Original Article

The Force Required to Fracture Endodontically Roots Restored with Various Materials as Intra-orifice Barriers

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Date of Acceptance:
12-Mar-2016

Abstract

Objective: To evaluate the effect of various materials as intra-orifice barriers on the force required fracture roots. **Materials and Methods:** One hundred-thirty five mandibular premolars were decoronated and prepared up to size #40. The root canals were filled and randomly divided into two control and seven experimental groups ($n = 15$), as follows: Positive control group (the intra-orifice barrier cavity was not prepared), negative control group (the intra-orifice barrier cavity was prepared, but not filled), filling using glass ionomer cement, nano-hybrid composite resin, short fiber-reinforced composite, bulk-fill flowable composite, MTA Angelus, Micro Mega MTA or Biodentine. A fracture strength test was performed, and the data were analyzed using one-way ANOVA and Tukey's *post hoc* tests. **Results:** Nano-hybrid composite, short fiber-reinforced composite, bulk-fill flow able composite, and glass ionomer cement increased the force required fracture the roots compared to the positive and negative control groups ($P < 0.05$). While MTA groups did not increase the force required fracture the roots compared to the control groups, Biodentine increased significantly. **Conclusions:** Within the limitations of the present study, the use of nano-hybrid composite, short fiber-reinforced composite, bulk-fill flowable composite, and glass ionomer cement as an intra-orifice barrier may be useful in reinforcing roots. MTA placement (MTA Angelus or Micro Mega MTA) did not significantly increase the fracture resistance of endodontically treated roots compared to the control groups, however Biodentine did.

Keywords: *Biodentine, bulk-fill, endodontically treated tooth, intra-orifice barriers, mineral trioxide aggregate, short fiber-reinforced composite*

Introduction

According to a published meta-analysis,[1] the healing of apical periodontitis increases with both adequate root canal treatment and adequate restorative treatment. This finding reveals the importance of coronal leakage to achieve successful endodontic treatment. Placement of an intra-orifice barrier has been shown to reduce coronal leakage significantly.[2] This was confirmed by an animal study by Yamauchi *et al.*,[3] in which the placement of intra-orifice barrier showed significantly lowered rates of periapical inflammation when compared to the group without intra-orifice barrier.

Several materials have been used intra-orifice barriers. Among them, MTA contains calcium oxide and silicon, which are fine hydrophilic particles that set in the presence of moisture.[4] Recently, a new tricalcium silicate based cement, Biodentine (Septodont, Saint Maur des Fossés, France), has been manufactured. It has reduced setting time. It is also advertised as a biocompatible and bioactive material. The powder contains tricalcium silicate, di-calcium silicate, calcium carbonate and oxide, iron oxide, and zirconium oxide. The liquid of Biodentine differs from MTA, and contains calcium chloride as an accelerator, and hydrosoluble polymer.

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/1119-3077.181390

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How to cite this article: Yasa E, Arslan H, Yasa B, Akcay M, Alsancak M, Hatirli H. The force required to fracture endodontically roots restored with various materials as intra-orifice barriers. Niger J Clin Pract 2017;20:1237-41.

Recently, new concepts of materials have been introduced. The fiber-reinforced composite (EverX Posterior™; GC Dental Products Corp. Tokyo, Japan) contains resin matrix, randomly oriented E-glass fibers and inorganic particulate fillers.[5] The resin matrix includes bis-polyacrylonitrile, triethylene glycol dimethacrylate, and poly(methyl methacrylate). This matrix provides good bonding properties and improves toughness of the polymer matrix.[6] Another material, bulk-fill, asserts to promote light transmittance to enable the success of depth of cure in excess of 4 mm. Although there are limited data about bulk-fill resin based materials, reduced cuspal deflection[7] and good marginal integrity[8] have been reported.

Endodontically treated roots are more susceptible to fracture because of weakened structure. Endodontic treatment procedures, including access cavity preparation, root canal instrumentation, irrigation, postspace preparation, and obturation could be considered as possible predisposing factors. Root reinforcement with intra-orifice barriers could be reduced the root fractures ratio after endodontic treatment.[9] Although the intra-orifice barriers was compared in terms of sealing ability in the literature widely,[10-14] there are limited studies in respect to strengthening effect of these barriers when placed into root canal. Therefore, the aim of the present study was to evaluate the effect of several materials (glass ionomer cement, composite resin, short fiber-reinforced composite, bulk-fill flowable composite, MTA Angelus, Micro Mega MTA, and Biodentine) as intra-orifice barriers on the force required fracture roots. The null hypothesis was that there would be no significant differences in force required fracture roots among the groups.

