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Research Article

Fracture Strength of Flared Roots Restored with an Innovative Glass Fiber Post Technique

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Abstract

Proposition: evaluate the fracture strength of endodontically treated flared roots after different techniques of intraradicular restoration.

Methods: Thirty human upper canines with similar root dimensions were sectioned transversely and the roots were treated endodontically. It was then proceeded by standardized post space preparations, where the roots were randomly divided into three groups (n=10) according to the restoration technique: G1 (control) – 1.5 mm glass fiber post (Reforpost/Angelus), and dual cure composite resin cement (Variolink II/Ivoclar-Vivadent); G2 – 1.5mm glass fiber post (Reforpost/Angelus) and dual cure composite resin (BisCore/Bisco); G3 – 1.5mm glass fiber post (Reforpost/Angelus) plus three accessory glass fiber posts (Reforpin/Angelus) and dual-cure composite resin cement (Variolink II/Ivoclar-Vivadent). Crown build-ups were made with a composite resin (Filtek Z250/3M-ESPE). The roots were fixed in metal rings with acrylic resin at a level of 2mm below the CEJ, and stored in 100% humidity for 24 hours. Fracture strength was then determined by a compressive load which was applied at an angle of 45° on the lingual surface of the composite resin crown build-up. The modes of failure as well as the results in kgf were analysed using ANOVA and Tukey Test ($P \leq 0,005$).

Results: G1 presented statistically lower resistance than G2 and G3 and the two root fractures were at the cervical level. Moreover, G2 and G3 were similar in statistics but presented crown fractures only.

Conclusion: The use of glass fiber posts accessory with main post, decreases the cement thickness, improves retention for the main post, and increases the resistance to fracture.

INTRODUCTION

Endodontically treated teeth are more fragile due to the loss of hard tissue during preparation and often need post-retain future restorations. The main factor that determines the use of an intraradicular post is the amount of remaining dental structure being able to support a restoration [1,2]. Though there are many alternatives but it is difficult to choose among the several direct prefabricated post systems and the long-established cast metal posts and cores. The latter technique presents disadvantages that may compromise the longevity of the restored tooth. Clinically [3], laboratory studies predicted that [4-8] corrosion, loss of retention, unfavorable concentration of stresses in critical areas of the root and a high incidence of catastrophic root fractures can be observed in teeth restored with cast metal posts. Besides, flexural strength much closer to the dental structure and a greater capacity of absorbing forces [9], usually leads to this provides resiliency and decreases the percentage of to a fewer and more favorable root fractures [10-12].

Comparatively evaluation of fractured strength of teeth restored with different posts revealed that the teeth restored with glass prefabricated posts presents favorable failure patterns compared with the metal cast [6,7]. New concept of intraradicular restoration that was established with the use of carbon fiber/epoxy resin posts, associated to an adhesive cementation technique [8]. Considering the benefits of glass and carbon fiber inside the canal, whose main objective to fill weakened roots to obtain the greatest possible amount of fiber inside the canal. Moreover, a lesser cement thickness, accessory glass fiber posts were introduced into the market (Reforpin / Angelus Science and Technology, Brazil). Currently, accessory glass fiber posts have been used to fill the excess space within the root canal instead of a fabricated post. This results in the cement having lesser thickness [2-13]. Therefore, this article evaluates the fracture strength of endodontically flared treated roots, which is divided into three groups according to how they were restored. The three techniques did not influence the resistance of the roots and therefore the hypothesis tested negative.

MATERIALS AND METHODS

In this study, thirty human upper canine teeth were extracted for therapeutic (with 4x magnifying lenses) and was stored in 4°C saline. The crown of each tooth was removed the cementum-enamel junction (CEJ) using a diamond-coated disc (KG Sorensen, Barueri, SP, Brazil) in a slow-speed hand-piece cooled with air/water spray. All the roots were measured and with approximate length of 17 mm, mesio-distal cervical diameter of 5 m to 5.5 mm and buccal-lingual cervical diameter of 7.5 mm to 8 mm.

