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RESEARCH ARTICLE

Fracture strength of endodontically treated roots restored with zirconia post and different core materials

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ABSTRACT

Objectives: The aim of this study was to investigate the effect of different core materials on the fracture strength of endodontically treated roots.

Materials and Methods: Twenty-one (CAD/CAM zirconia post) posts were cemented to the central incisors with a resin cement (Rely X Unicem). After fabrication of core restorations (zirconia, resin core, resin composite), the metal crowns were fabricated on these cores and cemented with a polycarboxylate cement. Each specimen was embedded in an acrylic resin mold. A compressive load was applied on the lingual surface (2 mm below the incisal edge) at 45º angle and crosshead speed of 0.5 mm/min until a fracture occurred. Then fracture strength was measured using a universal testing machine. Data were analyzed using one-way analysis of variance and Tukey tests ($p<0.05$).

Results: The core materials used had significant effect on fracture strength of tooth restored with zirconia post ($p<0.05$). The mean fracture strength values of the specimens restored with different core materials were ranked as follows: Zirconia core (480 ± 132 MPa) > resin composite (344 ± 60 MPa) ≥ resin core (332 ± 89 MPa).

Conclusions: Zirconia post-core system showed higher fracture strength values than resin composite and resin core groups. However, the fracture patterns observed in teeth restored with resin-based materials were more favorable than teeth restored with zirconia posts.

Keywords: Zirconia post, resin core, resin composite, fracture strength.

INTRODUCTION

To fulfill the demand of an aesthetic restoration, tooth-colored posts made of either fiber-reinforced resin composites or zirconia-based ceramics under all-ceramic crowns are preferred as alternatives to metal posts.[1-4] The fracture strength of post and core restorations depends on several factors including post material, luting agent, amount and condition of residual tooth structure, core material, preparation design and fixed restoration.[5] Previous studies reported the use of glass ionomers, resin composites, amalgam, and cast metal alloys as core materials in post-core restorations.[6,7] Recently, tooth-colored resin core materials are used as core build-up materials since they can prevent root fractures of non-vital teeth. They are expected to yield a more natural and esthetic appearance of the final restoration.[6,8] In addition, as an alternative to resin composite cores bonded to zirconia posts, high-strength ceramics are used with copy-milling systems for the fabrication of cores.[9,10]

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The tested null hypothesis in the present study was that, the type of core material has no contributory effect on fracture strength. Based on these considerations, the aim of this in vitro study was to investigate the effect of different core materials on fracture strength of endodontically treated roots restored with zirconia posts.

MATERIALS AND METHODS

Crown parts of 21 extracted human maxillary central incisors were sectioned transversally from the cementoenamel junction, leaving a standard root length of 14-mm. The apical foramen was prepared to size 40 and 0.06 taper. Roots were obturated with tapered gutta-percha points (Dentsply-Maillefer, Ballaigues, Switzerland) and root canal sealer (AH-Plus; Dentsply DeTrey, Konstanz, Germany). The gutta-percha was removed with a warm plugger (Sybron Dental Specialties, Romulus, MI, USA) leaving a minimum 5 mm apical seal and creating a standard post space of 9 mm from the coronal surface. Four peeso reamer no. 5 (ISO sized 1.5 mm in diameter) were used in this study. The posts were 9 mm in height and 1.5 mm in diameter.

Figure 1 shows the schematic illustration of sample preparation and fracture strength test. The single-unit zirconia post-core (Whitepeaks, Wesel, Germany) or zirconia posts without core were luted using a dual-curing resin cement (Rely X Unicem, 3M Espe) and photopolymerized with a light curing unit (LED, 3M Espe) for 20 s from mesial, distal, buccal and palatal surfaces. Then the specimens were randomly assigned into 3 groups with respect to the core material used (n = 7/group): group I: zirconia core (Whitepeaks), group II: resin core (Clearfil DC Core, Kuraray) and group III: resin composite (Clearfil AP-X, Kuraray). Following application of the core material, the specimens were light-cured with a LED light-curing unit (Elipar Freelight 2; 3M ESPE, St. Paul, MN) for 20 s in each of four directions (buccally, lingually, mesially and distally). For the standardization of applied force during the compressive test, metal crowns were made for all of the specimens. Impressions of the teeth were made with a vinyl polysiloxane material (Aquasil Ultra LV; Dentsply DeTrey GmbH, Konstanz, Germany) and metal crowns were fabricated using Ni-Cr alloy (Wiron 99; BEGO, Bremen, Germany). The crowns were designed with a small palatal rest 1 mm wide and 2 mm below the incisal edge. The crowns were cemented with resin cement (Clearfil SA, Kuraray). After storage in distilled water for 24 h at 37°C, a compressive load was applied on the lingual surface (2 mm below the incisal edge) on a testing machine (Lloyd LRX; Lloyd Instruments, Fareham Hants, UK) at a 45-degree angle and crosshead speed of 0.5 mm/min until a fracture occurred (Figure 1). The force was recorded using software (Lloyd Nexygen; Lloyd Instruments).

