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Research Article

Comparative Evaluation of Fracture Resistance of Root Dentine of Two MTA based Sealers and a Resin Sealer - An *In Vitro* Study

Meenu G Singla[1]* and Usha Tanwar[2]

[1]Professor, Department of Conservative and Endodontics, SRCDSR, Faridabad, Haryana, India

[2]Private Practitioner, India

***Corresponding Author:** Meenu G Singla, Professor, Department of Conservative and Endodontics, SRCDSR, Faridabad, Haryana, India.

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Abstract

Aim: To evaluate and compare the ability of two MTA based sealers: MTA Plus and EndoSeal MTA and an epoxy resin based sealer: AH Plus, to enhance the fracture resistance of root canal treated teeth.

Materials and Methods: Sixty-five single rooted mandibular premolars were decoronated at cementoenamel junction and were randomly divided into five groups: two control (n = 10) and three experimental (n = 15). Biomechanical preparation of root canals was done using Hero Shaper rotary files along with 3% sodium hypochlorite irrigation. Obturation was done using gutta percha with different sealers according to the groups- AH plus (group 3), EndoSeal MTA (group 4) and MTA Plus (group 5). Fracture resistance of the roots was evaluated using a Universal Testing Machine (UTM) under vertical loading.

Statistical Analysis: Inter-group comparison was done using One way analysis of variance (ANOVA) and Post-hoc bonferroni test.

Results: Among the three experimental groups, highest fracture resistance was shown by group 3 followed by group 4 then group 5. There was no statistically significant difference between group 3 and negative control group. Group 5 was not statistically significant than the positive control group.

Conclusion: EndoSeal MTA has the potential to reinforce root canal treated teeth and it was comparable to AH Plus.

Keywords: AH Plus; EndoSeal MTA; Fracture Resistance; MTA Plus; Obturation

Abbreviations

VRF: Vertical Root Fractures; UTM: Universal Testing Machine

Background

Vertical root fractures (VRF) are one of the most serious complications of root canal treatment and often lead to tooth extraction [1]. VRF may be extended from the root canal to the external root surface [2]. It is generally accepted that the amount of remaining tooth structure directly affects the strength of an endodontically treated tooth [3]. An endodontically treated tooth is weaker and more prone to fracture than vital tooth. Thus, it is imperative to use the obturating materials that strengthen the root [4].

An ideal root canal sealer should offer an excellent seal when set, dimensional stability, sufficient setting time to ensure enough working time, insolubility against tissue fluids, biocompatibility and proper adhesion with canal walls to strengthen the tooth [5,6]. Endodontic sealers or cements are categorized based on their prime constituent or chemical structure, such as: calcium hydroxide, zinc oxide eugenol, glass ionomer and epoxy resin that are used along with gutta-percha [7].

Recently, tricalcium silicate based sealers have been introduced after the increase in popularity of MTA (Mineral Trioxide Aggregate) due to its calcium releasing ability and bioactivity [8]. The sealing ability of MTA is largely attributed to its bioactive capacity to form an apatite layer [9]. Studies have been done to evaluate adhesive properties of MTA based sealers to root dentin. A study by Assmann., *et al*. stated that acceptable resistance to dislodgement was presented by MTA Fillapex, which was similar to AH Plus sealer filled samples while another MTA based sealer Endo-CPM had greater resistance to push-out bond strength than MTA Fillapex [10]. Another study by Mandava J., *et al*. reported that MTA Fillapex showed lower fracture resistance when compared with AH Plus and MetaSEAL [11]. A study by Sagsen., *et al*. reported that MTA Fillapex had the lowest push-out values to root dentin as compared with AH Plus and iRoot SP (another calcium silicate based sealer) [12]. This shows that all the MTA based sealers do not show similar results.

Majority of the studies of MTA based sealers are based on bond strength to root dentin but very few studies have been done to evaluate the fracture resistance of root canal treated teeth when various MTA based sealers are used.

A new MTA based sealer: MTA Plus (Prevest Denpro Limited, Jammu) has been introduced which is similar in composition to ProRoot MTA (Dentsply) but is ground finer. It has a greater surface area and less setting time than that of MTA because of its smaller particle size [13]. It is indicated as a root canal sealer as well as a root end filling material and a pulp capping cement [14].

Another pozzolan based MTA sealer, EndoSeal MTA (Maruchi, wonju, Korea), has recently been introduced. The incorporation of small particle pozzolan cement, resulted in a fast setting MTA without the addition of a chemical accelerator. It induces dentinal tubule biomineralization and has satisfactory biological and physical properties, favourable cytocompatibilty, and superior sealer distribution [15].

Objective of the Study

The objective of this study was to evaluate the ability of these two newly introduced MTA based sealer i.e. MTA Plus and EndoSeal MTA to increase the fracture resistance of endodontically treated root and compare it with an epoxy based resin i.e. AH Plus.