The instrumentation of the root canals was performed with a crown-down technique and filled with gutta-percha, using the thermoplastification technique (Moyco Union Broach, USA) and the Eugenol-free cement (Sealer 26, Dentsply Caulk, USA). The post preparations were completed with a Largo bur number 5 (Largo, Ø 1.5mm, Dentsply Ind. e Com. Ltda) which was used for a glass fiber post number 3 and diameter of 1.5 mm (Reforpost Glass Fiber, Angelus, Brazil). To imitate mechanical weakness, all root canals were widened with a long conical diamond bur (720G, KG Sorensen, Brazil) internal diameter of approximately 3.5 mm were obtained. Dimensions of all root canal walls were standardized according to these thicknesses: 0.75 to 1 mm mesio-distally and 2 to 2.25 mm buccal-lingually (dimensions of a clinically fragile root according to Saupe, Gluskin, Radkin Jr, [14] and Newman et al., [15]. The 30 roots were then divided randomly into three groups (n=10):

Group 1: Dual Resin Cement Variolink II (Ivoclar-Vivadent, Liechtenstein) associated with Reforpost Glass Fiber (Angelus, Brazil);

Group 2: Dual composite resin for core build-up BisCore (Bisco, USA) associated with Reforpost Glass Fiber (Angelus, Brazil);

Group 3: Dual Resin Cement Variolink II (Ivoclar-Vivadent) associated with Reforpost Glass Fiber and three Reforpin accessory glass fiber posts (Angelus).

The main post (Reforpost) length was standardized in 14 mm and sectioned with a high speed diamond bur (4138, KG Sorensen) under water irrigation. This corresponds to 9 mm of post inside the canal and 5 mm of post to support the composite resin build-up.

In Group 1, the posts were treated according to the manufacturer's recommendations. Which were, cleansing with alcohol, silanization (Silane/Angelus, Brazil), and application of a dual-cured adhesive system which was applied inside the root canal (Excite DSC). It followed with etching with 37% phosphoric acid, rinsing and gentle drying with air and paper points. The dual-cured resin cement (Variolink II) was inserted with the aid of a syringe (Centrix, USA), the post was positioned in the canal and the cement was light-cured for 60 seconds at 450 mW/cm^2 (curing unit XL1500/3M/ESPE, USA).

In Group 2, all steps were performed as described for Group 1, but a dual-cured composite resin for core build-up was used (Bis-Core dual resin/Bisco) instead of the dual-cured composite resin cement.

In Group 3, the methodology in Group 1 were repeated, however, three accessory posts were inserted inside the root canal together with the main post.

After post cementation, crown build-ups were fabricated with Filtek Z250 composite resin (shade A3, 3M/ESPE, Brazil).

All roots were fixed in metal rings with acrylic resin at the level of 2 mm below the CEJ. After the resin was cured and prior to the mechanical essay, the samples were stored in 100% humidity at +/- 4° C for 24 hours. The samples were tested in a universal machine DL2000 (EMIC, Brazil). A compressive load was applied at an angle 45° in the middle third of the lingual surface of the composite resin build-up with crosshead speed of 0.5 mm/min. A load (kgf) was applied until sample fracture occurred, which was classified as a root fracture, composite resin build-up fracture or post and composite resin build-up fracture.

RESULTS AND DISCUSSION

Table 1 shows the different statistical significance among Group 1 (lowest resistance) as well as Groups 2 and 3, where a reinforced composite resin and accessory posts were used respectively. Roots restored with one main glass fiber post and the resin cement showed significantly lower fracture strength. Regarding the modes of fracture, it was possible to observe a tendency of root fracture at the cervical third in Group 1 (20%). Groups 2 and 3 presented only crown fractures (100%).

The present study rejected the proposed null hypothesesas different intraradicular restoration techniques would not influence the resistance of the roots. In recent years, fiber-reinforced posts have been proposed for the restoration of endodontically treated teeth, mainly due to their enhanced mechanical resistance [16-19]. Their mechanical properties are similar to those of the dental hard tissues. They adhere to resin cements and, in case of glass fiber posts, their color favors the esthetic results of metal free restorations. Direct fiber posts are delivered in one single appointment, which makes their technique faster when compared to cast metal posts and, if necessary, are easy to remove [10-17].

In situations where there exist very wide canals and weakened roots, the fiber post which does not completely fill all large spaces, volume of cement is needed to achieve this purpose [13]. According to some studies, Weakened roots needs reinforcement

Table 1: Fracture strength values and types of fracture.