Materials and Methods

A total of 135 single-rooted, freshly extracted, noncarious human mandibular premolar teeth with similar dimensions were used for this study. To disinfect the teeth, they were immersed in 0.5% Chloramine-T solution (Merck, Germany) for 48 h. The teeth were stored in distilled water at room temperature until use. Soft tissue and calculus were mechanically removed from the root surfaces using a periodontal scaler. Buccolingual and mesiodistal radiographs were obtained, and teeth with curved root canals, internal or external resorption, two or more root canals, and calcifications were discarded. Furthermore, teeth that were evaluated to have a crack or a crack line using a stereomicroscope were discarded. After the samples were decoronated to obtain a standardized length of 15 mm, each specimen was enumerated and the weights in gram were calculated using a precision balance (Precisa XB 220A, Gravimetrics AG, Dietikon, Switzerland) which has a readability of 0.0001 g for standardization described by Ertas *et al.*[15]

A #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was moved down into the root canal until the file was just visible; the length of the file was recorded, and the working length was determined as 1 mm less than this length. The root canals were prepared up to F4 (size #40) by using ProTaper rotary instruments (Dentsply Maillefer). One milliliter of 2.5% NaOCl was used between instrument changes. The final irrigation protocol was performed using 5 mL of 17% EDTA for 1 min, 5 mL of 2.5% NaOCl, followed by 5 mL distilled water. The root canals were dried, and filled with 2 Seal sealer (VDW GmbH, Munich, Germany) and gutta-percha using the cold lateral compaction technique. The specimens were randomly divided into two control and seven experimental groups ($n = 15$) based on weight for standardization, as follows:

- Positive control group: The intra-orifice barrier cavity was not prepared
- Negative control group: The intra-orifice barrier cavity was prepared, but not filled. The coronal 3 mm of the root canal filling material was removed using a heated plugger (size 2; VDW GmbH, Munich, Germany). To standardize the width of the intra-orifice barrier cavity, a depth of cavity was prepared using a circular-shaped drill (size #3, 1.2 mm) (Unicore, Ultradent, Salt Lake City, UT, USA). The cavity was then irrigated with 5 mL of distilled water and dried with mild air flow.

In the experimental groups, the cavity was filled using glass ionomer cement (Equia; GC Corp., Tokyo, Japan), nano-hybrid composite resin (Filtek Z550; 3M Espe, St. Paul, MN, USA), short fiber-reinforced composite (everX Posterior; GC Corp., Tokyo, Japan), bulk-fill flowable composite (Filtek Bulk Fill flowable; 3M Espe), MTA Angelus (Angelus, Londrina, Paraná, Brazil), Micro Mega MTA (Micro-Mega, Besancon Cedex, France) or Biodentine (Septodont, Saint Maur des Fossés, France).

Prior to the composite resin, short fiber-reinforced composite and bulk-fill flow able composite placements, a two-bottle self-etch adhesive (Clearfil SE Bond, Kuraray, Tokyo, Japan) was applied. The specimens were then stored in 100% humidity for 1 week at 37°C.

The root surfaces were covered wax and the specimens were mounted in the acrylic resin (Imicryl, Konya, Turkey), exposing 2 mm of the coronal part. After the first signs of polymerization, the teeth were removed from the resin blocks, and the wax on the root surfaces was removed using a hand instrument. Light body silicone based impression material mixed with activator (Speedex Light Body, Coltene/Whaledent, Switzerland) was injected into the resin base, and the teeth were reinserted into the resin base. Thus, the standardized silicone layer that simulated the periodontal ligament was created [Figure 1].

The strength test was performed with a universal testing machine (AGS-X; Shimadzu Corporation; Tokyo; Japan) using a steel spherical tip with a diameter of 2 mm (perpendicular to the long axis of the tooth) at a constant crosshead speed of 1 mm/min. Loading segment with a spherical tip was aligned center of the canal opening of each specimen [Figure 2]. The force at the time of the fracture was recorded in Newtons (N). Statistical analysis was performed using one-way ANOVA and Tukey's *post hoc* tests for the data ($P = 0.05$) with SPSS software (SPSS Inc., Chicago, IL, USA).

