The Influence of Cavity Design and Glass Fiber Posts on Biomechanical Behavior of Endodontically Treated Premolars

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Abstract

The aim of this study was to evaluate the effect of cavity design and glass fiber posts on stress distributions and fracture resistance of endodontically treated premolars. Fifty extracted intact mandibular premolars were divided into 5 groups ($n = 10$): ST, sound teeth (control); MOD, mesio-occlusal-distal preparation + endodontic treatment (ET) + composite resin restoration (CR); MODP, mesio-occlusal-distal + ET + glass fiber post + CR; MOD2/3, mesio-occlusal-distal + two thirds occlusal-cervical cusp loss + ET + CR; and MODP2/3, mesio-occlusal-distal + two thirds cusp loss + ET + glass fiber post + CR. The specimens were loaded on a cusp slope until fracture. Fracture patterns were classified according to four failure types. Stress distributions were evaluated for each group in a two-dimensional finite element analysis. The fracture resistance of the MODP, MOD2/3, and MODP2/3 groups was significantly lower than the ST and MOD groups ($p < 0.05$). The loss of dental structure and the presence of fiber post restoration reduced fracture resistance and created higher stress concentrations in the tooth-restoration complex. However, when there was a large loss of dental structure (MODP2/3), the post reduced the incidence of catastrophic fracture types. *(J Endod 2008;34:1015–1019)*

Key Words

Composite resin, finite element analysis, fracture resistance, glass fiber posts, premolar

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Endodontically treated teeth are compromised by coronal destruction from dental caries (1), fractures (2–4), previous restorations (5), and endodontic access (6–9). How these compromised teeth should be reconstructed to regain their original fracture resistance has been the subject of many studies investigating restoration types and benefits of posts (10–16).

It has been found that adhesive systems play an important role because the bonding not only provides retention for a restoration (10, 17) but also enables re-establishment of the structural continuum between the buccal and lingual cusps of these weakened teeth (18–20), thus restoring fracture resistance. Inserting a fiber post into a root canal for restoration retention, however, has not always improved fracture resistance. In vitro experiments with endodontically treated mandibular molars restored with composite resins showed that fracture resistance was mainly determined by the number of residual coronal walls, whereas the presence of a post had no effect on fracture resistance (10, 16). Although fiber posts did not increase fracture resistance, it was noted that they improved fracture patterns from nonrestorable to restorable (10).

To fully understand the effect of restoration type and post application, it is not sufficient to only measure an endpoint as fracture resistance. A more comprehensive analysis is needed to determine the optimal procedures for reconstructing endodontically treated teeth. The biomechanical conditions that lead to fracture are characterized by the stress state in a tooth, which can be assessed by finite element analysis. Combining fracture resistance tests with finite element analysis improves understanding of the biomechanical conditions that lead to fracture (21–23).

The objective of this study was to test the hypothesis that a composite resin restoration and glass fiber post system affect stress distribution, fracture resistance, and failure mode in an endodontically treated premolar. These three factors were determined in a combined in vitro and numeric analysis of mandibular premolars restored with composite resin with or without a glass fiber post system.

Methods and Materials

Fifty intact extracted single-rooted human mandibular premolars free of caries, restorations, and fractures were used in this study (Federal University of Uberlândia Ethical Committee approval #213/04). The teeth were stored in distilled water and 0.2% thymol (Pharmacia Biopharma Ltda, Uberlândia, Brazil) solution at 37°C and tested within 3 months after extraction. The extracted teeth were radiographically inspected for single root and single canal (AGFA Dentus M2 Comfort; Heraeus Kulzer, Hanau, Germany). The mesiodistal and buccolingual tooth size, measured with a digital caliper, was 7.8 to 8.6 m and 6.0 to 7.1 mm, respectively. The teeth were randomly divided into 5 groups ($n = 10$). Each tooth was embedded in a polystyrene resin (Cristal; Piracicaba, Sao Paulo, Brazil) cylinder up to 2.0 mm from the cemento-enamel junction. A 0.3-mm thick periodontal ligament was simulated (24) by using a polyether impression material (Impregum F; 3M ESPE, St Paul, MN) (Fig. 1*C*). Using a high-speed diamond rotary cutting instrument (#1151; KG Sorensen, Barueri, SP, Brazil) under air-water spray, standardized mesial-occlusal-distal cavities were prepared in a cavity preparation machine (4) for all teeth except a control group. Table 1 lists the groups. The buccal and lingual cusps of the mesio-occlusal-distal + two thirds occlusal-cervical cusp