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Root canal flare: Effect on push-out strength of relined posts

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ABSTRACT

Purpose: The aim of this study was to investigate the push-out bond strength (PBS) of resin-relined and non-relined glass fiber posts (GFP) luted to flared root canals.
Material and methods: Root canals of 80 bovine incisors were enlarged to obtain 40 mildly flared and 40 over-flared post spaces. Half of the specimens from each group had the GFP resin-relined, whilst the remainders were not relined. A further 20 root canals were minimally flared and restored with a non-relined GFP (control group). Posts were luted into the root canal space using dual-cure resin cement. Three slices were sectioned from each specimen: one from the coronal third and the others from the middle and apical thirds. PBS test was performed in a universal testing machine at a speed of 0.5 mm/min.
Results: Two-way ANOVA for repeated measures and Tukey's test showed that PBS was affected by the root canal flare and relining procedure ($p < 0.001$). Relining significantly increased the PBS of GFP luted in roots with mildly flared canals when compared to those with excessive widening, regardless of the relining procedure. Relining GFP for over-flared canals had a PBS equivalent to that observed in the control group (minimally flared canal/non-relined GFP). PBS values were higher in the coronal third. No difference was found between the PBS values in the middle and apical thirds.
Conclusions: Depending on the extent of the root canal flare, relined fiber posts may outperform or at least perform as well as posts luted in minimally-flared canals.

1. Introduction

Endodontically treated teeth with extensive loss of the crown structure require intracanal posts to provide support to either direct or indirect restorations for adequate functional and esthetical rehabilitation [1].

Despite the fact that custom-cast metal posts can allow the use of a thin layer of luting cement and provide high retention [2], owing to the high elastic modulus of such posts [3], they have been related to increased risk of root fractures [2]. On the other hand, glass fiber posts (GFP) have an elastic modulus that more closely approaches that of dentin [3], which optimizes uniform stress distribution along the tooth and adjacent tissues, thus protecting the root against fracture [4,5]. In addition, other advantages can be attributed to fiber posts, such as a high resistance to fatigue, passive luting, chemical bond to adhesives and resin cements, esthetics, increased light transmission and relatively easy removal [5,6]. In fact, retrospective clinical studies have shown that teeth restored with GFP are more likely to suffer reparable fractures than teeth restored with custom-metal posts [7].

Despite the advantageous characteristics of GFP, in some clinical situations such posts do not have an intimate fit to the root canal walls. As a result, a thicker resin cement layer would be required, increasing the risk of air bubbles/voids and reduced bond strength, which, in turn, could increase the risk of post debonding [4,8–11]. In order to overcome these limitations, the use of resin composite at the interface between the fiber post and dentin has been proposed [8,12]. This introduced the so-called relined- or anatomic post, which extended the indications of GFPs in flared root canals [8,12–15] by increasing their adaptation to the root walls and reducing the thickness of the resin cement [8]. In addition, it has been demonstrated that relined posts keep the stress within its body and direct less stress towards the remaining tooth structure [16], which seems to account for its higher fracture resistance [17].

However, from a previous study which demonstrated that the quantity of light transmission reduces as the depth and distance between posts surrounded by composite resin increased [18], one can hypothesize that bond strength of relined-GFP to the root

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canal may be potentially affected by the flaring condition of the root canal. This is due to resin composite thickness increasing at the GFP surface as the root canal wall decreases in thickness. As a consequence, light transmission through the relined post may be hindered and thereby compromise resin cement curing. This may be a particular issue along the middle and apical thirds, which are located furthest away from the curing light source [13,19,20]. Considering that the effect of root canal widening on bond strength of relined posts to root canal remains unexplored, the aim of this study was to investigate the push-out bond strength (PBS) of resin-relined glass fiber posts (GFP) luted to flared root canals. The postulated null hypothesis was that the push-out bond strength values of resin-relined GFP would not be significantly affected by the extent at which the root canal was flared, regardless of the root portion (coronal, middle or apical).

2. Material and methods

2.1. Experimental design

This study had a randomized block design in a 5×3 factorial scheme. The independent variables were: *Root/Post condition*, at 5 levels (minimally flared root canal + non-relined post, as control; mildly flared root canal + relined post; mildly flared root canal + non-relined post;over-flaredflared root canal + relined post; over-flared flared root canal + non-relined post) and *Root canal third*, at three levels (coronal, middle and apical), which were considered as repeated measures within the same experimental unit. The experimental units were composed of 100 bovine incisor roots, randomly divided into five groups, according to the *Root/Post condition* ($n=20$). Cross sections from the coronal, middle and apical thirds were taken from each root, characterizing an experiment with repeated measures. The dependent variable was the PSB test of GFP, measured in MPa. In addition, fracture mode was qualitatively evaluated.

