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ORIGINAL ARTICLE

Effect of horizontal position of fiber post placement on fracture resistance and location in endodontically treated premolars with a MOD preparation

ABSTRACT

Aim: *To evaluate the effect of the position of fiber post placement on fracture resistance and location in endodontically treated teeth.*
Methods: *Forty healthy double-rooted human first premolars were divided into five groups. S: healthy teeth without intervention; C: endodontic treatment with MOD cavity preparation; CR: restoration with composite resin; CMP: fiber post placed horizontally in the center of the middle third of the crown; CAP: fiber post placed horizontally 2 mm below the center of the middle third of the crown. After thermocycling and fracture strength tests using a universal test machine, pulp floor involvement was evaluated. The Tukey test was used for statistical analysis.*
Results: *Means and standard deviations of fracture strength (N) were as follow. S: 2451^{A}±552.9; C: 32.63^{B}±4.89; CR: 398.7^{C}±73.8; CRMFP: 1253^{D}±82.15; and CRAFP: 1156^{D}±88.23 (different letters indicate statistical differences, P>0.05). Posts placed 2 mm below the center of the middle third of the crown were associated with catastrophic fractures of the pulp chamber floor.*
Conclusions: *The position of a fiber post seems to affect fracture location. The use of fiber posts, regardless of position, increases fracture resistance of endodontically treated teeth.*

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Introduction

Endodontically treated teeth have a higher risk of biomechanical failure than vital teeth, despite advances in restorative materials and procedures (1). The loss of structural integrity of cusps and ridges and the complete removal of the pulp chamber roof during endodontic access affect tooth function because of cusp deflection, which may lead to a higher occurrence of fractures (2).
Restorative treatments using posts placed horizontally across the dental crown seem to be an excellent method to increase the resistance to fracture of the crown in weakened teeth, although catastrophic fractures may still occur (3-6). According to Mangold et al (7), unfortunately, most tooth fractures occur 2 to 3 mm below the coronal margin, which may complicate restoration and make prognosis unclear. Dentists should be aware of the interaction between loads applied to the tooth, the distribution of areas of greatest stress and the types of potential fractures, so that they may plan a restorative treatment that eliminates or reduces the effect of these factors to preserve any remaining tooth structure as much as possible. This study evaluated the effect of horizontally placed fiber posts on fracture strength and location in endodontically treated premolars restored with a MOD preparation.
The initial null hypothesis was that there would be no influence of the horizontally placed fiber posts on fracture strength and location in the restored teeth.

Methods

This study was approved by the local Research Ethics Committee (CAAE 68708217.2.0000.5347).

Sample selection and preparation
Forty double-rooted human maxillary first premolars, free of carious lesions, restorations, or cracks were selected.
Buccolingual (9 mm ± 0.5 mm) and mesiodistal (7 mm ± 0.5 mm) dimensions of the crowns were measured at the most prominent part of their surfaces using a digital caliper (Mitutoyo, Suzano, SP, Brazil). After cleaning, the teeth were placed in 0.5% chloramine (Seachem Laboratories, Madison, GA) for 48 hours for disinfection. After that, they were randomly divided into five experimental groups (Table 1).

Preparation of specimens
Each tooth was individually included in PVC cylinder measuring 2 cm in height and 3 cm in diameter using a self-curing acrylic resin. The specimens were centered inside the PVC cylinder and the anatomic neck of the tooth was kept 2 mm above the edge of the acrylic material. After that, the specimens were stored in distilled water at 37 °C.

MOD cavity preparation
The inclination and movements of a #2143 diamond bur (KG Sorensen, São Paulo,

Table 1
Experimental groups

Groups	n	Group Description
S	8	Healthy tooth
C	8	MOD preparation (MOD) + endodontic treatment (RCT)
CR	8	MOD + RCT + composite resin restoration (R)
CMP	8	MOD + RCT + horizontal fiberglass post transfixed in the middle third of dental crown center + R
CAP	8	MOD + RCT + horizontal fiberglass post transfixed 2 mm below the center of middle third dental crown + R