Failure modes were observed with an optical microscope at a X40 magnification (Stereomicroscope; Wild M3B, Heerbrugg, Switzerland). The data were analyzed using one-way analysis of variance (ANOVA) and Tukey tests ($p<0.05$) (SPSS Inc., Chicago, IL, USA).

RESULTS

The mean fracture strength values, standard deviations and the differences within the groups are presented in Figure 2. One-way ANOVA revealed that type of core material had significant effect on fracture strength values ($p<0.05$). The mean fracture strength values of the specimens restored with zirconia core (480 ± 132 MPa) were statistically higher than the values of the specimens restored with resin core and resin composite ($p<0.05$). However, there was no significant difference between the specimens restored with resin core (332 ± 89 MPa) and the

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specimens with resin composite (344 ± 60 MPa) ($p = 0.976$).

The distribution of fracture modes is shown in Table 1. The groups with resin core and resin composite showed mostly coronal type of failure (% 85.7 and %71.4, respectively). Besides, in the groups having zirconia core, failures were mostly oblique root fracture (%85.7).

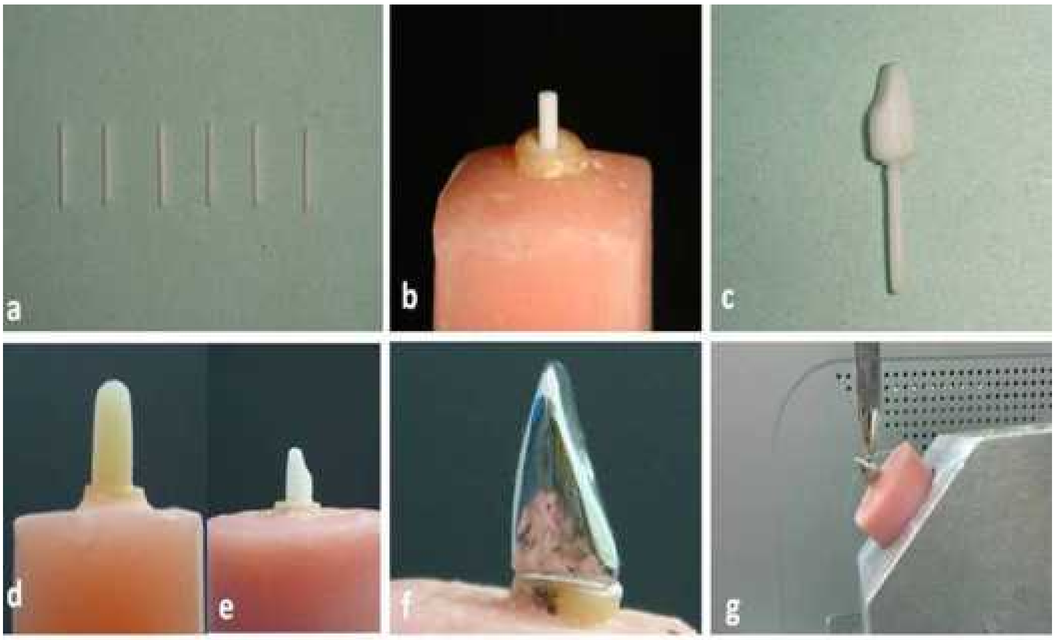

Figure 1. Schematic illustration of sample preparation and fracture strength test. (a) Zirconia post, (b) zirconia post in root canal, (c) one piece zirconia post-core (d) core material with resin composite, (e) zirconia core, (f) metal crown, and (g) the samples mounted in the universal testing machine for the fracture strength test.