Materials and Methods

Sixty-five single rooted mandibular premolars meant for extraction for orthodontic purposes were taken for this study. Teeth were examined with the help of magnifying loupes to rule out any fracture or craze lines. Both labiolingually and mesiodistally directed radiographs were taken to confirm that each tooth had a single canal. The teeth were decoronated maintaining standard root length of 14 mm using a flexible diamond disc. Buccolingual and mesiodistal dimensions and root length of all selected teeth were measured using a digital caliper. All the roots were of similar dimensions measuring 5 ± 1 mm buccolingually and 4 ± 1 mm mesiodistally.

Samples were randomly divided into two control (group 1 and 2) (n = 10 teeth each) and three experimental (n = 15 each) groups.

Grouping method

- Group 1: Negative control (No instrumentation or obturation).
- Group 2: Positive control (Instrumentation but no obturation).
- Group 3: Instrumentation followed by obturation with AH Plus sealer (Dentsply, Germany).
- Group 4: Instrumentation followed by obturation with EndoSeal MTA (Maruchi, wonju, Korea).
- Group 5: Instrumentation followed by obturation with MTA Plus (Prevest Denpro Limited, Jammu).

For the determination of working length (Group 2 - 5), a 10 K file was inserted in the root canal, till the file tip was seen exiting the apical foramen. Working length was measured and adjusted to 1 mm less to get the working length. Samples were instrumented using rotary Hero shaper files (micro mega) in a sequential manner till 30 no. with 6% taper in a crown down manner. Irrigation was done using 2 ml of 3% Sodium hypochlorite and normal saline. Apical patency was maintained by recapitulation with a size 10 K-file during shaping and cleaning of the canals. A final rinse of 17% EDTA for 1 minute followed by 5 ml normal saline was done to remove smear layer. The samples were then dried using no. 30 paper points. Mixing of the sealers was done according to the manufacturer instructions and the canals were coated with respective sealers (Group 3 - 5) using lentulospirals followed by obturation with Gutta percha cones of size 30 no. with 6% taper.

Post obturation radiographs were taken for all the experimental root samples, in both the bucco-lingual and mesio-distal directions to ensure a homogeneous and adequate root filling without any voids. Teeth were kept in 100% humidity for 72 hours at 37°C to allow the sealer to set. All the roots were mounted in cold cure acrylic resin blocks and resin was allowed to polymerize for 1 hour. Fracture resistance of the roots was evaluated using a UTM with a conical tip (tip diameter of 2.2 mm), aligned with the center of the canal orifice to contact the gutta-percha, parallel to long axis of each specimen. The tip of the rod was inserted into the root canal at a crosshead speed of 0.5 mm/min. The rod tip gradually applied a force within the canal through the gutta percha without touching the canal wall and stopped immediately after fracture was detected. The force at which each tooth fractured was recorded in Newtons (N).

Collected data was tabulated and subjected to analytical testing using SPSS version 21. Overall group comparison was done using one way ANOVA test. Inter-group comparison was done using Post-hoc bonferroni test.

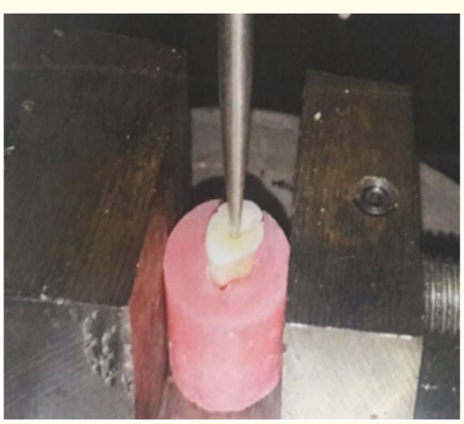

Figure 1: Fracture strength measurement using universal testing machine.

Results

Group 1 (negative control group) required the highest mean force to fracture (531.50) compared to rest of the groups. Group 3 (Resin based sealer) (475.53), group 4 (EndoSeal MTA) (406.00) and group 5 (MTA Plus) (353.60), required a higher mean force to fracture the tooth than the positive control group (231.50), but it was found to be less than the group 1. Group 3 showed maximum and group 5 showed minimum mean fracture resistance value out of the experimental groups. Group 3 showed highest fracture resistance among the experimental groups and the difference was significantly higher than group 4. There was no statistically significant difference between group 3 and group 1.

	Gr 2	Gr 3	Gr 4	Gr 5
Gr 1	<0.0001, S	1.00, NS	<0.001 S	0.034S
Gr 2	-	<0.0001, S	0.043, S	<0.001, S
Gr 3	<0.0001, S	-	0.017, S	0.675, NS
Gr 4	0.043, S	0.017, S	-	1.000, NS

Table 1: Inter-group comparison of fracture resistance of all five groups.

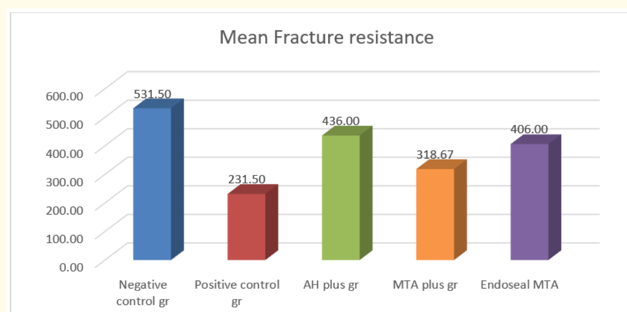

Figure 2: Mean fracture strength of different groups.

