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Evaluation Of Apical Sealing Ability of Ah Plus, Mta Fillapex And Bioceramic Sealer – An In Vitro Study.

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ABSTRACT

Aim – The present study aimed to compare apical sealing ability between AH Plus, MTA Fillapex and Bioceramic sealer.

Materials and method – Eighty extracted human maxillary anterior teeth with fully formed apex and straight root were collected for this study. The root canals were cleaned and shaped using a standard step-back preparation to size 60# master apical file at the established working length and divided into four groups: Group 1 – AH plus sealer with gutta-percha; Group 2 – MTA fillapex sealer with gutta-percha; Group 3 – Bioceramic sealer with gutta-percha; Group 4 – Positive control group (teeth were obturated without sealer). Dye leakage was carried out. Statistical analysis was done using the Statistical Package for the Social Sciences software and ANOVA test.

Results: The Bioceramic sealer group had a mean leakage of 1.39mm, MTA Fillapex had a mean leakage of 1.52 mm, whereas AH Plus had a mean of 2.68 mm. The standard deviations of AH Plus, MTA Fillapex and bioceramic sealer were 0.71, 0.77 and 0.39, respectively. ANOVA disclosed no significant difference ($P < 0.05$) between the groups.

Conclusion: None of the sealers used in the study could completely seal the apical foramen to have a fluid-tight seal. AH Plus, MTA Fillapex and bioceramic sealer showed no statistically significant difference in microleakage; the better result was shown by bioceramic sealer..

Keywords: *AH Plus, apical leakage, MTA fillapex, bioceramic sealer*

1. INTRODUCTION

The primary objective of root canal treatment is to achieve a three-dimensional view of the root canal system. (1) Inadequate apical sealing during obturation can lead to microleakage, as voids or gaps in the root canal allow oral microorganisms to enter, potentially resulting in endodontic treatment failure. Gutta-percha, combined with a root canal sealer, is the commonly used obturation material and has become the standard choice for this procedure. A root canal sealer is capable of filling the spaces between the gutta-percha and the root canal walls, as well as reaching accessory canals and areas that the gutta-percha cannot access. (2)

AH Plus (Dentsply Maillefer, Ballaigues, Switzerland) is the most commonly used epoxy resin-based sealer due to its excellent physical and chemical properties, as well as its strong sealing capability. MTA Fillapex, developed by Angelus (Londrina/Parana/Brazil), is a newer MTA-based sealer made from Portland cement, bismuth oxide, and dehydrated calcium sulphate. The manufacturer claims that it offers superior sealing ability and aids in cementum regeneration. EndoSequence BC Sealer (Brasseler USA, Savannah, GA) is a recently introduced bioceramic sealer that uses the moisture naturally present in dentinal tubules for its setting reaction. It consists of nanoparticles of calcium silicates, calcium phosphate monobasic, calcium hydroxide, and zirconium oxide. This sealer forms a gap-free interface between the gutta-percha, sealer, and dentin, as it does not shrink during setting. Additionally, it can create an apatite layer at the interface, promoting a chemical bond between the material and the radicular dentin. (3) This study aims to systematically evaluate and compare the apical sealing ability of three endodontic sealers—AH Plus, a bioceramic sealer, and MTA—through the dye penetration method.

2. MATERIALS AND METHODOLOGY

Eighty extracted human maxillary anterior teeth with fully developed apices and straight roots were collected for this study. The teeth were stored in 4% formalin until the sample collection was complete. Organic debris was removed by immersing the teeth in 5.25% sodium hypochlorite for 8 hours. Afterward, they were rinsed with tap water for 1 hour and stored in saline until further use. Power analysis is the most common and scientifically accepted method for calculating sample size. It is widely used in clinical studies and trials to determine the appropriate sample size. (4) A simple manual calculation was performed using the formula:

Sample size = $2 \times SD^2 \times (1.96 + 0.842)^2 / d^2$

Exclusion criteria

Incompletely formed root apex

Evident root fracture

Bifurcating canals

Calcified canals

Pulp stones.

Inclusion criteria

- Caries-free teeth

-Type I root canal anatomy

Root canal preparation

Using a diamond disc with water splash coolant, the teeth were decoronated to achieve a standardised length of 15 mm. Following pulp extirpation with a barbed broach, a size 15 K file was inserted into the canal until visible at the apical foramen to confirm apical patency. The working length was set to 1 mm short of this position. Root canals were cleaned and shaped using the standard step-back technique, with a size 60 master apical file at the established working length. Irrigation was performed with 5.25% sodium hypochlorite and saline between instrumentation steps, and the canals were dried using paper points. The teeth were then randomly divided into four groups of 20 each. (4)

Groups

Group 1 – AH Plus sealer with gutta percha

Group 2 – MTA Fillapex sealer with gutta percha

Group 3 – Bioceramic sealer with gutta percha

Group 4 – Control group (teeth were obturated without sealer)

Obturation

The teeth were obturated using the lateral compaction technique. Endodontic sealers were mixed and used according to the manufacturer’s instructions and introduced into the canal space using Lentulo spiral filler. (4)

Group 1: AH-Plus sealer with gutta percha

The AH Plus sealer was prepared following the manufacturer’s instructions and introduced into the canal using a lentulospiral, reaching the working length. A master cone was selected to fit snugly within the canal, coated with AH Plus sealer, and laterally condensed using finger spreaders. The excess coronal gutta-percha was removed with heat, and the remaining material was compacted.