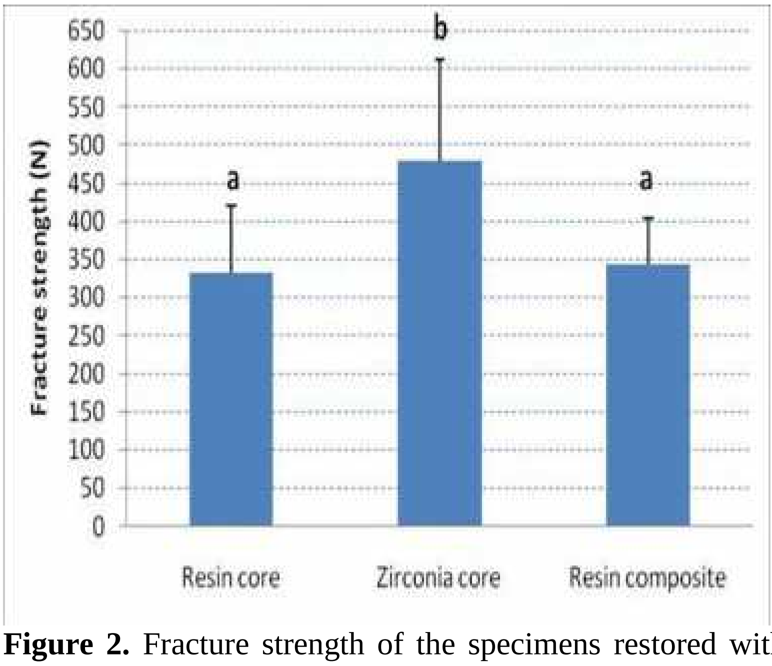

Figure 2. Fracture strength of the specimens restored with different core materials. Means with different letters are statistically significantly different ($p<0.05$).

Table 1. Fracture mode analysis of the specimens.

Core material	Coronal fracture	Oblique root fracture	Oblique root fracture in the cervical third of root canal
Resin core	6	1	0
Resin composite	5	2	0
Zirconia core	1	6	0

DISCUSSION

Recently, composite core build-up materials are used to complete the core around the posts.[1] However, the post and core are two separate entities and flexion of the post under functional forces stresses the post-core interface, resulting in separation of the core due to permanent deformation of post.[11] In the present study, the fracture strength of the single-unit post-core restoration fabricated entirely from high-strength zirconia was compared with resin-based core materials. The fracture strength of the specimens restored with zirconia core had significantly higher values than resin composite and resin core specimens. Therefore, the first null hypothesis that core material would not affect the fracture strength of endodontically-treated teeth was rejected. In accordance with the present study, a previous study by Heydecke et al.[9] demonstrated higher fracture strength values of zirconia post with ceramic cores compared with titanium post restored with composite core and cast post-cores.

In addition, in the present study, the groups restored with zirconia core exhibited more catastrophic, deep oblique root fractures, which usually render the tooth non-restorable and require extraction. The number of catastrophic fractures was less in the groups restored with resin and resin composite cores than that of restored with zirconia core. A root with a repairable fracture might allow the remade restoration of the tooth by means of crown lengthening or forced eruption and post and core build-up. Similarly, in a previous study, the majority of failures for one piece zirconia post and cores were catastrophic, presenting root fracture with or without post fracture.[12]

Additionally, a previous study by Bakke et al.[13] determined the occlusal forces on anterior teeth to be 222 N. According to the values obtained in the present study, all of the systems exceeded this value. Since the failures occurred at much higher values than the average occlusal forces reported for anterior teeth, none of them could be considered at risk for failure as a result of normal occlusal forces.

The design of this in vitro study has several limitations, making it difficult to compare the results with clinical situations. The first was the limited number of specimens tested in this study. Another limitation concerns the fact that the ferrule effect was reported to have an effect on fracture strength of endodontically treated teeth. However, the effect of ferrule was not investigated in this study. By the exclusion of a final restoration with a ferrule effect (excluding any strengthening effect of the crown),[14] it could be possible to solely test the effect of the post length, type and core material.

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Clinical long-term evaluation is crucial for understanding the mechanical behavior and reliability of zirconia posts with different core materials. Furthermore, future studies evaluating the effect of ferrule and thermal cycling on esthetic post-core materials are needed in understanding the longevity of posts under clinical conditions.

CONCLUSION

The use of zirconia core system significantly improved the fracture strength of endodontically treated roots. However, resin core and resin composite cores exhibited less catastrophic fractures than zirconia cores.

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