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Fracture resistance of endodontically treated teeth restored with intra-radicular post: The effects of post system and dentine thickness

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ABSTRACT

To investigate the influence of post system and amount of remaining root tissue on the fracture resistance of endodontically treated teeth. Seventy upper canine teeth were divided into seven groups ($n=10$), one control (sound teeth) and six experimental groups resulting from the interaction between the two study factors: post system (FB, fiber post; FPC, fiber post relined with resin composite; CPC, cast Ni–Cr alloy post and core) and amount of remaining root tooth tissue (2 or 1 mm of thick root). All teeth were restored with metal crowns and exposed to 250,000 cycles in a controlled chewing simulator. The samples were submitted to the fracture resistance test in a universal testing machine, at an angle of 135° and speed of 0.5 mm/min, until fracture occurred. Failure modes were observed, and the data of fracture resistance, in Newtons, were submitted to the analysis of variance (ANOVA), followed by Tukey's test ($\alpha=0.05$). Roots restored with FPC had the highest fracture strength of the experimental groups, being statistically similar to the intact teeth group ($P>0.05$). FP and CPC did not differ statistically ($P>0.05$) and were statistically lower than those of FPC ($P<0.05$). No statistically significant difference was observed between amounts of remaining root tooth tissue to the same post systems ($P>0.05$). A prevalence of irreparable failures was observed in specimens restored with CPC, whereas FP and FPC posts showed more repairable failures. The post system had an influence significant on fracture resistance. However, the remaining dentine with 2- or 1-mm thickness was not an important factor for the fracture resistance.

1. Introduction

Endodontically treated teeth are structurally different from nonrestored vital teeth and require specialized restorative treatment (Al-Omiri et al., 2010). The loss of dentin, including anatomic structures such as cusps and the arched roof of the pulp chamber, can result in tooth tissue fracture after the final restoration (Belli et al., 2005). In such cases, the use of intraradicular posts is recommended to promote the retention of the final restoration (Soares et al., 2008). A primary function of a post is to improve the retention of the final restoration and to distribute occlusal stresses along the remaining tooth structure. It has been demonstrated that posts do not strengthen the tooth (Trope et al., 1985; Zicari et al., 2013).

The fracture susceptibility of teeth restored with posts may be related to factors such as the amount of remaining tooth structure, which provides resistance to the fracture of the tooth (Ng et al., 2006), and the characteristics of the post, such as the material composition, modulus of elasticity, diameter, and length (Fokkinga et al., 2006; Bacchi et al., 2013; Zhou and Wang, 2013). A root fracture is the most serious type of failure in postrestored teeth (Ferrari et al., 2000). To avoid root fractures, a post having a modulus of elasticity similar to that of dentin helps in distributing the stress of occlusal load in a uniform pattern (Fokkinga et al., 2004; Maceri et al., 2007; Dietschi et al., 2008).

For a long time, cast metal post and core systems have been used as intraradicular retention (Dietschi et al., 2008), but they have disadvantages such as a high modulus of elasticity, increasing the possibility of irrecoverable fractures of the remaining tooth structure (Fokkinga et al., 2004; Nakamura et al., 2006; Zhou and Wang, 2013). Prefabricated fiberglass posts have led to great advancement, especially as regards mechanical properties, such as high flexural strength and modulus of elasticity similar to that of dentine, minimizing the transmission of stresses on the root walls and decreasing the possibility of fractures (Fokkinga et al., 2004; Lassila et al., 2004; Asmussen et al., 2005; Nakamura et al., 2006; D'Arcangelo et al., 2008). Furthermore, fiberglass posts

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are translucent, contributing to the esthetic qualities of tooth-colored restorations (Qualtrough and Mannocci, 2003), and their chemical composition is compatible with that of Bis-GMA monomer, present in the adhesive systems and resinous cements (Schwartz and Robbins, 2004; Farina et al., 2011). However, because most clinical failures in teeth restored with fiber posts occur because of postdebonding (Ferrari et al., 2000) in large root canals with thin tapered walls (Iglesia-Puig and Arellano-Cabornero, 2004), the use of the fiber post relined with resin composite has been proposed, creating individualized intraradicular posts with a better adaptation to root canals (Grandini et al., 2005; Macedo et al., 2010).

Therefore, the aim of the study was to investigate the influence of post system and amount of remaining root tissue on the fracture resistance of endodontically treated teeth. The hypotheses were that (1) post system influences on fracture resistance of root-filled teeth and that (2) 2 mm of thick dentin has the highest fracture resistance than 1 mm.

2. Materials and methods

Seventy extracted upper canines (gathered following informed consent, approved by the Commission for Ethics of the University of Passo Fundo, no. 044/2012) were stored at 37 °C in distilled water and used within 6 months after extraction. The inclusion criteria were the absence of caries or root cracks and the absence of previous endodontic treatments, posts, or crowns. Furthermore, teeth of similar size and shape were selected by root dimensions after measuring the height and buccolingual and mesiodistal widths in millimeters, allowing a maximum deviation of 10% from the determined mean.

