Reinforcement of Simulated Immature Permanent Teeth after Mineral Trioxide Aggregate Apexification

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Abstract

Objectives: The objectives of this study were to compare the fracture resistance of simulated human immature teeth that have undergone mineral trioxide aggregate (MTA) apexification and have been root-filled with fiber post, composite resin, MTA, or gutta-percha. **Methods:** Fifty-six human permanent maxillary incisors were selected. Ten teeth received no treatment (intact teeth group). The root canals of 46 teeth were prepared to an internal diameter of 1.75 mm. Six teeth were used as simulated immature teeth group. The remaining teeth received MTA apexification and were divided into 4 groups: MTA, fiber post, composite resin, and gutta-percha groups. The root canals of each group were filled with each test material. All teeth were thermocycled and received cyclic loading before compression testing by an Instron universal testing machine. The load to fracture was recorded. Data were subjected to statistical analysis by using one-way analysis of variance and Tukey multiple comparison test. **Results:** All teeth fractured at the cervical area of the root. The mean load to fracture of the intact tooth, MTA, fiber post, composite resin, gutta-percha, and the simulated immature tooth groups was 1988 N, 1921 N, 1691 N, 1623 N, 1476 N, and 962 N, respectively. Statistically, load to fracture of the simulated immature tooth group was significantly lower than in the intact tooth, MTA, fiber post, and composite resin groups but was not significantly different from the gutta-percha group. **Conclusions:** Within the limit of this study, after MTA apexification, intraradicular reinforcement with MTA, fiber post, or composite resin increased the fracture resistance of simulated immature teeth. *(J Endod 2017;■:1–5)*

Key Words

Immature permanent teeth, MTA apexification, reinforcement

Significance

After MTA apexification, intraradicular reinforcement with MTA, fiber post, or composite resin increased the fracture resistance of immature teeth. Practitioners should consider reinforcement of the immature roots to promote the function of treated teeth in the long term.

Mineral trioxide aggregate (MTA) apexification has been considered as an effective treatment for non-vital immature permanent teeth. It involves disinfection of root canal and sealing the root canal with apical MTA barrier along with root-filling materials. However, the capacity of these procedures to strengthen the thin and weak root is questionable (1). Recent studies showed that failure of MTA apexified teeth was associated with root fracture (1, 2). Therefore, the fate of immature teeth after the MTA apexification relies partly on the integrity of the remaining tooth structure and the permanent restoration. Ultimately, the restoration of immature teeth after MTA apexification should strengthen the weak root and maintain the tooth in function.

The concept of intraradicular reinforcement of immature teeth after MTA apexification has been in focus. Increasing the fracture resistance of immature root should minimize the incidence of root fracture, especially cervical root fracture in incisors (3). Several materials including resin-based root filling (4), composite resin (5, 6), MTA (5, 7), and post (8, 9) have been investigated for the reinforcing effect in bovine (6, 10) or human teeth (8, 9) under various simulated clinical conditions. The strength of the teeth was measured in terms of fracture resistance when tested teeth were subjected to compression test under static loading with an Instron testing machine. The promising results of root reinforcement with the use of adhesive materials and MTA have been demonstrated (11, 12). However, there are disagreements in the findings among studies such as the reinforcement effect of composite resin (4, 7).

Teeth are exposed to fluctuation of temperature and masticatory force during eating and drinking, which gradually affect the bond strength and flexural strength of the adhesive filling materials in the long term (8, 13). The literature shows limited data on the effect of thermocycling and cyclic loading on the fracture resistance of immature teeth restored with various intraradicular filling materials. The purpose of this study was to evaluate fracture resistance after thermocycling and cyclic loading of simulated human immature teeth restored with MTA, composite resin, fiber post, or gutta-percha.

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Materials and Methods

The study protocol was approved by the ethics committee of the Faculty of Dentistry, Chulalongkorn University (reference no 23/2013), Bangkok, Thailand. Human permanent maxillary central and lateral incisors were collected and stored in 0.5% chloramine-T. Under microscope examination (Carl Zeiss OPMI Proergo; Carl Zeiss Meditec AG, Jena, Germany), only teeth without resorptions, extensive caries, deformities, and crack or fracture line were included in this study.

Experimental and Control Groups

Fifty-six teeth were selected and randomly divided into 6 groups (n = 10 for each group except n = 6 for simulated immature group): group 1, intact teeth; group 2, simulated immature teeth; group 3, fiber post group; group 4, composite resin group; group 5, MTA group; and group 6, gutta-percha group. Teeth in the intact teeth group received no treatment. In the remaining teeth after the completion of access opening, root canals were enlarged by using TF Twisted Files (Sybron Endo, Glendora, CA) from size 25/.04 to 50/.04 and then followed by drilling the root canals with Peeso reamers from size 1 to 6 and Parapost drill with the diameter of 1.75 mm (Whaledent International, New York, NY). For teeth in the simulated immature group, the root canals were left unfilled. The access opening was restored with Premise composite resin (Kerr, Orange, CA).

