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ORIGINAL RESEARCH

Comparative evaluation of Fracture Resistance of Endodontically Treated Teeth Obturated with Pozzolan-based MTA Sealer and Epoxy Resin-based Sealer: An *in vitro* Study

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ABSTRACT

Aim: To evaluate and compare the effect of epoxy resin-based sealer and a pozzolan-based mineral trioxide aggregate (MTA) sealer on the fracture resistance of endodontically treated teeth.

Materials and methods: Thirty single-rooted mandibular premolars were decoronated to a standardized root length of 15 mm. ProTaper rotary files up to a master apical file size of F3 were used for cleaning and shaping the root canals followed by 2.5% sodium hypochlorite irrigation. The teeth were randomly divided into three groups (n = 10 each), and the obturation was completed using gutta-percha with Endoseal MTA (group I) and AH Plus (group II) as root canal sealers. Group III served as control (instrumented and unfilled). Each specimen was then subjected to fracture testing by using a universal testing machine at a crosshead speed of 1.0 mm/minute until fracture. The force required to fracture each specimen was recorded and the data were subjected to statistical analysis using one-way analysis of variance (ANOVA), followed by pairwise comparison using *post hoc* Games-Howell test ($p < 0.05$).

Results: The fracture resistance of groups I and II were significantly higher than those of group III. No significant difference in the fracture resistance was observed between group I (Endoseal MTA) and group II (AH Plus) groups.

Conclusion: It can be concluded that the new root canal sealer, Endoseal MTA, is able to reinforce the tooth against fracture as good as AH Plus.

Clinical significance: Endoseal MTA is a sealer for the reinforcement of endodontically treated teeth.

Keywords: AH Plus, Endodontically treated teeth, Fracture resistance, Sealer.

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INTRODUCTION

Endodontically treated teeth are structurally different from unrestored vital teeth, and their strength is affected by several factors like excessive loss of tooth structure because of caries or trauma, dehydration of dentin, access cavity preparation, instrumentation and irrigation of the root canal, excessive pressure during root obturation, and preparation of intraradicular post space.[1] All these factors interact cumulatively to influence the stress distribution or concentration, ultimately increasing the possibility of catastrophic failures.

As endodontically treated teeth are weaker and more prone to fracture than vital teeth,[2] the obturating material that strengthens the root is mandatory.[3] Therefore, the use of a root canal sealer possessing an additional quality of strengthening the root against fracture would be of obvious value.[4]

Several root canal sealers like zinc oxide eugenol sealers, calcium hydroxide-containing sealers, glass ionomer-based sealers, resin-based sealers, and mineral trioxide aggregate (MTA)-based sealers have been used along with gutta-percha (GP) for the obturation of root canals. Among them, the most widely investigated and reported material in the recent past is AH Plus sealer. AH Plus is an epoxy resin-based sealer containing bisphenol-A and bisphenol-F epoxy resins, dibenzyldiamine, aminoadamantane, calcium tungstate, tricyclodecane diamine, zirconium oxide, silica, and iron oxide pigments. Conflicting reports have been reported regarding the effect of root canal sealers on the fracture resistance of roots. Some studies have indicated that neither zinc oxide eugenol-based sealers nor epoxy resin-based sealers were able to strengthen the endodontically treated roots significantly,[5,6] while other studies have reported positive results for epoxy resin-based sealers and glass ionomer sealers.[4,7]

Endoseal MTA is a new endodontic sealer containing calcium silicates, calcium aluminates, calcium aluminoferrite, and calcium sulfates. It is a premixed, paste-type root canal sealer based on pozzolan cement that has excellent physical and biological properties of MTA. It is preloaded in a syringe that allows direct application of the sealer into the root canal. According to the manufacturer, it has fast setting time, antibacterial effect, biocompatibility, adequate flowability, excellent film thickness, and also promotes hard tissue formation. But, the ability of this MTA sealer in enhancing the fracture resistance of endodontically treated teeth has not been investigated.

Therefore, the purpose of this study is to evaluate the effect of Endoseal MTA and AH Plus sealers on the fracture resistance of endodontically treated teeth.

MATERIALS AND METHODS

Specimen Selection and Preparation

Ethical clearance was obtained from the ethical committee (IEC 337/2016) of Manipal University, Manipal, Karnataka, India. Thirty single-rooted human mandibular premolar teeth, with completely formed apex with approximately similar buccolingual and mesiodistal dimensions, extracted for periodontal reasons were selected and stored in 0.2% sodium azide (Sigma Chemical Co, St Louis, MO, USA) at 4°C until the experiment. The teeth with calcified canals, cracks or fractures, development defects, multiple canals, root caries, and endodontically treated teeth were excluded.

