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Fracture resistance of mechanically compromised premolars restored with polyethylene fiber and adhesive materials

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ABSTRACT

No previous study has tested the strength of teeth restored with a fiber post inside the root canal combined with a ribbon fiber in the crown surrounding the post. The aim of this study was to compare a new adhesive technique to other conventional techniques in the fracture resistance of endodontically treated premolars. Fifty superior premolars were divided into 5 groups ($n=10$), prepared as follows: intact teeth used in G1 as control; in the other experimental groups (G2, G3, G4 and G5), mesio-occlusal-distal cavities were prepared, extending toward the palatal cups (MODP), and root canal treatments were performed. Groups were restored by varying the restorative technique: G2 – only with composite resin (CR); G3 fiber post+CR; G4 – polyethylene fiber (Ribbond)+CR; and G5, fiber post+Ribbond+CR. The teeth were thermocycled 1000 times. After 24 h, the specimens were loaded in a universal testing machine until fracture, and the failure mode was checked. ANOVA and Tukey–Krammer tests were used for statistical analysis ($\alpha=0.05$). Results: The fracture strength (N) of control (G1 – 410.7 ± 106.9) was not significantly different ($P>0.05$) from Ribbond+CR (G4 – 300.7 ± 80.2) and fiber post+Ribbond+CR (G5 – 377.5 ± 107.7). Specimens restored only with CR (G2 – 177.7 ± 52.1) and fiber post+CR (G3 – 264.6 ± 88.5) were statistically similar ($P>0.05$), but both had their mean values differed from the control ($P<0.05$). Longitudinal and oblique crown fractures were predominant in all groups. Ribbon–fiber reinforced resin restorations provided superior fracture resistance of premolars with MODP and endodontic access cavities when compared to conventional direct techniques.

1. Introduction

Restoration of nonvital teeth is a challenging procedure, mainly in premolars with class II mesio-occlusal-distal (MOD) cavities with cusp reduction, due to excessive loss of tooth structure [1–3].

After tooth preparation, the remaining dental structure can restore the fracture resistance when restored with adhesive materials, rather than post-core techniques [4–8]. This occurs because the elastic properties of composites approximate to those of the tooth structure, such that a lesser amount of forces will form at the tooth/restoration interface and the stress created from occlusal loads will be distributed along the tooth [9,10]. For these reasons, direct composite resin restorations may be considered as a valid potential restorative technique, especially for the restoration of premolars with extensive loss of tooth structure [9–12]. However, studies have demonstrated that root-filled tooth with a large amount of coronal structure cannot present sufficient support for the restoration [13,14]. In these situations, composite resin restorations should be combined with a prefabricated glass fiber post inside root canal [13,15]. Fiber posts may act as a distributor of stress applied to the crown [13–16] and the whole tooth restoration will be a single unit and can improve fracture strength [10]. Nonetheless, there is little consensus with regard to the fiber post providing real teeth reinforcement [12,16,17].

Ribbon fiber (Ribbond) is another reinforcement adhesive material made of long longitudinal and crystallized polyethylene fibers, which provides adequate mechanical characteristic [18,19]. It has a spectrum of 215 fibers, with a very high molecular weight and coefficient of elasticity [18]. Ribbon fibers absorb water because of the "gas-plasma" treatment to which they are exposed. This treatment reduces the fibers' superficial tension, so as to ensure a good chemical bond to composite materials [20]. Ribbon fiber is biocompatible, esthetic and translucent [21]. Its fibers are also characterized by an impact strength five times higher than that of iron [23]. The open architecture of the Ribbond allows the fiber to adapt closely to the tooth contours [18,24,25].

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Due to the Ribbond wide intended properties, this fiber is indicated in various clinical dentistry situations such as the restoration of fractured teeth, the fixation of partial prostheses, orthodontic purposes, the stabilization of traumatized teeth and the direct-bonded endodontic posts and cores [6,11,21,22].

To date, only a small number of studies have compared the fracture resistance of endodontically treated premolars restored directly with composite resin and fiber posts [15,16] or with composite resin and ribbon fiber [6,11,19,20]. Moreover, no previous study has tested the strength of teeth restoration using a glass fiber post inside the root canal combined with a ribbon fiber in the crown surrounding the post.

The aim of this *in vitro* study was to compare a new adhesive technique with other conventional techniques in the fracture resistance of endodontically treated premolars. The null hypothesis is that there is no difference between the fracture resistance of premolars with access cavities and MODP preparations restored with adhesive direct techniques and intact premolars.

2. Experimental

The study protocol was reviewed and approved by the local Ethics Committee. Fifty sound superior premolars stored in steam of 0.1% thymol solution at 4 °C were washed in running water for 24 h to eliminate thymol residues. The teeth without root canal calcification and resorptions were radiographically selected and examined at 20 × magnification using a stereomicroscope (Leica Microsystems, Wetzlar, Germany) to discard those with caries, fissures or cracks. The selected premolars had a mesio-distal dimension of 6.0–7.5 mm and a vestibulo-palatal dimension of 6.0–8.0 mm. The fifty premolars were randomly divided into four experimental groups (G2, G3, G4 and G5) and one control (G1) ($n=10$).

