Review Article

Evaluate and Compare the Effect of Different Root Canal Sealers on the Fracture Resistance of Endodontically Treated Teeth using AH Plus, Apexit Plus, Bioceramic MTA Root Canal Sealers

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Abstract

After a root canal, teeth are more prone to fracture, with studies showing a prevalence between 4% and 32%. This vulnerability is often attributed to the removal of dentin during the procedure, which compromises the tooth's structural integrity. While traditional methods such as posts and cores are used to strengthen these teeth, a new approach focuses on the root canal sealer itself. Beyond its primary function of sealing the canal, a new generation of sealers is being explored for its potential to reinforce the remaining dentin. This study will compare three different types of sealers – AH Plus, Apexit Plus, and mineral trioxide aggregate bioceramic – to determine if they can increase the fracture resistance of endodontically treated teeth. The null hypothesis is that these sealers do not provide any fracture resistance.

Keywords: Endodontically treated teeth, Fracture resistance, Root canal sealers.

Introduction

Endodontically treated teeth (ETT) are at a higher risk of fracture than teeth with vital pulp tissue. The prevalence of fractures varied from 4% to 32%.[1] Although most debated, the theories explaining the fracture proneness of (ETT) include increased brittleness of dentin due to reduced moisture, loss of dentin bulk due to cavity preparation, overzealous instrumentation, etc., hampering the structural durability. In addition, excessive pressure during obturation of the canal has also been associated with the fracture of ETT.[2,3]

One of the main purposes of the restoration of teeth is to reinforce the remaining weak structure and make it functional. Similarly, obturation of the canal, apart from providing the seal, would be of great benefit if it could reinforce the dentin. Gutta-percha, being the most commonly used restorative for obturation, does not provide adequate modulus of elasticity.[4] Although age-old methods of canal reinforcement, such as posts, core build-up, and fiber-reinforced composite materials[5,6] are in use, a novel technique of utilizing canal sealer as dentin-reinforcing materials has been drawing attention.

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Canal sealers perform a multitude of functions, ranging from lubrication, as a binding agent between the gutta-percha and canal wall, to filling of anatomical spaces that the primary filling material has failed to reach. Together with the gutta-percha, they provide a complete peri-radicular seal of the canal from the microenvironment. Hence, the concept of the sealer performing as a canal reinforcement has emerged, leading to the development of various types of sealers that can act as adhesives within the canal wall and provide adequate reinforcement against fracture. They are classified as resin-based, silicate-based (bioceramics), calcium hydroxide-based, and silicone-based sealers.[7]

AH Plus is a resin-based sealer that is known to provide a tight seal between the filling and the radicular dentin. Mineral

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trioxide aggregate (MTA) bioceramic is a silicate-based hydrophilic sealer with good biocompatibility. Apexit Plus is a calcium hydroxide-based sealer, known for its additional antimicrobial property.[8,9]

Hence, the present study aimed to evaluate and compare three root canal sealers, namely AH Plus, Apexit Plus, and Bioceramic MTA, for their fracture resistance when applied to ETT.

Null hypothesis of the study is that the application of root canal sealers does not aid in fracture resistance of ETT.

Materials and Methods

Mandibular premolars ($n = 40$) extracted for periodontal and orthodontic purposes were collected for the study. Teeth with caries, cracks, obliterated/calcified canals, multiple canals root caries, and ETT were excluded [Figure 1]. Once collected, soft periodontal tissue was removed from the teeth using a periodontal curette. Were rinsed under running water and stored in 0.1% thymol solution until further usage. Decoronation with a diamond disc was done at the cementoenamel junction for all the teeth, and the root length was standardized to 15 mm [Figure 2]. Working length was determined with a K file [Figure 3], following which they were instrumented with ProTaper files up to the master apical file size F3 [Figure 4]. The canal was irrigated with 3 mL of 2.5% sodium hypochlorite between each file size. Post-instrumentation, the smear layer was removed with 3 mL of 17% EDTA flushing. Finally, the canals were rinsed with 5 mL distilled water and dried using ProTaper paper points. Teeth were then randomly divided into four groups of ten teeth each, based on the type of sealer, as follows:

- Group 1 ($n = 10$): AH Plus, Dentsply
- Group 2 ($n = 10$): MTA Bioceramic Root Canal Sealer (PRIME Dental products Private Limited)
- Group 3 ($n = 10$): Apexit Plus (Ivoclar Vivadent)
- Group 4 ($n = 10$): Control Group - Neither sealer was applied nor obturated.

Teeth from the Groups 1, 2, and 3 were coated with respective sealers and obturated with gutta-percha using the lateral compaction technique [Figures 5,6]. Teeth from the control group were neither coated with a sealer nor obturated. Post obturation, 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 using a curette. The cleaned root surfaces were coated with a thin layer of medium body polyvinyl siloxane 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 [Figure 7]. 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/min until fracture. The maximum force required to fracture each specimen was recorded in Newtons.

