Relative Assessment of Fracture Resistance of Endodontically Treated Teeth with Epoxy Resin-Based Sealers, AH Plus, MTA Fillapex, and Bioceramic Sealer: An In vitro Study

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Abstract

Aim: This study aims to analyze and compare the fracture resistance of endodontically treated extracted teeth with epoxy resin-based sealers AH Plus, MTA Fillapex, and Bioceramic Sealer. Materials and Methods: Single-rooted mandibular premolars (sixty) were divided into three groups (n = 20 each) after decoronation at cementoenamel junction. Root canal preparation was carried out using ProTaper rotary files, and sodium hypochlorite in 3% concentration was used for irrigation. Finally, obturation was accomplished with AH plus (Dentsply, Germany) (Group 1), MTA Fillapex (Angeles, Brazil) (Group 2) and Bioceramic (Brasseler, USA, Savannah, GA) (Group 3) sealers and gutta-percha. Fracture point in the root was recorded using universal testing machine. The data were analyzed statistically using one-way analysis of variance. This was followed by pair-wise comparison using Tukey’s post hoc test. Results: Bioceramic Sealer showed better fracture resistance. This was followed by MTA Fillapex and AH Plus. However, the results among the three groups were not statistically significant. Conclusion: The highest fracture resistance was offered by Bioceramic Sealer when compared with MTA Fillapex and AH Plus.

Keywords: AH Plus sealer, Bioceramic Sealer, endodontic monoblocks, MTA Fillapex sealer, universal testing machine, vertical root fracture

INTRODUCTION

After endodontic treatment, teeth are structurally different from untreated vital teeth, so these teeth require specialized treatment. The toughness of an endodontically treated tooth is associated to the tooth structure left.[1,2] In vertical root fracture, resection of the affected root or extraction of the tooth is mandatory. Hence, this is a serious concern as there is an unfavorable prognosis leading to endodontic failure. One major cause for tooth fracture is found to be endodontic treatment in many in vivo studies.[3,4]

Vital teeth are less prone to fracture than nonvital teeth.[5] It is a well-known fact that loss of structural integrity associated with the access preparation results in increased cuspal deflection during function leading to a higher occurrence of fractures. It is difficult to establish whether the occurrence of fractures depends on change in dentin structure or missing tooth structure.[5,6] If endodontically treated teeth are not restored immediately, there is bacterial contamination and coronal microleakage, and this can lead to retreatment or endodontic failure. Hence, bonded restorations must be used to avoid microleakage.[7]

To compensate the weakening effect, obturating materials must be used. Due to the use of resin-based adhesive sealers, the potential to strengthen the endodontically treated teeth have increased. So to strengthen the root, bonding of root canal sealer to dentin may be required. Sealers that bond well with dentin must create monoblocks within the canal space.[8,9]

MATERIALS AND METHODS

This study used 60 mandibular premolars (single rooted and noncarious). To remove the superficial soft tissue and surface disinfectant, the teeth were soaked in 5% sodium hypochlorite for 24 hours. Root canal preparation was carried out using ProTaper rotary files, and sodium hypochlorite in 3% concentration was used for irrigation. Finally, obturation was accomplished with AH plus (Dentsply, Germany) (Group 1), MTA Fillapex (Angeles, Brazil) (Group 2) and Bioceramic (Brasseler, USA, Savannah, GA) (Group 3) sealers and gutta-percha. Fracture point in the root was recorded using universal testing machine. The data were analyzed statistically using one-way analysis of variance. This was followed by pair-wise comparison using Tukey’s post hoc test. Results: Bioceramic Sealer showed better fracture resistance. This was followed by MTA Fillapex and AH Plus. However, the results among the three groups were not statistically significant. Conclusion: The highest fracture resistance was offered by Bioceramic Sealer when compared with MTA Fillapex and AH Plus.

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hypochlorite (NaOCl) solution for 2 h. The collected teeth were checked for craze lines, fractures, multiple canals, calcifications by preoperative radiographs. This was followed by decoronation 1 mm coronal to the cementoenamel junction. The teeth were divided into three experimental groups, and access preparation was done using #245 bur, and the patency of the canal was checked. For establishing the accurate working length, a size 10 k file was inserted into the canal (with the instrument tip visible at the apical foramen), and then 1 mm was subtracted from this length.

Using 1:64 gear reduction Anthogyr handpiece (Dentsply) at a speed of 300 rpm cleaning and shaping of the root canals were done with ProTaper rotary Ni-Ti files (Dentsply Maillefer, Switzerland). For irrigation, NaOCl solution in 3% was used. Obturation was done with F3 gutta-percha (Dentsply Maillefer) after confirming the fit of master cone in radiograph.