All teeth except those of the control group (G1) were submitted to endodontic treatment. The biomechanical preparation was carried out using a Protaper system (Dentsply-Maillefer, Petrópolis, RJ, Brazil) in the following sequence: S1, S2, F1, F2 and F3. The canals were irrigated with 1% sodium solution and were dried with absorbent paper points (Dentsply-Maillefer, Petrópolis, RJ, Brazil). The teeth were filled with gutta-percha (Tanari, Manacapuru, AM, Brazil) and the AH Plus sealer (Dentsply-Maillefer, Petrópolis, RJ, Brazil) using lateral condensation technique.

The external root surface was covered with a thin layer of a polyether impression material (Impregum Soft; 3 M ESPE, St. Paul, MN, USA) to simulate the periodontal ligament [8]. The teeth were inserted into a metallic rectangular matrix (16.5 mm in width × 31.0 mm in length), and were embedded in auto-polymerized acrylic resin (Jet Clássico, São Paulo, SP, Brazil) up to 2.0 mm below the cemento-enamel junction (CEJ), so as to simulate the alveolar bone [16,24].

Class II cavities were prepared using a #1090 cylindrical diamond bur (KG Sorensen, Barueri, São Paulo, SP, Brazil), using a high-speed handpiece (Dabi Atlante, Ribeirão Preto, SP, Brazil) with air–water spray. Proximal boxes were kept 1.0 mm above the CEJ. After performing the MOD cavities, teeth preparations extended toward the palatal cups. The cusp was reduced using the same bur, in such a way that the remaining structure was 3.5-mm high and 3.0-mm thick (Fig. 1).

The measurements were checked using a digital caliper (Mitutoyo, South America Ltda, SP, Brazil. A calcium hydroxide dressing (Dentsply-Maillefer, Petrópolis, RJ, Brazil) was placed in the entrance of the root canals of all experimental teeth [18].

Groups were restored by varying the restorative technique: G2 – only with composite resin; G3 – fiber post + composite resin; G4 – Ribbon fiber + composite resin; and G5 – fiber post + ribbon fiber + composite resin. The restorative procedure of all groups is described as below:

G1 – Intact teeth used as control.

G2 – Teeth restored only with composite resin. Cavity preparations were etched with 37% phosphoric acid (3 M ESPE, St. Paul, MN, USA) for 30 s, washed for 15 s with water and dried with absorbent paper. The adhesive system (Single Bond; 3 M ESPE, St. Paul, MN, USA) was applied in two layers, using a microbrush (KG Sorensen, São Paulo, SP, Brazil) and light-cured for 20 s using a halogen lamp (Ultralux electronic; Dabi Atlante, Ribeirão Preto, SP, Brazil) at 600 mW/cm^2. The composite resin (Filtek Z250; 3 M ESPE, St. Paul, MN, USA) was inserted in increments (starting in the proximal boxes) and light was activated for 20 s (Ultralux electronic; Dabi Atlante, Ribeirão Preto, SP, Brazil). The last layer was light activated for 40 s. One operator performed all the preparations and restorations.

G3 – Teeth restored with intraradicular glass fiber posts and composite resin. The postspace was prepared using a #3 Largo bur (Dentsply-Maillefer, Petropólis, RJ, Brazil) to remove 2/3 of the filling material from root canal. Acid etching was performed for 15 s in dentin canal walls and cavity was washed for 15 s. The canal was gently dried with absorbent paper points. Later, a layer of the adhesive system (Scotchbond Multi-Purpose Plus; 3 M ESPE Dental Products, St. Paul, MN, USA) was applied to canal walls according to the manufacturer, using a microbrush. The adhesive system was light-cured for 20 s. After this, the fiber post (Angelus, Londrina, PR, Brazil) was selected, cleaned with alcohol and a layer of silano (Angelus, Londrina, PR, Brazil) was applied over its surface. The excess of silano was removed with compressed air for 5 s. The fiber post was cemented with resinous cement (RelyX ARC, 3 M-ESPE, St. Paul, Minnesotta, USA), manipulated according to the manufacturer's recommendations. The cement was inserted into the root canal using a #40 lentulo bur and applied over the post surface. Then the post was inserted into the canal in a single movement and kept under digital pressure for 60 s. The cement excess was removed and the material was light-activated with a halogen lamp (Dabi Atlante, Ribeirão Preto, SP, Brazil) for 30 s on each tooth face

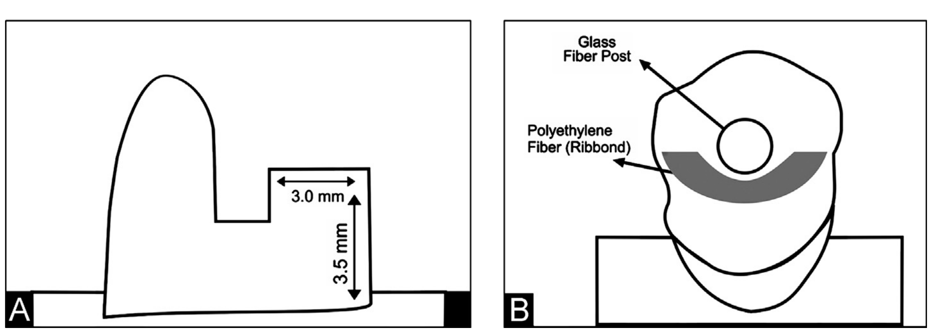

Fig. 1. (A) MODP cavity with the remaining palatal cusp measurements and (B) Ribbon fiber fixed in the cavity surrounding the fiber post.