Statistical analysis

Data were analyzed using the Statistical Package SPSS 26.0 (SPSS Inc., Chicago, IL). Normality of the data was assessed using the Shapiro–Wilk test. The difference in the mean fracture values between the groups was assessed using one-way analysis of variance, followed by Tukey's *post hoc* test. The level of significance was set at $P < 0.05$.

Results

Mean fracture resistance was highest for the teeth coated with AH Plus (Mean ± SD = 609.66 ± 13.47), followed by MTA bioceramic sealer (Mean ± SD = 580.20 ± 20.19). Apexit Plus demonstrated a lower fracture resistance (Mean ± SD = 413.33 ± 16.49) when compared to Groups 1 and 2, and the least fracture resistance was seen in the Control group (Mean ± SD = 280.34 ± 18.29). The difference between the means was highly significant ($P = 0.0001$) (Table 1).

Discussion

The outcome of the present experiment is not in conjunction with the proposed null hypothesis, thereby reinforcing the role of sealers in fracture resistance of ETT.

Sealer bonding to root canal dentin strengthens the tooth structure, increasing its resistance to fracture by absorbing more energy before the fracture occurs.[10] This is achieved through the sealer's ability to adhere to the dentin and penetrate the dentinal tubules, creating a more solid, monolithic structure.[11]

When a sealer effectively bonds to the dentin, it helps to maintain the integrity of the tooth structure, particularly within the root canal system. This is crucial because ETTs are more brittle and susceptible to fracture due to the removal of pulp and reduction of tooth structure.[12]

The teeth coated with AH Plus sealer demonstrated the highest fracture resistance in this study. This result is in accordance with multiple studies.[13-16]

Table 1: Comparison of mean fracture resistance values of four groups

Groups	Mean ± SD	*P*-value
Group 1 (AH Plus)	609.66±13.47	0.0001*
Group 2 (MTA Bioceramic)	580.20±20.19	
Group 3 (Apexit Plus)	413.33±16.49	
Group 4 (Control group)	280.34±18.29	

Figure 1: Forty mandibular premolar teeth

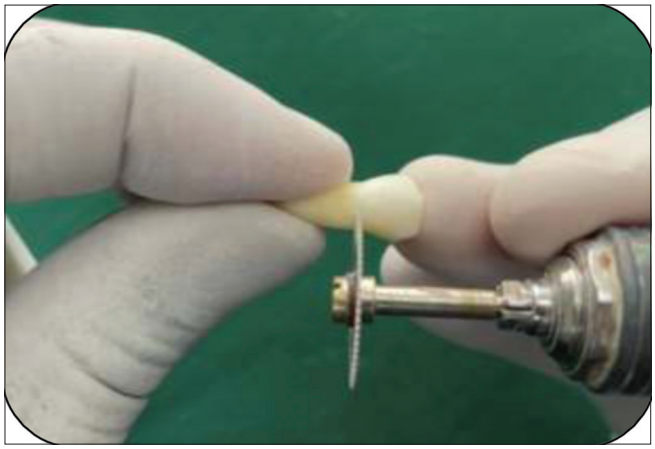

Figure 2: Decoronation at cementoenamel junction

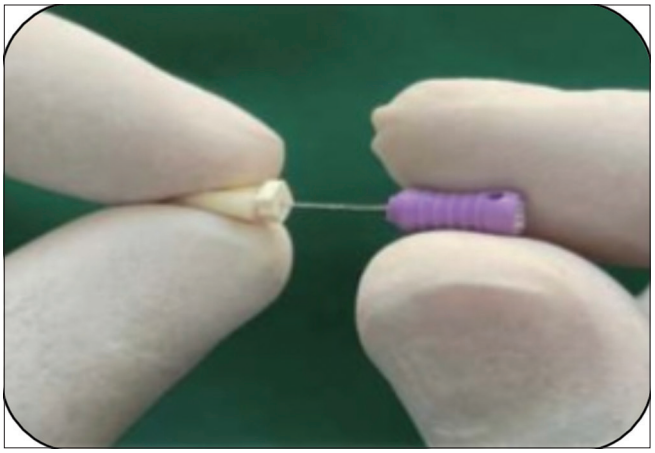

Figure 3: Working length determination

The AH Plus sealer tends to form a covalent bond between the open epoxide ring and the exposed amino groups of the collagen.[10]

In addition, AH plus not only has a higher polymerization period but also good flowability, leading to penetration of micro irregularities, thereby improving the mechanical locking between the sealer and root dentin.[17,18]

Also, McMichen *et al*.[19] have researched the physical properties of various sealers and found that AH Plus had lower water solubility and higher film thickness.