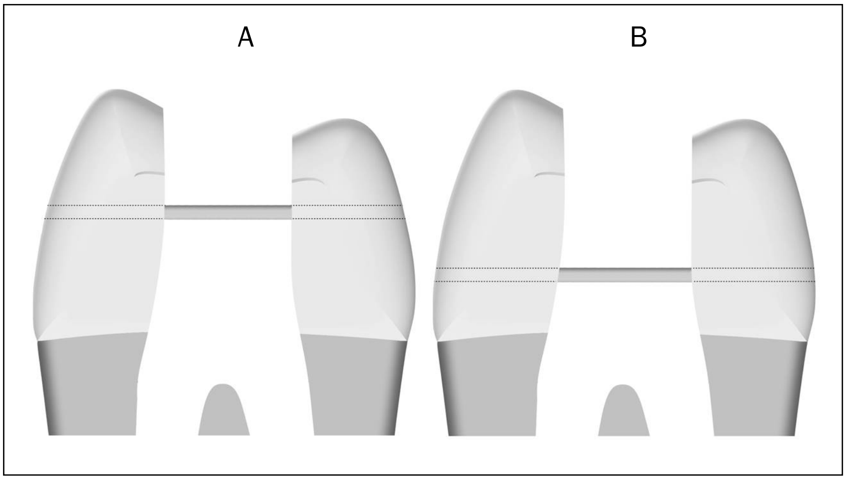

Figure 1
Schematic drawing of the transfix position of the fiberglass post in the dental crown **A)** middle third of dental crown; **B)** 2 mm below the middle third of dental crown.

Brazil) were standardized for the preparation of MOD cavities.
Cavity preparations followed the method described by Cötert et al (8) and Beltrão et al (9). A line from the central groove was drawn to ensure that the buccal and palatal walls of the prepared area were at a distance that corresponded to two-thirds of the intercuspal distance. This line ran over the central groove, to the mesial surface, over the marginal ridge and towards the tooth neck to define a height of 4 mm for the preparation. The same buccolingual width previously determined on the occlusal surface was defined for the mesial surface, and the same width was defined for the proximal boxes. A #2143 diamond bur initially positioned on the mesial surface over the central line was used along a predetermined length. Next, a mesiodistal box as wide as the tip was prepared. The buccal and palatal walls followed the predetermined limits, so that the gingival floor was connected to the pulp floor of the occlusal box, forming a single mesiodistal corridor. Therefore, the MOD preparation had only buccal and palatal walls and a common mesiodistal floor; the buccal and palatal angles of the pulp chamber floor were rounded using a #2143 bur, replaced after each five cavity preparations. The superficial cavity angle was finished manually using #28 and #29 margin cutters (SSWhite Art. Dentários Ltda., Rio de Janeiro, Brazil). In group S, no MOD cavity was prepared.
After MOD preparation, the specimens were again stored in distilled water at 37 °C.

Endodontic treatment
The pulp chamber was accessed using #02 and #04 Carbide burs (KG Sorensen Ind. E Com Ltda., Barueri, SP, Brazil) at high speed, under water cooling. Convenience form was established using the Endo Z tip (Dentsply Ind. E Com Ltda, Petrópolis, Brazil).
The working length was set at 1 mm short of the foramen, and canals were prepared following a serial technique using #15, #20, #25, #30, and #35 K-files (Dentsply/Maillefer, Ballaigues, Switzerland). Canals were irrigated with 2.5% sodium hypochlorite applied with a 10-mL plastic syringe and a 30-ga Navitip® (Ultradent Products, Inc. South Jordan, UT). The cervical area was prepared before canal preparation using a #35 La Axxess® bur (SybronEndo, Glendora, CA), 0.6 mm taper, to a depth of 5 mm of canal access, under irrigation with hypochlorite.
After cleaning and before filling, the canals were rinsed with 17% EDTA under agitation with a #35 file for 3 minutes. The canals were filled with gutta-percha cones and AH Plus® epoxi resin-based sealer (Dentsply/Maillefer Instruments SA, Ballaigues, Switzerland) using the Tagger hybrid technique and a #60 McSpadden® compactor (Dentsply/Maillefer Instruments SA, Ballaigues, Switzerland).