**Grouping method**

1. Group 1: Preparation done and AH Plus sealer used for obturation
2. Group 2: Preparation done and MTA Fillapex sealer used for obturation
3. Group 3: Preparation done and Bioceramic Sealer used for obturation

Irrigation with 17% ethylenediaminetetraacetic acid (EDTA) and 3% NaOCl was done for 1 min before obturation, and a final flush was done with normal saline (5 ml) and dried with absorbent paper points. Than the sealers were mixed as per the manufacturer’s instructions and using lentulospirals at 300 rpm, the root canals were coated, and obturation was done with F3 ProTaper gutta-percha points. Radiographs in labiolingual and mesiodistal directions were taken after obturation to ensure proper filling of the material. To permit the sealers to fully set, the specimens were housed in incubator (Asian Universal Testing Machine) for 24 h in 100% humidity. The teeth were then fixed in resin blocks vertically about 2 mm below cementoenamel junction. The root samples were tested for resistance in universal testing machine. To apply force to the root for vertical root fracture, a 2.2 mm diameter steel rod (cylindrical) with a pointed tip was attached to the upper part of the universal testing machine. For this, load (at a speed of 0.5 mm/min) was exerted vertically. This was carried out till fracture of the root takes place, and it was observed that most of the samples fractured with a crack that was audible. The force was recorded in Newton.

The fracture load was changed to megapascals (from Newtons) by using the following formula

\[
\text{MPa} = \frac{\text{Maximum load in Newtons (N)}}{\pi \times \left( \frac{\text{Area of cross - section of plunger of contact}}{4} \right)^2}
\]

- \(\pi = 3.14\) (constant value)
- Area of cross-section of plunger = 2.2 (uniform for all specimens).

To examine the forces of root fracture, one-way analysis of variance (ANOVA), was used. Then Tukey’s multiple post hoc test was used to compare the groups. Finally, at confidence level of 95%, statistical analysis was carried out.

**RESULTS**

The readings were recorded in master chart, and the data analysis was carried out statistically using one-way ANOVA.

The mean force required to fracture the Bioceramic Sealer was higher (474.8 MPa) compared to MTA Fillapex and AH Plus [Table 1]. MTA Fillapex (397.9 Mpa) sealer had a mean force to fracture higher than the epoxy resin-based sealer AH Plus (266.2 Mpa).

From the results [Table 2], significant difference was observed between groups \(F = 12.205, P < 0.05\) at 5% level of significance. The mean fracture resistance values for Bioceramic Sealer [Figure 1] was higher than MTA Fillapex [Figure 2] but was not statistically significant. AH Plus [Figure 3] showed lesser resistance to fracture when compared to MTA Fillapex but statistically not significant. Analysis of variance and Tukey’s significance difference post hoc tests were run on the data to determine significant differences between the groups at \(P < 0.05\). Hence, there was no notable difference between all the three groups [Table 3].

**DISCUSSION**

Reinforcing the remaining tooth structure is also one of the primary goals of endodontics and not just treating the diseased

![Figure 1: Graph recorded from Bioceramic group displaying gradual rise in fracture force (n) against insertion depth in millimeters](image)
As adherence of Bioceramic to root dentin is greater than MTA Fillapex and AH Plus, might be the reason for the result in the present study which showed that Bioceramic has significantly higher fracture resistance than MTA Fillapex and AH Plus [Table 1].

Due to the production of hydroxyapatite throughout setting, Bioceramic formulates a bond (chemical) in the presence of dentine. Also because of its hydrophilic nature, it has low contact angle, thereby allowing an easy spread over the canal walls. This impart a strong and healthy hermetic seal.

MTA Fillapex sealer should also be able to strengthen the roots as they have a compressive elastic modulus similar to dentin, and also have the potential to form hydroxyapatite. These results are similar with the studies done by Buraksagsen et al. (2012) and Mandava et al. However, MTA Fillapex did not strengthen the root as much as Bioceramic did in the present study. This could be due to low bonding of MTA to dentin.

Factors such as poor cell adhesion, decreased hardness, low biocompatibility, and interference in hydration could result when MTA Fillapex is treated with 17% EDTA. In a study conducted by Assmann et al. (2012) and Mandava et al. However, MTA Fillapex did not strengthen the root as much as Bioceramic did in the present study. This could be due to low bonding of MTA to dentin.

In this study, mandibular premolars were preferred as they are fracture prone due to their crown size, anatomy, crown/root ratio, and function. Also because of their placement in the dental arch, they are exposed to both shear and compressive forces.