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 [3].

Due to the growing interest in reinforcing the root canal system, there has been development of adhesive root canal sealers which has ability to enhance the fracture resistance [16]. So, this study was conducted to evaluate and compare the fracture resistance of root canal treated teeth with the use of two MTA based sealers: MTA Plus and EndoSeal MTA and an epoxy resin based sealer: AH Plus.

Mandibular premolars were selected for this study as they have circular cross-section in mid to apical region which results in uniform distribution of load and they also simulate the clinical situation where chewing forces are maximum [17].

Standardization of samples was done by decoronating the teeth to maintain a root length of 14 mm. All the roots were of similar dimensions measuring 5 ± 1 mm buccolingually and 4 ± 1 mm mesiodistally. The teeth were prepared using Hero shaper rotary files (Micro Mega) till size 30 - 6% in a sequential manner as rotary instrumentation consumes less time and is more effective in shaping and cleaning of the canal walls [18]. The apical enlargement upto 30 - 6% was done to achieve effective cleaning without thinning of the root dentin [11]. A standard irrigation regimen, using 2 ml of 3% sodium hypochlorite, final rinse of 17% EDTA for 1 minute followed by 5 ml normal saline was used to remove the smear layer.

The teeth were mounted in cold cure acrylic resin blocks without periodontal ligament simulation with elastomeric material, as in few studies [19], Ribeiro., *et al*. (2008) [20], Saw and Messer (1995) [21] it has been shown that attempts to mimic the anatomical and biological aspects of tooth structure are insufficient and could contribute to the introduction of artificial changes in force distribution themselves. Soros., *et al*. (2008) [22] stated that elastomeric materials are incapable of withstanding compaction forces in the way that the natural ligament does and that they may collapse under pressure.

Fracture resistance value was found to be maximum in negative control (group 1) and minimum in positive control (group 2). Out of the experimental groups, maximum fracture resistance value was found in AH plus (group 3), followed by EndoSeal MTA (group 4) and least with MTA Plus (group 5). The results showed that no statistically significant difference was found between AH plus group (group 3) and negative control group (group 1). The result is in accordance with a study conducted by Mandava J., *et al*. (2014) [11] who also found insignificant difference in fracture resistance between intact teeth and teeth that were obturated with AH Plus. Kala M., *et al*. (2014) [17] and Mittal A., *et al*. (2017) [3] stated that AH plus along with GP increased the fracture resistance of instrumented teeth. AH Plus has long polymerization period which is already been proven to result in better penetration into the microirregularities. 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 [4].

Statistically no significant difference was found between the fracture resistance of AH Plus and EndoSeal MTA group which is a pozzolan based cement. MTA products derived from pozzolan cement show faster setting time and higher wash-out resistance than those of other MTA products [23]. Present study result is in accordance with a study done by Upadhyay., *et al*. (2017) [4] who also reported EndoSeal MTA to have statistically similar fracture resistance to AH Plus. According to them, the particle size of EndoSeal MTA is 1.5 µm, which allows it to penetrate into ramifications and irregularities of root canal system thereby reinforcing the tooth. Although, Endoseal MTA does not bind to dentin, it increases the frictional resistance of the obturating material due to interfacial deposition of hydroxyapatite, thus enhancing the fracture resistance of the tooth. Lim ES., *et al*. (2015) [24] reported that EndoSeal MTA exhibited significantly higher flow compared to AH Plus sealer. The fracture resistance of EndoSeal MTA might be attributed to its higher flow rates and biomineralization of dentinal tubules.

MTA Plus (Group 5) showed least fracture resistance among all the experimental groups, which is available as powder and gel form, although it showed higher fracture resistance than the positive control group values. A study conducted by Formosa LM., *et al*. (2014) [25] reported that the use of the gel instead of water resulted in a decrease in pushout strength, which might be attributed to the increased viscosity the gel imparts to the cement paste, which may affect marginal adaptation. Another study conducted by Neelkantan P., *et al*. (2015) [26] reported that MTA Plus mixed with the gel showed a reduction in bond strength owing to the viscosity of the gel and it also showed that the bond strength of MTA Plus depends on the irrigation protocol. It was also founded that irrigation with EDTA decreases the sealing efficacy of MTA Plus group. In our study the final irrigant was EDTA followed by saline. There is a possibility of some amount of EDTA being left over in the canals, which may interfere in the bonding of MTA Plus. This could be the reason that MTA Plus group showed least fracture resistance in our study.

On the basis of the present study, 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, but further studies should be carried out to evaluate the fracture resistance of teeth using MTA Plus without the use of EDTA as final irrigant.

Conclusion

1. AH Plus showed the highest fracture resistance and it was not significantly different from the negative control group (uninstrumented).
2. EndoSeal MTA showed high fracture resistance and the results were comparable to AH Plus.
3. MTA Plus showed least fracture resistance out of the three experimental groups, although the values were higher than the positive control group but the difference was not statistically significant.

Prior Publication

Nil.

Support

Nil.

Conflicts of Interest

Nil.

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