Perforation for post placement
The fiber posts used were Reforpost® (Angelus, Londrina, Brazil) measuring 1.1 mm in diameter. They were perforated on the buccal and palatal walls using a #3145 diamond tip (KG Sorensen, São Paulo, Brazil) at high rotation and under refrigeration. As the #3145 tip has a diameter of 1.2 mm, slightly larger than that of the post, the posts fit the perforated holes. The perforation of both buccal and palatal walls was simultaneous and along the axis of tip insertion. The tip was changed after perforation of each five teeth.
The teeth of the CMP group were perforated in the central area of the middle third of the crown on the two tooth surfaces. In the CAP group, the perforations were made 2 mm below the most prominent point of the middle third of the crown (Figure 1).

Bonding of fiber posts place horizontally and restorative procedures

Bonding of the posts placed horizontally followed the protocol below:

-cleaning of the posts with 70% alcohol and drying with air spray;

-application of a silane layer (FGM Produtos Odontológicas, Joinville, Brazil); drying at room temperature, followed by application of air spray from a distance of 15 cm for one minute;

-application of a thin layer of Singlebond Universal adhesive (3M ESPE, St. Paul, MN), and photoactivation using a LED light unit (Bluephase, Ivoclar) for 20 seconds;

-enamel and dentin etching with 35% phosphoric acid (Dentsply Ind. e Com. Ltda, Petrópolis, Brazil) applied to the holes for 15 seconds, then rinsing for 20 seconds and air drying for 5 seconds;

-etching of enamel on the cavity surface with 35% phosphoric acid for 30 seconds, rinsing for 30 seconds and air drying for 5 seconds;

-application of the Singlebond Universal adhesive to the holes, cavity and pulp chamber preparation, drying for 5 seconds, and photoactivation for 20 seconds on each surface;

-insertion of Bulkfill flow resin (3M ESPE, St. Paul, MN) into the pulp chamber up to the middle of the cavity below the site of the holes, and photoactivation for 40 seconds; all teeth, with or without posts were filled from the pulp chamber to the middle of the area prepared using the Bulkfill flow resin, applied to a thickness of about 4 mm;

-insertion of Bulkfill flow resin into the holes, placement of the fiber posts horizontally in the holes, removal of excess resin with a microbrush, and photoactivation for 40 seconds;

-application of Z250 resin (3M ESPE, St. Paul, MN) to the MOD cavity in four increments of 2 mm each, and photoactivation for 40 seconds for each incremental application.

After restorations, the specimens were placed back in distilled water and stored for 48 h at 37° C.

Mechanical compression test

Specimens were thermocycled between 5° C and 55° C for 500 cycles. Fracture strength was determined using an EMIC DL 2000 universal testing machine (São José dos Pinhais, Brazil) with a 10 kN load cell at a crosshead speed of 0.5 mm/min. A 6.0-mm metal sphere was used for contact only with the inclined planes of the intercuspal surface of the occlusal surface of the specimen, without any contact with the restorative material. Compressive stress was applied parallel to the long axis of the tooth until fracture. The maximum fracture strength (rupture) was recorded in Newton for each specimen

Analysis of type of tooth fracture

A magnifying glass (4X magnification) was used to examine specimens visually for fractures, which were classified either as a pulp chamber floor fracture associated or not with the cusp, or as a cusp fracture only. Floor fractures separated the tooth into two parts at the pulp chamber floor, in a buccolingual or mesiodistal direction. Cusp fractures involved one or more cusps totally or partially, with or without displacement.

Statistical analysis

The Shapiro-Wilk test was used to evaluate normality of the results, and data were analyzed using one-way ANOVA and the Tukey test (α=5%). The GraphPad Prism 7 software (GraphPad Software Inc., San Diego, CA) was used for all statistical analyses.

Results

Table 2 shows that teeth restored with fiberglass post and composite resin (CMP and CAP) presented statistically higher fracture load than teeth filled with composite resin only (CR). However, there is no difference in fracture load between groups CMP and CAP regardless of fiberglass post localization. The presence of fiberglass post in the middle of the crown (CMP) promoted lower pulp floor fracture percentage than CAP and CR groups.