It was noted in the present study, that fracture in most of the specimens took place in facio lingual directions as stated by Lertchirakarn et al. The physicochemical communication between filling material, sealer, and root canal wall, leads to adherence between resin-based sealers, and dental structures. The inclination of the dentinal wall, sealant, and resin core, gave them the capacity to strengthen the walls against fracture.

| Table 1: Descriptive statistics of the three groups |
|--------------------------------------------------|
| Descriptive                                         |
| Fracture resistance (MPa)                          |
| $n$ Mean SD SE 95% CI for mean Minimum Maximum     |
| Lower bound Upper bound                            |
| AH Plus 20 184.755 44.7728 10.0115 163.801 205.709 110.3 266.2 |
| MTA Fillapex 20 241.123 108.535 24.2692 190.327 291.920 21.3 397.9 |
| Bioceramic 20 .220 72.8798 16.2964 275.112 343.329 203.4 474.8 |
| Total 60 245.033 93.7178 12.0989 220.823 269.243 21.3 474.8 |
| SD: Standard deviation, SE: Standard error, CI: Confidence interval |

| Table 2: Comparison of fracture resistance within groups and between groups |
|--------------------------------------------------------------------------|
| ANOVA Fracture resistance (MPa)                                          |
| Sum of squares df Mean square F P                                         |
| Between groups 155375.121 2 77687.561 12.205 0.000                      |
| Within groups 362823.851 57 6365.331                                  |
| Total 518198.972 59                                                     |
| ANOVA: Analysis of variance                                               |

As adherence of Bioceramic to root dentin is greater than MTA Fillapex and AH Plus, might be the reason for the result in the present study which showed that Bioceramic has significantly higher fracture resistance than MTA Fillapex and AH Plus [Table 1].

Due to the production of hydroxyapatite throughout setting, Bioceramic formulates a bond (chemical) in the presence of dentine. Also because of its hydrophilic nature, it has low contact angle, thereby allowing an easy spread over the canal walls. This impart a strong and healthy hermetic seal. MTA Fillapex sealer should also be able to strengthen the roots as they have a compressive elastic modulus similar to dentin, and also have the potential to form hydroxyapatite. These results are similar with the studies done by Buraksagsen et al. (2012) and Mandava et al. However, MTA Fillapex did not strengthen the root as much as Bioceramic did in the present study. This could be due to low bonding of MTA to dentin.

Factors such as poor cell adhesion, decreased hardness, low biocompatibility, and interference in hydration could result when MTA Fillapex is treated with 17% EDTA. In a study conducted by Assmann et al. when MTA Fillapex and AH Plus were treated with 17% EDTA they had similar bond strengths, handling characteristics, and pattern of failure. According to Sarkar et al. AH Plus sealer showed the lowest
Yendrembam, et al.: Fracture resistance of endodontically treated teeth with different sealers: An in vitro study

Table 3: P value for fracture resistance among the groups using post hoc test

| Group (I) | Group (J) | Mean difference (I-J) | SE | P     | 95% CI       | Lower bound | Upper bound |
|----------|-----------|----------------------|----|-------|-------------|-------------|-------------|
| AH Plus  | MTA Fillapex | −56.3685             | 25.2296 | 0.074 | −117.081    | 4.344       |
| Bioceramic | MTA Fillapex | −124.4655*          | 25.2296 | 0.000 | −185.178    | −63.753     |
| MTA Fillapex | AH Plus | 56.3685              | 25.2296 | 0.074 | −4.344      | 117.081     |
| Bioceramic | MTA Fillapex | −68.0970*          | 25.2296 | 0.024 | −128.810    | −7.384      |
| Bioceramic | AH Plus | 124.4655*           | 25.2296 | 0.000 | 63.753      | 185.178     |
| Bioceramic | MTA Fillapex | 68.0970*           | 25.2296 | 0.024 | 7.384       | 128.810     |

*The mean difference is significant at the 0.05 level. HSD: Honestly significant difference, SE: Standard error, CI: Confidence interval

CONCLUSION

On the groundwork of the findings presented, it may be concluded that
1. The highest fracture resistance within the sealer groups was shown by Bioceramic and followed by MTA Fillapex and AH Plus
2. MTA Fillapex showed reasonable fracture resistance values in comparison with AH Plus, despite the lower bond strength compared to Bioceramic
3. However, the result among the three groups was not statistically significant.

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Conflicts of interest
There are no conflicts of interest.

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Figure 3: Graphs recorded from AH Plus Group displaying gradual rise in fracture force (n) against insertion depth in millimeters

Within the constraint of the present study, it can be winded up that the Bioceramic Sealer improve the fracture resistance of endodontically treated teeth more than MTA-based sealer (MTA Fillapex) or with epoxy resin-based sealer (AH Plus).

However, it is recommended to evaluate the long-term effect and the ability of all the sealers to enhance the resistance to fracture of the endodontically treated teeth.
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