Restoration Technique	**Fracture modes**			
	Values (kgf)	**Root**	**Crown**	**Post fracture**
Group 1 Variolink	47.45 (A) +/- 14.61	20%	80%	-
Group 2 BisCore	66.57 (B) +/- 14.40	-	100%	-
Group 3 Reforpin	74.11 (B) +/- 15.58	-	100%	-
Values with the same letter are not statistically different (P ≤ 0.005)				

because they are more susceptible to fracture [1-18]. In order to avoid the extraction of flared roots, filling of the radicular space with restorative materials, such composite resins and accessory glass fiber posts have been suggested [2-19].

Cast metal posts have been extensively used, but due to their mechanical behavior they have also been questioned [17]. Then, anew suggested alternatives were used in filling the root canal with composite resin [20]. It has been demonstrated that light-cured composite resin associated to smaller cast metal posts doubled the fracture resistance of weakened roots, when compared to perfectly adapted cast metal posts [14].

To evaluate possible effects of root reinforcement, two products were tested in this study: 1) a dual cure composite resin with a high percentage of filler particles and main indication for core build-ups (BisCore/Bisco). 2) Accessory glass fiber posts (Reforpin/Angelus). Compared to the main post (Reforpost), Reforpin accessory posts presented the same glass fiber/epoxy resin composition but were conical, smooth, and smaller in length and diameter.

Several types of tests are used to compare the mechanical properties of posts. A recent study [19,7-17-22] compared the flexible strength of fiber-reinforced and metal posts. They demonstrated that metal posts present greater stiffness than that of dentin, which could possibly explain the main cause for fractures observed when using such posts. Meanwhile, fiberreinforced posts present rigidity and elastic modulus similar to dentin, which propagates loads evenly along the root, reducing the risk of fracture.

A study using finite element analysis, observed that fragile roots must always have their walls reinforced before post insertion, preferably with composite resin [23]. For these authors, the association of fiber post and composite resin provides a more favorable dissipation of stress along the root. Their result was confirmed in another study, which tested the fracture strength of fragile roots in a universal machine [24]. Hu et al., [25] also showed that the fracture strength of fragile roots was greater when fiber-reinforced posts were associated to an intraradicular filling of composite resin when compared to cast metal posts. However Fukui et al., [26] and Kumagae et al., [27] relate that composite resin is not influence by the increased resistance. In this study, when glass fiber posts were associated to dual-cured resin composite there was an improvement in fracture risk.

The main post selected was the largest of this brand (Reforpost/Angelus number 3; 1.5 mm diameter), however is still insufficient to fill the wide root canals. Then, the roots were filled with a dual resin cement (Variolink II/ Ivoclar-Vivadent) in the control group. A dual composite resin for core build-ups (BisCore/Bisco) and glass fiber accessory posts (Reforpin/ Angelus) were used in control groups. Composite resins are more commonly used to reinforce weakened roots as they show more effectiveness when compared to cement [25]. The resin cement used in this study is a compact material, composed of 82% load particles (zirconium glass and silica) with high microhardness and diametral tensile strength [22]. It has monomers with functional groups that induce adhesion to dentine; moreover, it is composed of filler particles (glass of barium and silica), which can improve its mechanical proprieties. Since luting cement is the weakest link in the tooth/post/core complex [13], the large amount of Cement needed to cement the post might have contributed for the prognosis in this study.

The 7 mm-high composite resin crown build-ups, were loaded in compression according to previous studies [5]. Crown build-ups need to be correctly made because fiber posts cannot be exposed to moisture, otherwise it may result in a significant loss of some mechanical properties [28].

The insertion of large amounts of fiber in the root canal was verified by Sirimai, Riis and Morgano [29], Newman et al., [15]. It found that filling the canal with resin-impregnated fiber ribbonds provided highest fracture strength values compared to groups restored with fiber posts and resin cement.

Groups 2 and 3 higher strengths could be explained by the higher content of filler particles in BisCore (Group 2) and for a greater amount of glass fiber inside the root canal, due to the presence of three Reforpin accessory posts (Group 3). This extra quantity of fiber decreases the thickness of the resin cement and consequently, decreases the polymerization stresses inside the root canal. Less polymerization contraction would favor the quality of adhesion between root canal walls and resin cement as well as between posts and resin cement.

This present study also evaluated the fracture modes of the samples. Compared to other studies, a higher incidence was expected; however, only two root fractures occurred in the proximal walls in two samples of Group 1 (control). These results based on clinical evidence, encourage the use of fiber posts in endodontically treated teeth.

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