2.1. Endodontic treatment

Root canals that would receive posts were endodontically treated. All root canals were prepared by one trained operator. Each tooth was decoronated below the cementoenamel junction perpendicular to the longitudinal axis using a slow-speed, water-cooled diamond disc (Isomet 2000; Buehler Ltd., Lake Bluff, IL, USA). The roots were cut to a uniform length of 15 mm from the apical end. The apexes of the teeth were sealed with a temporary filling material. Endodontic treatment was performed following a standardized crown-down technique using rotary Ni–Ti instruments of the K3 System (Sybron-Endo, Orange County, CA, USA). The apical foramen was prepared to size 50. The following irrigation regimen was used. Before a new instrument, the canal was filled with 2% chlorhexidine gel (CHX) (Natufarma, Passo Fundo, RS, Brazil). After the use of each instrument, 5.0 mL distilled water was used as an irrigating solution with a 5-mL syringe and a 30-G needle 3 mm short of the working length. Final irrigation with 2 mL 17% EDTA for 3 min followed by irrigation with 5 mL distilled water was performed to remove the smear layer. After that, all canals were dried with sterile paper points to conclude the protocol (Souza et al., 2012). The root canals were filled with gutta-percha points and Endofill (Dentsply Maillefer, Ballaigues, Switzerland) using the lateral condensation technique and accessory gutta-percha points. After root canal filling, any excess gutta-percha and sealer was removed, and coronal portion was sealed. The specimens were immersed and kept in distilled water at 37 °C for a period of 1 week, corresponding to the root canal sealer setting time.

2.2. Specimens preparation

The teeth were divided into seven groups ($n=10$), including the control group with sound teeth, which received no treatment (intact teeth), and six experimental groups defined by the two factors investigated: amount of remaining root tooth tissue (2 or 1 mm of thick root) and post system (FB, fiber post; FPC, fiber post relined with resin composite; CPC, cast Ni–Cr alloy post and core) (Fig. 1).

2.3. Intraradicular preparation

Two thirds of the root canal length was prepared, standardizing the post space to 9.0 mm and preserving 5.0 mm of root filling at the apex. The root canal sealer and core materials were removed from the root canals with heated instruments and using size 3 Largo burs (Dentsply Maillefer) with a low-speed handpiece. Additionally, the roots in this group were prepared with a spherical diamond bur (no. 1014; KG Sorensen, Barueri, São Paulo, Brazil) that was initially used at slow-speed to flare the root canal to a depth of 9 mm and another spherical diamond bur (3017 HL; KG Sorensen) that was used for middle third flaring, reaching a depth of 5 mm. Final preparation was performed using size 4 Largo burs to a depth of 9 mm. With the aid of a thickness meter, constant measurements were made until dentinal walls with a thickness of 2 mm were obtained in thirty roots. The thickness of the other thirty roots was 1 mm. CHX was the chemical auxiliary used with the Largo burs for root canal preparation. Distilled water was the irrigating solution used to remove CHX and the material originated from the preparation of the root canal. Diamond bur was used with a slow speed diamond and under copious distilled water spray.

2.4. Restorative procedures

2.4.1. Fiber post

After preparation, the root canals were cleaned with a 2% chlorhexidine and dried. The dentin was etched with 37% phosphoric acid, and Adper Scotchbond Multi-Purpose (3M ESPE, St Paul, MN) was applied according to the manufacturer's recommendations and light polymerized for 40 s. The fiberglass posts (Angelus, Londrina, PR, Brazil) with 1.1 mm of diameter were cleaned with alcohol, and immediately after applying the adhesive system to the post, it was light polymerized for 20 s on each side.

2.4.2. Fiber post relined with resin composite

Bonding procedures were realized to the root dentin similar to that of the previous group. Afterward, the canal walls were lubricated with a hydrosoluble gel (Natrosol; Drogal Pharmacy, Piracicaba, SP, Brazil). The fiber post was covered with

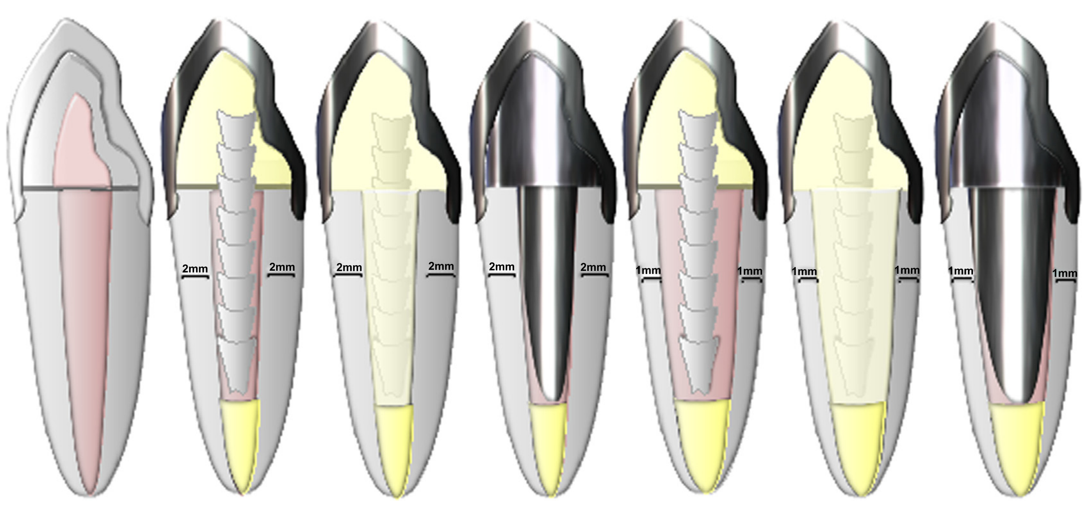

Fig. 1. Specimens preparation for all groups defined by two study factors: amount of remaining root tooth tissue (2 or 1 mm of thick root) and post system (FB, fiber post; FPC, fiber post relined with resin composite; CPC, cast Ni–Cr alloy post and core). Group 1, root intact; group 2, FB and 2 mm of thick root; group 3, FPC and 2 mm of thick root; group 4, CPC and 2 mm of thick root; group 5, FB and 1 mm of thick root; group 6, FPC and 1 mm of thick root; and group 7, CPC and 1 mm of thick root.