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Original article

The effect of glass fiber posts and ribbons on the fracture strength of teeth with flared root canals restored using composite resin post and cores

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A B S T R A C T

Purpose: This study evaluated the fracture strength and mode of failure of structurally compromised teeth with flared root canals restored using composite resin with four different systems.
Methods: Sixty endodontically treated bovine teeth were uniformly shaped to simulate human mandibular premolars with flared root canals. The roots were divided into four groups of 15 specimens each based on the type of restoration: composite resin core only (control), glass fiber post, cylindroid glass fiber ribbons, and glass fiber post and ribbons. All specimens were loaded until fracture occurred using a universal testing machine. Average fracture loads were compared with a one-way ANOVA and Tukey HSD test ($\alpha = .05$). The modes of failure were observed and the Fisher exact test and Bonferroni correction were used for statistical analysis.
Results: The fiber post and ribbon group (1035.70 N) and the fiber ribbon group (881.77 N) showed significantly higher fracture strength than the controls (567.97 N) ($p < .05$). The fiber post and ribbon group also showed significantly higher fracture strength than the fiber post group (769.40 N). Almost all specimens showed unrestorable root fractures ($p < .008$). The control group had a significantly higher ratio of core sectional fractures ($p < .017$).
Conclusions: Cylindroid glass fiber ribbons significantly increased the fracture strength of the composite resin post and cores in the case of the dentin within the thin root canal wall. Based on the results, this study recommends the combined use of glass fiber post and ribbons.

1. Introduction

Endodontically treated teeth have always been restored using posts and cores. Dental professionals consider cast posts and cores to be the gold standard due to their high intensities and high compatibilities with dowel spaces [1–6].

Currently, composite resin materials have also been used for posts and cores because of their improved physical properties and adhesion to root canal dentin. Some studies [7–10] indicated that resin composites reinforce dentin because they have a similar adhesion and flexural modulus to that of dentin, which would prevent root fractures.

Conversely, tooth structures restored using resin composites sometimes result in horizontal root fractures at the cervical region of the tooth [7,11–14]. Lateral stress applied to teeth increased when the endodontically treated teeth were restored as abutments in fixed partial dentures, or as removable partial dentures, when compared to teeth that were individually restored as single crowns.

Prefabricated glass fiber posts enhance the strength of resin cores. Some studies [8,15–17] have shown that teeth structures restored using a resin composite with prefabricated glass fiber posts showed high fracture resistance.

The fracture resistance of the restored endodontically treated tooth depends on the thickness of the remaining tooth structure and the presence of the ferrule [4,8,9,18–22]. Nonetheless, in recent years, the restoration of even severely damaged teeth has become the norm.

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Flared root canals restored using cast posts and cores easily result in root fractures due to differences in the flexural moduli of metal and dentin. This causes the stress concentration to act on the thin dentin. [9,23–27]. Furthermore, cast posts and cores can become predisposed to the effects of the wedging force at the weakened coronal portion [23–25,28]. Thus, it is considered appropriate to restore such teeth with a resin composite to reinforce the thin dentin.

Lui [28] reported that teeth with weakened, thin root dentin had been reconstituted and reinforced by composite resin. The end result of such a tooth showed high fracture strength when restored using a cast post and core following reinforcement with composite resin [23,24,26,29].

Recently, in consideration of metal allergies or aesthetics, metal-free restoration has become a mainstream process [3]. As a result, this study intends to improve the strength of post and core systems in the restoration of flared canals by using metal-free systems.

In flared root canals, it is unclear if prefabricated glass fiber posts reinforce composite resin posts and cores. Some studies reported that the stress concentrated on the cervical area of the tooth restored with a composite resin post and core [11,30], indicating that it would be more effective to strengthen the outside of the post space rather than the center. Consequently, a new core buildup system was investigated, which used cylindroid glass fiber ribbons intended to strengthen resin-core restored teeth with flared root canals.

The aim of this study was to evaluate the fracture strength and mode of failure of structurally compromised teeth with flared root canals that were restored using composite resin with four different systems. The hypothesis was that the composite resin cores strengthening the outside of the post space would have high fracture resistance.

2. Materials and methods

2.1. Experimental conditions

The post and core systems evaluated in this study are shown in Fig. 1.