Results

MTA placement (MTA Angelus or Micro Mega MTA) did not significantly increase the fracture resistance of endodontically treated roots compared to positive and negative control groups ($P > 0.05$) [Figure 3]. However, Biodentine increased the force required fracture the roots compared to the control groups ($P < 0.05$). Also, glass ionomer cement, nano-hybrid composite resin, short fiber-reinforced composite, and bulk-fill flow able composite increased the force required fracture the roots compared to positive and negative control groups ($P < 0.05$). However, there were no significant differences in force required fracture roots among glass ionomer cement, composite resin, short fiber-reinforced composite, and bulk-fill flowable composite groups ($P > 0.05$).

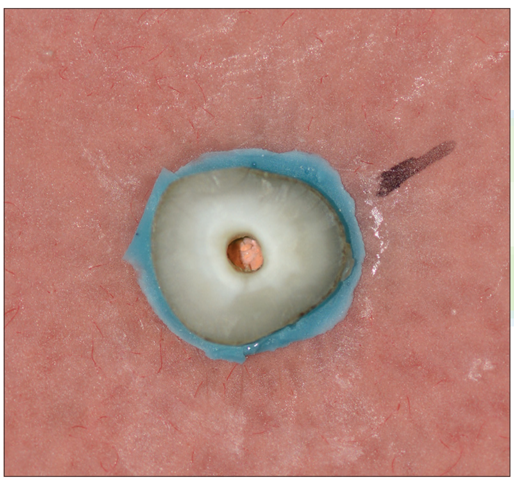

Figure 1: Specimen with standardized silicone layer, which simulated the periodontal ligament

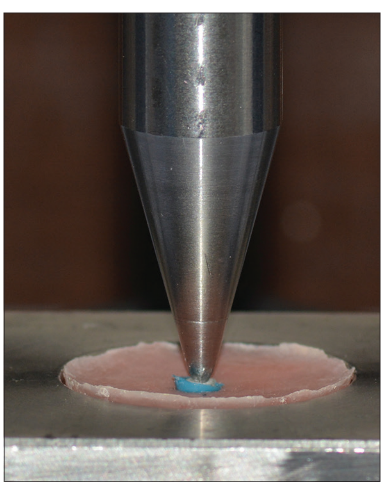

Figure 2: Design of fracture strength test with a universal testing machine using a steel spherical tip with a diameter of 2 mm

Discussion

Endodontically treated roots are susceptible to fracture because of their weakened structure. Thus, one of the goals of root canal treatment is to reinforce the endodontically treated root.[9] As well as intra-orifice barriers have been popular in recent years to obtain reduced coronal leakage,[10-14] root canal treatment with an intra-orifice barrier in comparison without barrier can increase the fracture resistance.[9] Therefore, the present study aimed to evaluate the effect of several materials (glass ionomer cement, nano-hybrid composite resin, short fiber-reinforced composite, bulk-fill flowable composite, MTA Angelus, Micro Mega MTA, and Biodentine) as intra-orifice barriers on the force required fracture roots. The null hypothesis was that there would be no significant differences in force required fracture roots among the groups. However, our findings indicated that there were significant differences between these groups; therefore, the null hypothesis was rejected.

According to the results of the present study, glass ionomer cement, nano-hybrid composite resin, short fiber-reinforced composite, and bulk-fill flowable composite increased the force required fracture the roots compared to positive and negative control groups. This finding could be explained by their good adhesive properties. However, the use of short fiber-reinforced composite, and bulk-fill flowable composite had not additional advantage over the composite resin in terms of reinforcing roots.

