups showed that the Panavia F/ED Primer group presented no significantly higher mean values compared with RelyX U100, and that both presented significantly higher mean values when compared with RelyX ARC/Single Bond 2 group. These results were also observed in the roots with no periodontal disease.

Discussion

The present study evaluated the influence of periodontal disease on the push-out bond strength of resin cements to root dentin. Different resin cements with different application protocols were analyzed. There were no differences in bond strength mean values of cements used in roots related or not to periodontal disease. Therefore, the main hypothesis of the present study was accepted.

Endodontically-treated teeth present different responses to mechanical loads from intact teeth. The removal of pulp and root dentin diminishes a protective feedback mechanism and reduces the stress–strain capacity of the teeth, compromising the root fracture resistance [4,28]. The stability of the teeth is reduced by endodontic preparative procedures, leading to more root deformations and less stiffness [29,30]. The success of restoration techniques for endodontically treated teeth is dependent upon variations in length, diameter and shape of a post. Quantity of dentinal structure, and materials and techniques used in the reconstruction are also important [4,7,8,31]. It is accepted that posts do not reinforce endodontically treated teeth. The placement of posts reduces the stress in the cervical area by directing along the post length the occlusion stress of the mouth [1,4,11,31]. Moreover, posts should be used when there is a need to provide additional retention for the core build-up [8,10,13].

Post debonding is one of the most unfavorable situations for post-restored teeth and the use of different resin cements can influence the results [6,32,33]. A prerequisite for the use of fiber posts is their adhesive cementation, which creates a bond between the post and the root canal dentin and form a structurally and mechanically homogeneous complex. The combination of an adhesive bond to the root canal dentin with a resin core build-up allows the restoration of nonvital teeth while preserving the remaining tooth structure [3,11,13]. However, the goal is not only to achieve a high retentive bond strength of the fiber post, but also to avoid any microbiologic leakage along the root canal or post and to avoid degradation of the fiber post structure [34]. The purpose of the push-out test applied to the specimens in this study was to cause fracture of the dentin/cement and cement/post interface. This occurs because the cement has a lower elasticity modulus than the root dentin and the fiber post, creating a location of high stress concentration [2].

Due to the variability of the substrate, bonding to intra-radicular dentin has been considered a challenge and a variety of cements and corresponding adhesive systems may be proposed for bonding fiber posts to root canal dentine. Micromechanical adhesion of "etch-and-rinse" and "self-etch" adhesive systems is assumed to be the prime bonding mechanism. This is achieved by an exchange process by which inorganic tooth material is replaced by resin monomers that become interlocked in the exposed collagen of dentin [35]. As a consequence, adequately removing the smear layer together with demineralizing dentin to a small extent, good wetting, diffusion, penetration and good polymerization of the resin components are all important [35]. The self-adhesive resin cement has a bonding mechanism based on micromechanical retention and chemical adhesion. The cement contains multifunctional hydrophilic monomers with phosphoric acid groups which can react with hydroxyapatite and also infiltrate and modify the smear layer. The chemical interaction between the acidic monomers and hydroxyapatite ensures its adhesion to dentin [36,37].

The Panavia F cement presented no significantly higher mean values compared with RelyX U100 cement, and both presented significantly higher mean values when compared with RelyX ARC/Single Bond 2 group. Simplified adhesive systems (two step etch-and-rinse) are incompatible with self-cured and dual-cured resin cements. This may occur by the presence of acid resin monomers in the non-polymerized adhesive residual layer caused by oxygen inhibition, which react with the tertiary amine of the resin cement. Moreover, these adhesives promote a permeable hybrid layer, allowing water diffusion from the dentin and forming water droplets along the adhesive resin-cement interface [2,38]. The major concern with the self-etching primers is their efficacy in infiltrating thick smear layers such as those produced during post space preparations. Furthermore, the chemical polymerization of the adhesive may inhibit the non-polymerized adhesive residual layer caused by oxygen [16]. The recently introduced self-adhering resin cements represent a promising new and simple luting strategy for bonding fiber posts to root canal dentine. The cement has an adequate interaction with dentin, because of the close relationship between the calcium ions of the dentin with the fixing agent of the cement. This interaction starts during mixing process, when the acid is partially neutralized by the hydroxyl released from the breakdown of calcium hydroxide during the reaction, or by water present in dentin. This reaction releases the phosphate group that is responsible for the tooth bonding to calcium [15,39].

Tooth affected by periodontal disease presents exposure of root dentin by gingival recession, periodontal pocket or scaling therapy. These complications may promote loss of cementum and dentine structure, increasing dental permeability to bacteria, as well as fluid movement between the pulp cavity and periodontium [27,40]. There is an inverse relationship between bond strength and permeability. It was observed that bond strength may be higher when permeability is low and it may be smaller when permeability is high [41]. Fortunately, it was not observed differences in bond strength mean values of roots related or not to periodontal disease but periodontal destruction is frequently observed in endodontically treated teeth. A retrospective study showed that periodontal problems constituted 32% of the failures of post-endodontic teeth, which was higher than the 8.6% of failures due to endodontic causes [42]. The impact of the periodontal status on the survival of endodontically treated teeth was observed [43,44]. As the height and density of the alveolar bone changes, tooth mobility increases due to the reduced support, altered centers of resistance and the associated increased moment of force [30]. A finite element study suggested that dentin stresses were 4–10 times higher than in teeth with normal bone height when the bone height is 6 mm below the cemento–enamel junction [45]. Bone loss may lower the fracture resistance of post-restored teeth, mostly due to increased root stress near the post apex and the cervical root portion [43,44].

The retention of fiber posts in roots is dependent upon the adhesion between the resin cement and the dentin, as well as on the adhesion between the resin cement and posts, but the adhesion between resin and dentin is considered to be a weak point in luting a fiber post. In the present study, different cements with different adhesive methods influenced on the push-out bond strength of fiber post tested. The self-etch adhesive system in combination to Panavia F and the self-adhesive cement presented significantly higher mean values when compared with the etch-and-rinse adhesive and RelyX ARC. There were no differences in bond strength mean values of roots related or not to periodontal disease. Consequently, it is possible to assume that periodontal disease may not influence fiber posts cementation.

Conclusion

According to the results of the present study, it was possible to conclude that periodontal disease did not affected the bond strength mean values of fiber posts cementation. Adhesive system and resin cement significantly affected the push-out bond strength values.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

GCFS participated in the study design development, laboratory analysis, literature review, and in the writing of the manuscript. ESG participated in the design development, in the writing of the manuscript and is the coordinator. RLS participated in the design development and in the writing of the manuscript. HLC participated in the writing of the manuscript and did the manuscript final review. SB participated in the study design development, laboratory analysis and did the manuscript final review. VMGF participated in the writing of the manuscript. All the authors have read and approved the final manuscript.

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