Effect of Mineral Trioxide Aggregate Apical Plug Thickness on Fracture Resistance of Immature Teeth

Ersan Çiçek, DDS, PhD, Neslihan Yılmaz, DDS,[†] M. Murat Koçak, DDS, PhD,[‡] Baran Can Sağlam, DDS, PhD,[‡] Sibel Koçak, DDS, PhD,[‡] and Burcu Bilgin, DDS[‡]*

Abstract

Introduction: The aim of this study was to compare the fracture resistance of simulated immature teeth after using different thicknesses of mineral trioxide aggregate (MTA) apical plugs. **Methods:** Fifty-two human maxillary anterior teeth were used. Five teeth were the positive control group; they were prepared using Peeso reamers to simulate immature teeth without any access cavity preparation. Access cavities of the 47 teeth were prepared, and the canals were instrumented with Peeso reamers. Five teeth served as the negative control; they were filled with calcium hydroxide. Forty-two teeth were divided into 3 groups; in groups 1, 2, and 3, MTA was placed into canals as a 3-mm and a 6-mm apical plug and a thorough canal length, respectively. The rest of the canals in groups 1 and 2 were filled with gutta-percha and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany). After the storage period, the roots were covered with a polyether impression material and were embedded into self-curing resin blocks. Each specimen was then subjected to fracture testing using a universal testing machine. Data were analyzed using 1-way analysis of variance with the Tukey post hoc test for multiple comparisons. **Results:** The negative group showed the lowest fracture resistance compared with the other groups. The 3-mm apical plug group showed the highest fracture resistance ($P < .05$). No significant differences were found between the 3-mm and 6-mm apical plug groups ($P > .05$). **Conclusions:** MTA should be used as an apical plug instead of root canal filling material to increase the fracture resistance of immature teeth. *(J Endod 2017;■:1–4)*

Key Words

Apical plug, fracture resistance, immature teeth, mineral trioxide aggregate

Significance

During the single-visit treatment of an immature tooth, an MTA apical plug could be placed up to 6-mm thickness. Clinicians should avoid complete obturation of a root canal with MTA.

Traumatic dental injuries frequently occur in young and adolescent age and mostly affect the maxillary central incisors (1). Such injuries often result in pulpal necrosis, which could cause the termination of apex formation in developing teeth; these teeth are called immature teeth (2). The treatment of immature teeth is a challenge because of the weak dentinal walls and the high risk of root fracture (3, 4).

Root canal instrumentation and the achievement of an adequate apical stop are challenges during the treatment of immature teeth. To allow condensation of the filling material and to provide an apical seal, an artificial apical barrier or closure of the apical foramen with a calcified tissue is essential. Apexification was defined as “a method to induce a calcified barrier in a root with an open apex or the continued apical development of an incomplete root in teeth with necrotic pulp” (5). Although several procedures using different materials have been proposed to induce root-end barrier formation, calcium hydroxide ($Ca[OH]_2$) has gained wide acceptance. Although this technique is efficient with predictable outcomes, it has several disadvantages such as the unpredictable time required to form an apical barrier, the need for multiple visits, patient compliance, reinfection because of the loss of temporary restoration, and predisposition of the tooth to fracture (6, 7).

In such cases, the clinician should consider treatment options including regenerative endodontic or apexification treatments (8). The apical barrier technique is commonly used when regenerative treatment has failed or is not considered an option (8). Various materials have been recommended for the apexification of immature teeth. $Ca(OH)_2$ has been used for the induction of an apical barrier in an immature tooth because of its high pH and antimicrobial activity for many years (9, 10). However, $Ca(OH)_2$ has several disadvantages such as requiring multiple visits, microleakage between visits, and the patient’s adaptation (11, 12). Furthermore, $Ca(OH)_2$ treatment may extend up to 1 year, which may decrease the fracture resistance of immature teeth because of the changes in the organic matrix of the dentin (4, 6, 12, 13). Single-visit apexification treatment using mineral trioxide aggregate (MTA) may eliminate such drawbacks (14–16) because of its good physical, chemical, and biological properties. Therefore, MTA was recommended as an alternative material to $Ca(OH)_2$ for the induction of an apical barrier in an immature tooth (17). Bonte et al (17) stated

---

From the *Private Clinic, Samsun, Turkey; [†]Oral Health Center, Karabük, Turkey; and [‡]Department of Endodontics, Faculty of Dentistry, Bülent Ecevit University, Zonguldak, Turkey.

Address requests for reprints to Dr Baran Can Sağlam, Department of Endodontics, Faculty of Dentistry, Bülent Ecevit University, Zonguldak, Turkey. E-mail address: barancansaglam@gmail.com

0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2017.05.007

that apexification with MTA was superior to $Ca(OH)_2$ to achieve an earlier coronoradicular filling and to limit the risk of root fracture.

Considering the various drawbacks associated with $Ca(OH)_2$ apexification, the use of the apical plug method could be an alternative treatment option in such cases. In this method, a compact plug is placed into the open area of the root end to induce the formation of a calcified barrier in the periapical region. After the setting of this plug, the remaining part of the canal could be obturated with gutta-percha. The advantages of this technique are shorter treatment time and the development of a good apical seal. A number of materials have been proposed for this purpose (18, 19). Of all the materials available, MTA has been widely used for 1-visit apexification because of its superior sealing ability, biocompatibility, regenerative capability, and antibacterial property; it also enhances the fracture resistance of immature teeth (20–22).

Recent studies evaluated the success of MTA in the treatment of immature teeth (17, 20, 21). However, the optimal thickness of an MTA apical plug is controversial. Therefore, the aim of this *in vitro* study was to compare the fracture resistance of simulated immature teeth after using different thicknesses of an MTA apical plug.