MTA Apexification

The root canals of teeth in fiber post group, composite resin group, MTA group, and gutta-percha group were irrigated with 2.5% NaOCl and filled with UltraCal XS (Ultradent, South Jordan, UT). After 1 week, MTA (ProRoot MTA; Dentsply Tulsa Dental Specialties, Tulsa, OK) was prepared according to the manufacturer's instructions (3:1 powder/liquid ratio) and placed into the root canals with a messing gun (Endogun; Medidenta, Woodside, NY) to create a 4-mm thickness of MTA. After MTA apexification, teeth received intraradicular reinforcement with different materials, and the access opening was restored with Premise composite resin.

Intraradicular Reinforcement

In the fiber post group, the placement of size 4 UniCore quartz fiber post (Ultradent) in conjunction with the use of PermaFlo DC, a dual-cure composite luting/restorative material resin (Ultradent), was done following the manufacturer's instructions.

In the composite resin group, by following the manufacturer's instructions, root canals were backfilled with dual-cure PermaFlo DC from the MTA barrier to cementoenamel (CEJ) level.

In the MTA group, MTA was placed incrementally into the root canal to the level of CEJ.

In the gutta-percha group, root canal walls of teeth in group 6 were lightly coated with AH Plus sealer (Dentsply DeTrey GmbH, Konstanz, Germany) with a size 80 K-file, and then they received a gutta-percha backfill to the canal orifice by using an Obtura II (Obtura Spartan Endodontics, Algonquin, IL).

Thermocycling and Cyclic Loading

All teeth were thermocycled in Yamatake SDC20 temperature controller (Honeywell 4D5, Morris Plains, NJ) for 500 cycles at 5°C and 55°C with a 30-second dwell time and 5-second transfer time (6). All teeth were inserted into polyvinyl rings and mounted in self-curing acrylic resin (Dentsply GAC, Bohemia, NY) from the apex to the level of 2 mm below the CEJ. A jig as described by Tanalp et al (9) was prepared that allowed the fixation of the cylinders at an angle of 45° to the horizontal plane (Fig. 1). The cyclic loading and static loading for fracture test were performed in an Instron universal testing machine (Instron Corp, Norwood, MA). All samples were subjected to 160,000 cycles at the force of 60 N and 5 Hz frequency (simulating 6 months of oral masticatory stresses) (14). Load cycles were applied by using an attached stainless steel sphere 2 mm in diameter that contacts lingual surface of the tooth above the cingulum at an angle of 135° to the long axis of the tooth. After cyclic loading, teeth were stored in 0.5% chloramine-T at 37°C for a period of less than a week and were subjected to fracture testing.

Fracture Testing

A compressive load was applied at 135° to long axis of the tooth above the cingulum with a stainless steel chisel-shaped tip (Fig. 1) at a crosshead speed of 0.5 mm/min until fracture. Load to fracture of each sample was recorded in newtons, and fracture pattern was examined.

Statistical Analysis

Statistical analysis was performed with SPSS 17.0 (SPSS, Chicago, IL). The mean load to fracture value and standard deviation of each group were calculated. Data were analyzed by using one-way analysis of variance (ANOVA) and Tukey multiple comparison test to ascertain any significant differences between groups ($P < .05$).

Results

All teeth tested showed horizontal or oblique fracture through the cervical area of the root (Fig. 2*A–C*). Four of 10 teeth of the fiber post group showed oblique root fracture extending from cervical area to the middle third of the root (Fig. 2*D–F*). The results of the compressive force test are shown in Figure 3. The mean load to fracture of each group is presented in Table 1. One-way ANOVA revealed significant difference among treatment groups. A post hoc test with Tukey multiple comparison test showed the following:

1. Load to fracture in the simulated immature teeth group was lower than in the intact teeth group.
2. The fiber post, composite resin, and MTA groups demonstrated higher fracture resistance in comparison with the simulated immature teeth group.

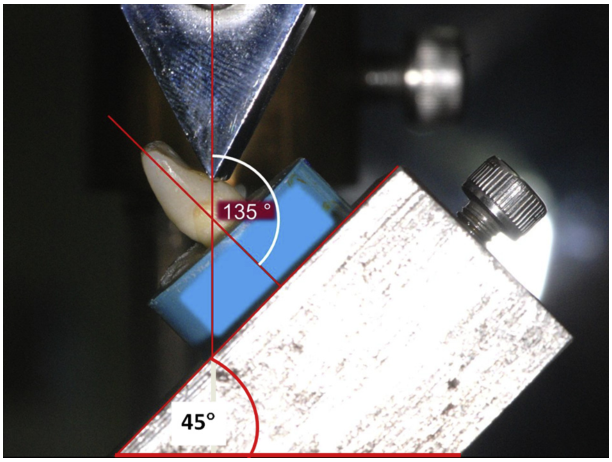

Figure 1. Compression force applied to tooth by using an Instron testing machine. Chisel-shaped Instron tip was positioned above the cingulum with 135° angle to long axis of the tooth.