Discussion

Fractures of endodontically treated teeth are common in clinical practice, and numerous studies have reported a high incidence of fractures of maxillary premolars

Table 2

Fracture strength, Newtons (N), coefficient of variation (CV), strength recovery in relation to group S, and pulp and cusp floor fracture in different experimental groups

Groups	Mean ± SD (N)	CV	Strength recovery	Pulp floor fracture	Cusp fracture
S	$2451^{A} \pm 552.9$	23%	——	12.5% (1)	87.5%(7)
C	$32.63^{B} \pm 4.89$	15%	-98.6%	100% (8)	—
CR	$398.7^{C} \pm 73.8$	18%	-83.7%	87.5% (7)	12.5% (1)
CMP	$1253^{D} \pm 82.15$	7%	-48.8%	62.5% (5)	37.5% (3)
CAP	$1156^{D} \pm 88.23$	8%	-52.8%	87.5% (7)	12.5% (1)

Means followed by different uppercase letters differ significantly in one-way ANOVA and Tukey's test ($p<0.05$).

(10-12). Ibrahim et al (13), Taha et al (14), and Aslan et al (4) also used premolars in their experimental studies.

The use of intraradicular posts in these types of cases has not shown additional benefits (15), since the retainers vertically cemented inside the root canal have as main purpose to promote the retention of the restorative material and not to increase the resistance to dental structure (16). This can be seen in the study by Aslan et al (4) in which the use of the fiberglass post transfixed to the dental crown of a premolar with MOD preparation showed better results of resistance to dental fracture than cases in which the post was placed inside the root canal. According to Saatian et al (17), all types of intraradicular posts produce some degree of tension within the root dentin, causing some stress force to be transmitted vertically along the root (18), which can cause deeper levels of fractures and complex (4). In addition, when preparing the canal to receive the retainer, more root dentin is usually removed; thus, resistance to occlusal forces is decreased and the possibility of fracture increases (19).

This study simulated an unfavorable clinical scenario, in which the cusps lose tissue support and tend to undergo greater deflection, and used class II MOD preparations for restorations, as in the studies by Salameh et al (20), Soares et al (21), and Taha et al (14). Lopes et al (22) showed that MOD preparations in premolars reduce cusp stiffness to a third of that of a healthy tooth, which makes them more susceptible to fracture.

Horizontally placed posts associated with the material used for restorations in endodontically treated teeth, regardless of placement position, had greater fracture resistance than teeth restored without posts. These findings are in agreement with the studies by Karzoun et al (3), Aslan et al (4), and Dhingra et al (5), who also worked with horizontal post placement in premolars with MOD cavities.

The horizontal placement of posts in the center of the middle third of the crown is associated with a greater chance of fractures at the cusp level, without involvement of the pulp floor. These fractures have a better prognosis and result in better tooth survival and restoration. In specimens that received other treatments in this study, including horizontal post placement 2 mm below the center of the middle third of the crown, most fractures occurred catastrophically at or below the floor of the pulp chamber. All fractures were above the horizontal post, which is in agreement with the study conducted by Kao (23), who found that less catastrophic tooth fractures are largely associated with post placement position, that is, posts placed closer to the occlusal surface have better outcomes.

The cervical constriction of premolars may play an important role in the extension of tooth fractures to the most cervical region, at or below the floor of the pulp chamber. Restorations should be carefully planned to predict the site of a possible future fracture. Dentists may, thus, induce and direct the fracture to a position that, should it happen, ensures good conditions for a better restoration.

Almost all fractures in this study were in the palatal area of the teeth, in agreement with findings by Mangold and Kern (7). According to Panahandeh et al (24), the stress area on the palatal cusp is greater than on the buccal cusp.

Conclusions

The use of fiber posts for restorations, regardless of their position, increases fracture resistance of endodontically treated teeth. However, their placement position seems to affect fracture location.

Clinical Relevance

Restorative treatments using posts placed horizontally across the dental crown seem to be an excellent method to increase the resistance to fracture. However, their placement position seems to affect fracture location.

Conflict of Interest

The authors declares that there is no conflict of interest.

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