The crowns of all the teeth were removed by using a diamond disk to adjust the length of the roots to a standardized length of 15 mm. The working length was determined by subtracting 1 mm from the length of an inserted #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) with its tip visualized at the apical foramen. All teeth were instrumented up to a master apical file size of F3 with ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland) by using torque- and speed-controlled electric motor (X Smart; Dentsply, Maillefer, Ballaigues, Switzerland) as per the manufacturer's instructions.

A 3 mL of 2.5% Sodium hypochlorite solution (KMC Pharmacy, Manipal, Karnataka, India) was used between each file size. After completion of instrumentation, the smear layer was removed by flushing the root canals with 3 mL of 17% ethylenediaminetetraacetic acid (EDTA) solution (Merck, Darmstadt, Germany). The canals were finally rinsed with 5 mL distilled water and dried with ProTaper paper points (Dentsply Maillefer, Switzerland).

The teeth were then randomly divided into two experimental groups and one control group (n = 10).

Grouping Method

- *Group I*: Received canal preparation and were obturated with Endoseal MTA sealer (Maruchi, Wonju, South Korea).
- *Group II*: Received canal preparation and obturated with AH Plus sealer (Dentsply DeTrey, Konstanz, Germany).
- *Group III*: Received instrumentation but no obturation (Control).

In group II, AH Plus (Dentsply DeTrey, Konstanz, Germany) base and catalyst were mixed according to the manufacturer instructions and introduced into the root canal using lentulospiral (Dentsply, Maillefer, Ballaigues, Switzerland) at 300 rotations per minute, whereas in group I, Endoseal MTA (Maruchi, Wonju, South Korea) was introduced into the root canal via intracanal tip, inserted into the canal, not less than the coronal one-third. An F3 master GP cone (Dentsply Maillefer, Switzerland) with good tug-back was coated with sealer and slowly inserted into the canal until the working length was reached. Excess GP was removed with a hot instrument and all the filled root specimens were subsequently sealed with temporary filling material (Cavit-G, Espe Dental, Seefeld, Germany).

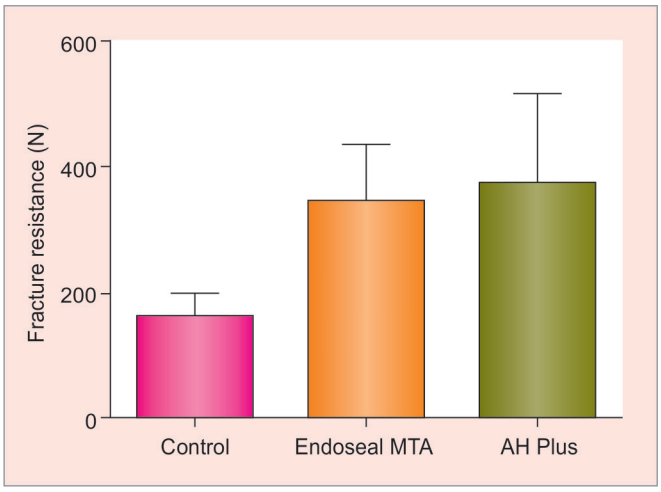
Mesiodistal and buccolingual radiographs were taken to ensure homogeneous adequate root filling without voids and then the teeth were stored at 37°C at 100% humidity for 7 days to allow the sealer to set.

Mechanical Testing

To simulate a periodontal membrane, the apical 10 mm of all roots was covered with wax before embedding the roots into acrylic resin. Each tooth was then mounted vertically in cold cure acrylic resin (Imicryl, Konya, Turkey) using a metal mold of dimensions 2.5 × 2.5 × 3 cm exposing 5 mm of the coronal part of the roots.

As soon as polymerization of the acrylic resin started, the roots were removed from the resin, and the wax was cleaned from the root surfaces by using a curette. The cleaned root surfaces were coated with a thin layer of medium body polyvinylsiloxane impression material (Coltene/Whaledent AG, Altstatten, Switzerland), and then they were again embedded back into acrylic resin which was allowed to polymerize overnight.

A universal testing machine (Instron 3366, Inston corp, Canton, MA, USA) was used for testing the fracture resistance. The acrylic blocks were fixed on the lower plate of the machine and the upper plate consisted of a spherical steel tip with a diameter of 1.5 mm. The tip was centered over the canal orifice, and a slowly increasing vertical force was exerted at a crosshead speed of 1 mm/minute until fracture. The maximum force required to fracture each specimen was recorded in Newtons.



Graph 1: Mean fracture resistance and standard deviations for all the groups

All the analysis was done using Statistical Package for the Social Science (SPSS) version 18. Comparison among the three groups was done using one-way analysis of variance (ANOVA) with *post hoc* Games-Howell test at a confidence interval of 95%.