Materials and Methods

Tooth Selection

Fifty-two extracted human maxillary anterior teeth with a single root and canal were selected. The teeth had been extracted for periodontal reasons that were unrelated to this study. All teeth were inspected under a stereomicroscope (×20 Olympus SZ61 with a SC100; Richmond Hill, ON, Canada) to detect any carious lesions, external resorption, cracks, or fracture lines. Periapical radiographs were taken in both the buccolingual and mesiodistal directions to verify the absence of calcification, internal resorption, or an additional root canal. Teeth with carious lesions, a calcified canal, root resorptions, fractures, and/or cracks were discarded. The buccolingual and mesiodistal diameters of the roots were measured at the cervical, middle, and apical levels using a digital caliper (Mitutoyo, Tokyo, Japan). Similar teeth with a length of 20 ± 0.51 mm were selected for standardization. The apical 5 mm of each tooth was removed using a low-speed diamond saw (SP1600; Leica Microsystems, Wetzlar, Germany).

Treatment Procedures

Five teeth served as the positive control. These teeth were prepared from the apical to the coronal direction of the canal using Peeso reamers up to size 5 to simulate immature teeth without any access cavity preparation.

Forty-seven teeth were prepared as follows. Coronal access was prepared using a size 4 round bur (Dentsply Maillefer, Ballaigues, Switzerland) in a high-speed handpiece. The pulps were removed using a barbed broach (Kerr Corporation, Orange, CA) without any instrumentation. The canals were instrumented with Peeso reamers (size 1–5, Dentsply Maillefer) until a size 5 Peeso could easily pass 1 mm beyond the apex to stimulate immature teeth (3). The canals were irrigated with 2.5% sodium hypochlorite during instrumentation. A size 6 Peeso reamer was used to extend the preparation of the canal 3 mm below the cementoenamel junction to approximate Cvek's stage 3 of root development (3, 4). After the instrumentation, each canal was irrigated with 3 mL 2.5% sodium hypochlorite and then irrigated with 3 mL saline. Five teeth served as the negative control, and the canals were filled with $Ca(OH)_2$ (Calcicur; Voco, Cuxhaven, Germany). The $Ca(OH)_2$ paste was placed into the root canal from the access cavity with a Lentulo spiral (G-Star Medical Co Ltd, Guangdong, China). The access cavity was sealed with a temporary filling material (Cavit; ESPE, Seefeld, Germany), and the specimens were stored at 37°C and 100% humidity for 4 weeks.

Forty-two teeth were divided into 3 experimental groups ($n = 14$). White MTA (Angelus Solucoes Odontologicas, Londrina, Brazil) was mixed at a powder to liquid ratio of 3:1 (17). MTA was placed into the root canals from the coronal access to provide an apical plug. The apical plug thickness was performed as follows (Fig. 1*A–C*). In group 1, MTA was placed into the simulated immature roots and condensed with a hand plugger to obtain a 3-mm-thick apical plug. In group 2, MTA was placed into the simulated immature roots and condensed with a hand plugger to obtain a 6-mm-thick apical plug. In group 3, MTA was placed into the simulated immature roots and condensed with a hand plugger to obtain a completely obturated root canal with the material. The homogeneity and thickness of the apical plug were confirmed with 2 radiographs in both the mesiodistal and buccolingual directions.

All specimens were stored at 37°C and 100% humidity for 4 hours, and the remaining parts of the canals in groups 1 and 2 were filled with gutta-percha and AH Plus (Dentsply DeTrey, Konstanz, Germany) sealer using the warm vertical compaction technique to the cementoenamel junction. The quality of the obturation was confirmed with radiographs. The access cavities were sealed with resin composite restoration (Clearfil Majesty Esthetic; Kuraray, Tokyo, Japan). The samples were stored at 37°C and 100% humidity for 4 weeks.

Fracture Testing

The root surfaces were covered with a polyether impression material to mimic the periodontal membrane. The roots were embedded in self-curing resin blocks (Lucitone; Dentsply International Inc, York, PA) until there was a 2-mm gap between the cementoenamel junction and the top of the resin (23, 24). Each specimen was mounted in a universal testing machine (Instron; AG-IS, Shimadzu, Japan). The spade, which was used to apply the force to the specimen, was placed on the facial surface at 135° to the long axis of the tooth in a buccal/lingual direction at a point 3 mm above the cementoenamel junction to stimulate a traumatic blow on the middle third of the dental crowns (24). The samples were loaded at a crosshead speed of 1 mm/min until the fracture occurred. The peak load to fracture was recorded in newtons.

Statistical Analysis

SPSS 19.0 software (SPSS Inc, Chicago, IL) was used for statistical analysis. The buccolingual and mesiodistal dimensions and weights were subjected to the Kolmogorov-Smirnov statistical test to test the normality of these continuous variables. The 1-way analysis of variance test was used to evaluate the difference among the buccolingual and mesiodistal dimensions and the weight of the samples. After completing the fracture test, the data were subjected to statistical analysis using 1-way analysis of variance with the Tukey post hoc test for multiple comparisons. The testing was performed at the 95% level of confidence ($P < .05$).

Results

The mean peak load (newtons) and standard deviation of the groups are shown in Table 1. The teeth were fractured horizontally or obliquely through the cervical area of the root. The negative group showed the lowest fracture resistance compared with the other groups ($P < .0001$). The 3-mm apical plug group showed the highest fracture resistance. No significant differences were found between the 3-mm (727.24 ± 52.85 N) and 6-mm (721.56 ± 32.00 N) apical plug groups ($P > .05$).