2.2. Specimen preparation

The soft tissue surrounding the 300 bovine incisors was removed with a curette and pumice/water slurry using bristle-brushat low speed and then stored in 0.1% thymol solution. Teeth were sectioned at the cement-enamel junction using a precision saw (Isomet 1000; Buehler Ltd; Bluff, IL, USA) in order to obtain 300 roots with 17 mm in length, as measured by a digital gauge (MIP/E—103, Mitutoyo Sul Americana Ltd, Suzano, SP, Brazil).

Pulp tissue was removed from the root canal using endodontic files #40 (Dentsply/Maillefer, Petrópolis, RJ, Brazil) and 1% sodium hypochlorite solution as irrigant (Ricie/Wirath Indústria e Comércio Ltda, São Paulo, SP, Brazil). The diameter of the roots was then measured mesio-distally and buccal-lingually, using a digital gauge. One hundred of the 300 roots, being the ones with the lowest internal diameter, were included in this study.

A stereomicroscope (EK3ST, Eikonal Equip. Ópticos e Analíticos, São Paulo, SP, Brazil) was used to check the roots for cracks and fractures. The apical portion was sealed with epoxy resin (Araldite, Brascola, Joinville, SC, Brazil) and allowed to dry for 24 h. The 100 sealed roots were then randomly divided into 5 groups ($n=20$) according to root canal preparation and post relining procedure.

2.3. Root canal preparation

The root canals from the control group were prepared using the tapered round-ended carbide bur dedicated to the GFP kit (Exacto no 2, Angelus, Londrina, PR, Brazil) to obtain minimally flared root canals. The bur had an active portion 0.9 mm in diameter and 1.6 mm in length. The preparation was extended to a depth of 9 mm using a low speed handpiece (Kavo do Brasil, Joinville, SC, Brazil).

The specimens from the mildly flared group had their canals prepared using a spherical diamond bur of 1.4 mm in diameter (#1014HL, Microdont, São Paulo, SP, Brazil), to a depth of 9 mm. A second preparation was made with a 1.8 mm diameter spherical bur (# 3016, Microdont, São Paulo, SP, Brazil) to a depth of 4.5 mm. Preparations were performed using a high speed handpiece (Kavo do Brasil, Joinville, SC, Brazil). For the over-flared group, diamond burs with larger diameters (1.6 and 2.9 mm, #1019 and # 3018, Microdont, São Paulo, SP, Brazil) were used instead. The burs were replaced after every 4 preparations. The canals were rinsed with distilled water, which was then aspirated using an endodontic cannula.

2.4. Treatment of the glass fiber posts

The GFPs (Exacto no 2, Angelus, Londrina, PR, Brazil) were degreased with 70% ethanol for 30 s, rinsed under running water for 60 s and dried. A layer of silane (3 M ESPE, St. Paul, MN, USA) was applied with disposable brushes (FGM, Joinville, SC, Brazil).

2.5. Relining procedure

The root canals were lubricated with a water-based gel (K-Y gel, Johnson & Johnson, São José dos Campos, SP, Brazil). Filtek Z250 resin composite (shade A2, 3 M ESPE, St. Paul, MN, USA) was applied to the post surface using a metal spatula. The post was then covered with the composite resin and introduced into the canal.

The excess of composite resin was removed and light-cured in the canal using a halogen light (Dabi Atlante Ltda, Ribeirão Preto, SP, Brazil) through the post for 5 s, creating a mold of the root canal. Upon removal, the post-composite set was light-cured for an additional 60 s.

2.6. Cementation procedure

The root canal dentin was etched with 37% phosphoric acid (Condac 37, FGM, Joinville, SC, Brazil) for 15 s, rinsed with water for 30 s, which was then aspirated using an endodontic cannula. Absorbent paper points (Dentsply/Maillefer, Petrópolis, RJ, Brazil) were used for drying. A layer of activator (Adper Scothbond Multipurpose, 3 M ESPE, St. Paul, MN, USA) was applied into the root canal according to the manufacturer's instructions using disposable brushes, followed by air-drying for 5 s. The primer (Adper Scothbond Multipurpose, 3 M ESPE, St. Paul, MN, USA) was applied and air-dried for 5 s. A layer of catalyst (Adper Scothbond Multipurpose, 3 M ESPE, St. Paul, MN, USA) was then applied with a fresh disposable brush.

The resin cement (RelyX ARC, 3 M ESPE, St. Paul, MN, USA) was dispensed onto mixing pads, mixed for 10 s, according to the manufacturer's instructions, and inserted into the canal using a Lentulo spiral (Dentsply/Maillefer, Petrópolis, RJ, Brazil). The GFP was positioned into the canal and kept under digital pressure for 5 min to allow resin cement to chemically cure. The excess of resin cement was removed and light-cured through the GFP in the occlusal–apical direction for 40 s.

2.7. Push-out bond strength

Specimens were stored in relative humidity at 37 °C for 5 days and fixed onto acrylic plates with sculpting wax (Kota, São Paulo, SP, Brazil) so that the long axis of the post was parallel to the plate surface and perpendicular to one of its edges. The plates were then fixed onto a precision saw (Isomet 1000; Buehler Ltd; Bluff, IL,