RESULTS

The mean values and their respective standard deviations of the force required to fracture the roots are presented in Graph 1.

Among the groups, group II (AH Plus sealer) had the highest fracture resistance, followed by group I (Endoseal MTA), and then group III (control). Both test groups exhibited significantly higher fracture resistance compared to control group ($p < 0.001$). However, no significant difference in the fracture resistance among the test groups was observed ($p > 0.05$).

Two fracture modes were detected, a split vertical fracture that extended along the long axis of the root and a comminuted fracture that shattered the root into fragments. The most common fracture mode observed was the split vertical fracture in buccolingual direction.

DISCUSSION

The primary goal of endodontics is not only to restore the tooth structure but also to increase the inherent strength of the remaining tooth structure. As the endodontically treated teeth are weaker compared to natural tooth, fatigue failures might result even from normal functional stresses and from increased functional and parafunctional stresses.[8] In order to avoid such situations, various endodontic filling materials can be used to reinforce the endodontically treated tooth and improve its fracture resistance.[9,10]

In the present study, the effectiveness of Endoseal MTA sealer on fracture resistance was compared with that of AH Plus sealer. The results showed that the fracture resistance of AH Plus and Endoseal MTA sealer reinforced teeth was superior when compared to the fracture resistance of unreinforced teeth (control group). The highest mean fracture value was found in the teeth obturated with GP and AH Plus (Group II). This is because of greater adhesion of AH Plus to root dentin than Endoseal MTA. Sagsen et al[11] showed that AH Plus sealer increased the fracture resistance of instrumented root canals. AH Plus has already been proven to have better penetration into the microirregularities because of its creep capacity and long polymerization period.[12] The retention of the filling material may be improved by mechanical locking between the canal walls and the sealers resulting in greater resistance to fracture.[11]

In the previous research study by Mandava et al,[8] teeth obturated with AH Plus showed the highest fracture resistance compared to those with Meta SEAL and MTA Fillapex. The results of our study are in accordance with these findings.

Mineral trioxide aggregate-based root canal sealers have been recently used in root canal obturation because of their high biological compatibility and favorable biological response obtained in laboratory tests and clinical applications.[13,14] An earlier study by Tanalp et al,[15] it was reported that MTA Fillapex did not improve the fracture resistance of immature teeth. Contrary to that, another study demonstrated that MTA Fillapex did increase the fracture resistance of endodontically prepared teeth.[12]

The ability of an obturating material to reinforce the tooth depends on its ability to flow or penetrate into the dentinal tubules, which in turn depends on the size of the dentinal tubules, the particle size of the material, and the rate of reaction of the material.[16] The greater fracture resistance values obtained for Endoseal MTA in the present study can be attributed to its higher flow rates and biomineralization of dentinal tubules.[17] Lim et al reported that Endoseal MTA exhibited significantly higher flow compared to AH Plus sealer. Endoseal MTA is a premixed material supplied in syringes and the freshly extruded mix exhibits thixotropic behavior. Its flow is further facilitated by low mean particle size of 1.5 µm,[18] which allows it to penetrate into ramifications and irregularities of root canal system there by reinforcing the tooth.[19] Though, Endoseal MTA does not bond to dentin, it causes interfacial deposition of hydroxyapatite, which increases the frictional resistance of the obturating material, thus enhancing the fracture resistance of the tooth. This was confirmed in an earlier study which showed that Endoseal MTA enhanced biomineralization of the dentinal tubules beyond the penetrated sealer tag (350–400 µm from the tubule orifice) as observed under scanning electron microscope.[18]

Topcuoglu et al[20] used Tech Biosealer Endo, an MTA-based sealer in the form of a powder and liquid for obturation and reported that it did not increase the root fracture resistance of the teeth, indicating that powder/liquid formulation exhibit less flow compared to paste formulations. In the present study, both AH Plus and Endoseal MTA are supplied as pastes and showed increased fracture resistance possibly due to higher flow and better penetration into dentinal tubules than sealers with a powder/liquid formulation.

As in other mechanical studies,[5,6] the force in the present study was applied along the long axis of the root resulting primarily in a splitting stress applied over the access opening. This is more clinically relevant as it better simulates the support given to healthy teeth by alveolar bone and results in less catastrophic stress buildups caused by unrealistic bending movements.[3]

CONCLUSION

Within the limitation of this *in vitro* study, it can be concluded that the new root canal sealer Endoseal MTA has the potential to reinforce endodontically treated teeth, and it showed no significant difference in the fracture resistance as compared to AH Plus.

CLINICAL SIGNIFICANCE

Endoseal MTA can be considered as a sealer of choice to improve the fracture resistance of endodontically treated teeth.

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