Four experimental groups were analyzed; Group RC, which is just the composite resin core (Clearfil DC Core Automix, Kuraray Noritake Dental Inc., Tokyo, Japan) alone (control); Group FP involving a prefabricated glass fiber post (Clearfil Fiber Post No.6, φ 1.6 mm, Kuraray Noritake Dental Inc.) with a composite resin core; Group FR involving cylindroid glass fiber ribbons (Construct Ribbon, Kerr Dental Corp., Orange, CA, USA) with a composite resin core; and Group FPR, which involved a prefabricated glass fiber post (Clearfil Fiber Post No.6, φ1.6 mm, Kuraray Noritake Dental Inc.) with cylindroid glass fiber ribbons (Construct Ribbon, Kerr Dental Corp.) and a composite resin core. In all groups, the abutment of all specimens was uniformly shaped.

2.2. Specimen preparation

2.2.1. Tooth specimens and endodontic treatments

Sixty extracted bovine mandibular incisors free of cracks and fractures were used in this study. They were preserved at −15 °C. Before the experiment, the specimens were defrosted at room temperature and divided into four groups of 15 specimens each.

Endodontic treatment was performed in all groups. All specimens were sectioned at 18 mm from the apex with a low-speed diamond saw (Isomet, Buehler Ltd., Lake Bluff, IL, USA) and the crowns were removed. All root canals were shaped with K-files up to No. 120 (Files K, GC Co., Tokyo, Japan), and then washed with 6% sodium hypochlorite solution and 2.5–3.5% hydrogen peroxide solution. The specimens were subsequently dried, and the root canals were obturated with root canal obturation material (GUTTA PERCHA POINTS, GC Co.) and calcium hydroxide root canal sealer (Canals N, Showa Yakuhin Kako Co., Ltd., Tokyo, Japan).

Twenty-four hours after endodontic treatment, the specimens were uniformly shaped on a small desktop lathe (KS-310, Toyo Associates Ltd., Tokyo, Japan) to simulate human mandibular premolar roots. After adjusting the specimen length to 12 mm, a dowel space 8 mm in depth was prepared using a diamond instrument (H250 033, Horico, Berlin, Germany) with water coolant. The thickness of the dentin wall was adjusted to .8 mm at the cervical area through measurements conducted using digital calipers (Digimatic Caliper; Mitutoyo Co., Kanagawa, Japan).

2.2.2. Core build-up

a) Composite resin core (Group RC)

A bonding agent (Clearfil Bond SE ONE, Kuraray Noritake Dental Inc.) was applied to the dentin in the root canal wall and in the cervical shoulder regions at the top of the root for 10 s. The excess bonding agent was removed with paper points, and the root canal was air-dried. The treated specimens were then cured with a light curing unit (Blueshot, Shofu Inc., Kyoto, Japan) at an intensity of 650 mW/cm^2 for 20 s.

An automix resin composite was injected using a slim guide tip to fill the dowel space. Following irradiation from the curing light on the occlusal, buccal, and lingual sides for 20 s each, the abutment was built up with the automix resin composite using an exclusive core form, and was then light-cured from the occlusal side for 20 s. The exclusive core form and the surplus composite resin were then removed using a resin knife (Composite filling instrument TMDU #4 Silver, YDM Co., Tokyo, Japan) and light-cured from the occlusal, buccal, and lingual sides for 20 s each. The height of the abutment was adjusted to 5 mm using a diamond bur (K2 R289/012, GC Co.) with water coolant. To apply the testing load, the buccocoronal edge of the abutment was cut at 45° to the long axis of the root. The specimens were stored in 100% humidity at 37 °C for 24 h in the dark.

b) Glass fiber post-reinforced composite resin core (Group FP)

The length of prefabricated glass fiber posts was adjusted to 11 mm; the posts were applied with 40% phosphoric acid gel (K-Etchant Gel, Kuraray Noritake Dental Inc.) for 5 s, and were then rinsed with deionized water and air-dried. The posts were coated with silane coupling agent (Clearfil Ceramic Primer, Kuraray Noritake Dental Inc.).

A bonding agent (Clearfil Bond SE ONE, Kuraray Noritake Dental Inc.) was applied to the dentin in the root canal wall, and was subsequently light-cured as described above.

An automix resin composite was injected to fill the dowel space, and the post was inserted into the center of this space. Following irradiation from the curing light on the occlusal, buccal, and lingual sides for 20 s each, the abutment was built up, adjusted, and stored as described above.

c) Glass fiber ribbon-reinforced composite resin core (Group FR)

Glass fiber ribbons were infused with resin (Construct Resin, natural, Kerr Dental Corp.) and wrapped around cylindrical material approximately 1.6 mm in diameter that had been coated with hydrophilic petrolatum. The resin-infused glass fiber ribbons were then light-cured for 10 s. The ribbons were carefully slipped off the cylindrical material and light-cured 20 s. The length of cylindroid glass fiber ribbons was adjusted to 8.0 mm. The ribbons were placed in an ultrasound bath with deionized water, and were