Figure 4: Bio-mechanical preparation

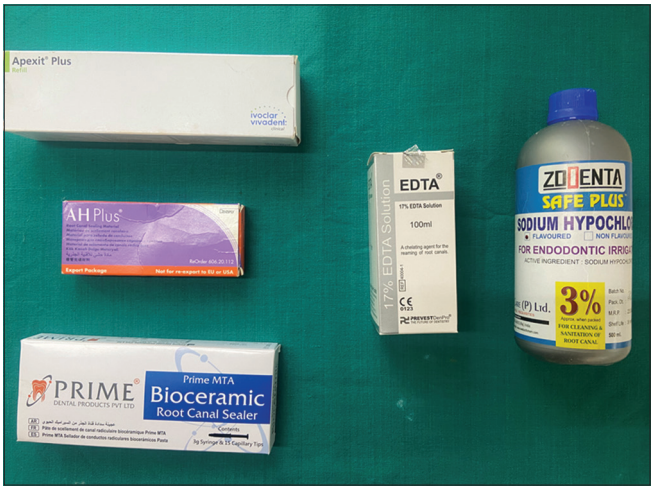

Figure 5: Sealers and irrigants used in the study

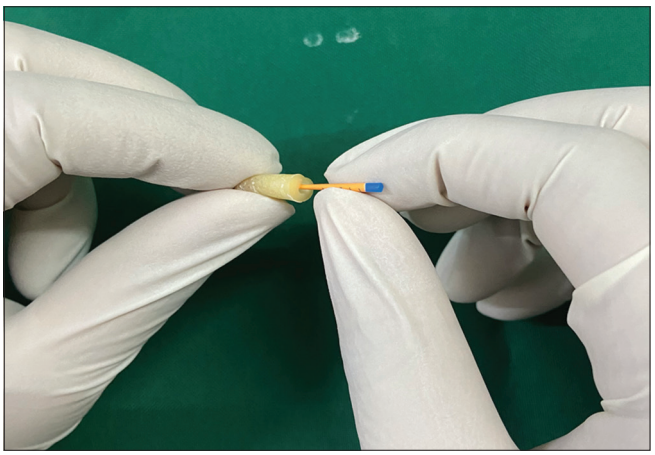

Figure 6: Obturating the canals

The mean fracture resistance of teeth coated with MTA Bioceramic was close to that of AH Plus, signifying the ability of MTA-based sealers in resisting fracture. The mechanisms explaining the binding of a bioceramic sealer to dentin range from mechanical interlocking to permeation of minerals

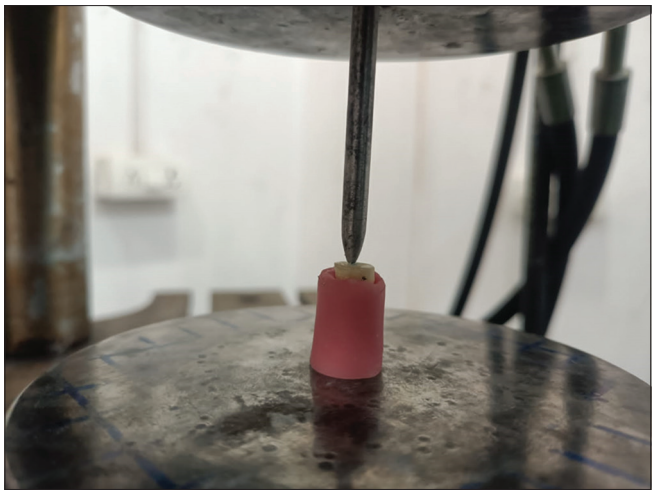

Figure 7: Evaluation of fracture resistance using a universal testing machine

from the sealer into intertubular dentin, creating a mineral infiltration zone and formation of hydroxyapatite along the mineral infiltration zone.[20-22]

Another sealer used in the study was Apexit Plus, a calcium hydroxide-based sealer. Apexit Plus is known for its good antimicrobial activity and is suitable for permanent root canal filling with various obturation techniques. It is a non-shrinking, radiopaque sealer containing calcium hydroxide.[13]

In the present study, Apexit Plus showed lower fracture resistance than AH Plus and MTA Bioceramic. This could be explained by the factor solubility of calcium hydroxide-based sealers. According to McMichen *et al*.,[19] the solubility value of Apexit Plus was 200 times higher when compared to AH Plus, indicating substantial breakdown of the sealer, leading to a compromised seal of the canal.

The present study utilized a Universal Testing machine, which subjects the samples to vertical load only. However, the masticatory forces of the oral cavity are multidirectional. Hence, future studies need to try and simulate the natural masticatory forces. Furthermore, given the *in vitro* nature of the study and small sample size, one should be cautious in generalizing the results of this study to a larger population.

Conclusion

Within the scope and limitations of this study, sealer application significantly enhances fracture resistance of ETT, with AH Plus and MTA bioceramic sealers demonstrating higher fracture resistance in comparison to Apexit Plus sealer.

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