According to the results of the present study, MTA placement (MTA Angelus or Micro Mega MTA) as an intra-orifice barrier did not significantly increase the fracture resistance of endodontically treated roots compared to the control groups. Nagas *et al*.[9] investigated and compared the root reinforcement potential of three different intra-orifice barriers and found that MTA did not exhibit any reinforcing effect as an intra-orifice barrier in comparison with a resin-modified glass ionomer cement and fiber-reinforced composite

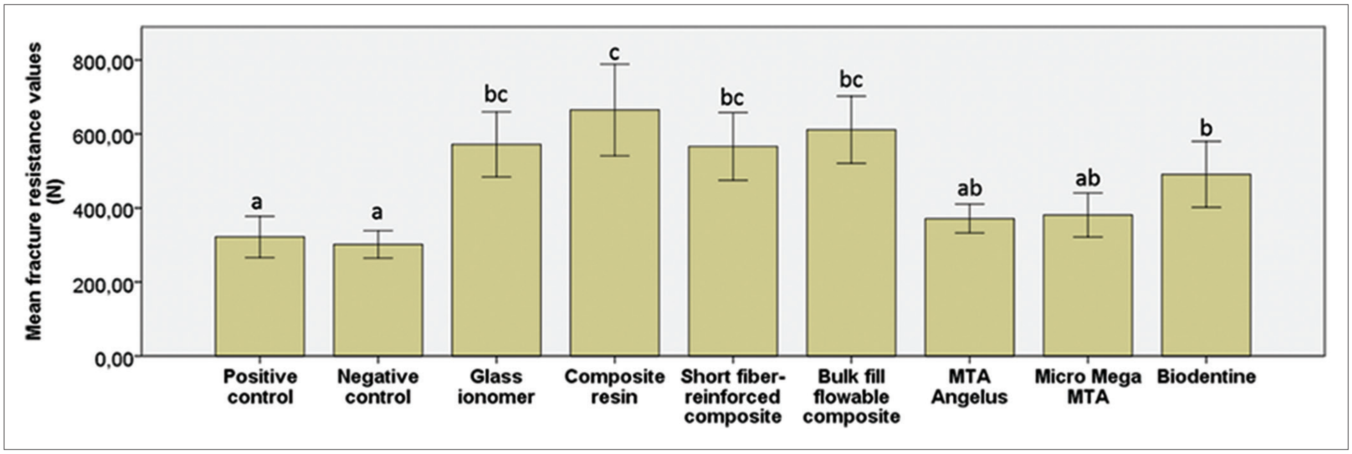

Figure 3: The details of force required fracture roots of the groups (Newtons). Different letters show statistically significant differences between the groups ($P < 0.05$)

This finding is in harmonious with the results of the present study. This result could be due to the inability of MTA in bonding to root dentin. Another finding obtained from the present study, Biodentine increased the force required fracture the roots compared to the control groups. There is no available data in the literature to compare this finding. Topçuoglu *et al*.[16] evaluated the fracture resistance of simulated immature teeth that had been backfilled using different materials after using Biodentine as the apical plug material. They found that the backfilling with fiber postafter, an apical Biodentine plug provided the highest fracture resistance among all experimental groups. Although a direct comparison could not be done, this finding is in harmonious with the results of the present study. The increased force required fracture roots in Biodentine group than MTA could be explained by the smaller particle size and uniform components of Biodentine, which affects the adhesion of material into dentinal tubules.[17] Additionally, the adhesion ability of Biodentine can arise from the tag-like structures within the dentinal tubules and give rise to a micromechanical anchor.[18] Likewise, Han and Okiji[19] also demonstrated that Biodentine lead more calcium and silicon ion uptake into root canal dentin and tag-like structures formation in comparison with MTA.

In the present study, all controllable factors were standardized as much as possible: The specimens in all groups were human mandibular premolar teeth, the teeth were randomly distributed to the groups, teeth with similar dimensions were selected, the root length of the specimens was standardized to 15 mm, weight of specimens were standardized in the groups, and the root canals were enlarged and obturated using the same technique. Moreover, simulated periodontal ligament was first used to mimic *in vivo* conditions in root fracture strength studies. Previous studies[9,20] used specimens apical part merely embedded in acrylic resin without simulated periodontal ligament. When the current fracture strength values compared to that of aforementioned studies, lower values were observed. This could be based on methodology supporting roots from apical part by acrylic resin when the fracture occurred.

Conclusions

Within the limitations of the present study glass ionomer cement, nano-hybrid composite resin, short fiber-reinforced composite, and bulk-fill flowable composite increased the force required fracture roots compared to the control groups. MTA placement (MTA Angelus or Micro Mega MTA) as an intra-orifice barrier did not significantly increase the fracture resistance of endodontically treated roots compared to the control groups, however Biodentine did.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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