Group 2: MTA Fillapex sealer with gutta percha

MTA fillapex sealer was mixed according to the manufacturer’s instructions and introduced into the canal. The apical part of the master gutta-percha cone was coated with sealer and placed into the canal. The master cone was laterally condensed by a finger spreader, inserted 1 mm short of the working length space created by the spreader, and was filled with an auxiliary gutta-percha point. Excess gutta-percha was trimmed with a hot plastic instrument and was condensed with a plugger.

Group 3: Bioceramic sealer with gutta percha

The bioceramic sealer was placed following the manufacturer’s instructions and introduced into the canal using a lentulospiral, reaching the working length. A master cone was selected to fit snugly within the canal, coated with bioceramic sealer, and laterally condensed using finger spreaders. The excess coronal gutta-percha was removed with heat, and the remaining material was compacted.

Group 4: control group

Teeth were obturated without any sealer.

After obturation, the coronal 2 mm of gutta-percha was removed from the filled root canals using a warm instrument, following the hardening of the sealer. The coronal ends of all canals were then sealed with glass ionomer cement.

The teeth were stored in an incubator at 37°C with 100% humidity for 48 hours to ensure complete setting of the sealers. To prepare for the dye leakage procedure, the root surfaces of all samples were coated with two layers of nail varnish, leaving the apical 2 mm uncoated. (4)

3. LINEAR DYE LEAKAGE METHOD

The root surfaces of all teeth were thoroughly dried and coated with two layers of nail varnish, leaving the apical 2 mm uncoated. Each layer of varnish was allowed to dry completely before applying the next.

The samples were then vertically suspended in a 1% methylene blue dye solution using sticky wax and placed in a glass container. They were incubated at 37°C for 72 hours to allow dye penetration via capillary action. After removal from the dye, the teeth were rinsed under running tap water to eliminate excess dye, and the nail varnish was scraped off using a Bard-Parker blade.

The samples underwent demineralisation and clearing. Demineralisation was achieved by immersing the teeth in 5% nitric acid, which was replaced daily for five days. This was followed by dehydration, where the teeth were sequentially immersed in 70%, 80%, 90%, and absolute alcohol for one hour at each concentration. Finally, the clearing process was completed by immersing the teeth in methyl salicylate solution.

The samples were examined under a stereomicroscope at a magnification of 4–40× to evaluate dye penetration. A single examiner measured the extent of microleakage, and the dye penetration scores were recorded and tabulated. The data were then subjected to statistical analysis. (4)

4. RESULTS

The study was performed to evaluate the apical sealing ability between AH Plus, MTA Fillapex and bioceramic sealer. The efficacy was evaluated based on the dye penetration test. This in in-vitro study was conducted to evaluate the apical sealing ability between the above three sealers.

The original values of apical microleakage for the three sealers were recorded. (table 1) The MTA fillapex and AH plus showed more apical leakage compared to bioceramic sealer. Mean leakage values and standard deviation (SD) for apical leakage of AH Plus, MTA fillapex and bioceramic sealer are shown in Table 1. The results showed that the AH Plus group had a mean leakage of 2.68 mm, whereas MTA fillapex had a mean of 1.52 mm and bioceramic had a mean of 1.39. The SD of AH Plus, MTA Fillapex and bioceramic sealer were 0.71, 0.77 and 0.39, 0.39respectively [Table 1].

Statistical analysis done using the Statistical Package for Social Sciences software and ANOVA disclosed no significant difference (P > 0.05) between the groups.

Table 1 shows the distribution of dye penetration scores in all groups (microleakage).

	Number	Mean	Std. deviation	Std. Error	Minimum	Maximum
Group 1 (AH plus)	**20**	**2.68**	**0.71**	**0.13**	**1.00**	**1.87**
Group 2 (MTA fillapex)	**20**	**1.52**	**0.77**	**0.18**	**0.40**	**1.45**
Group 3 (bioceramic)	**20**	**1.39**	**0.39**	**0.26**	**0.00**	**1.24**
Group 4 Control	**20**	**2.92**	**0.82**	**0.23**	**1.41**	**2.40**

P value- < 0.001

5. DISCUSSION

Achieving a hermetic seal by completely filling the root canal space reduces the risk of residual microorganisms coming into contact with oral or periapical fluids, which could serve as a nutrient source. This interaction may result in endodontic therapy failure, even years after treatment. Therefore, leakage studies play a vital role in assessing the various factors influencing the root canal obturation process. (5,6) In general, apical microleakage can be evaluated by several methods, including bacterial leakage, fluid filtration, glucose leakage models, linear dye leakage, etc. (7, 8, 9)

Various methods have been proposed to detect and evaluate microleakage. In this study, microleakage was assessed using the dye penetration method with 1% methylene blue, in which samples were immersed for 72 hours. This method is widely favoured due to its simplicity and reliability. Theoretically, if the root canal filling prevents the penetration of small molecules like dyes, it is likely to also prevent leakage of larger molecules, such as bacteria. (2, 10, 11)

MTA Fillapex is a distinctive salicylate resin-based sealer containing 15% MTA powder. (12, 13) The primary component of MTA Fillapex is the salicylate resin matrix, with MTA serving as a minor additive. Its composition includes oxides, resins, silica nanoparticles, and pigments. (11,14) Compared to calcium silicate cements, MTA Fillapex absorbs less water, releases significantly fewer calcium ions (Ca^{2+}), and exhibits reduced alkalinising activity and apatite deposition. While salicylate resins are intended to enhance the physicochemical properties and handling characteristics of sealers with bioactive components, the resin matrix limits the bioactivity of MTA. Additionally, MTA Fillapex demonstrates high flowability and prolonged setting time due to the unbalanced ratio between the resin and MTA, particularly when compared to the bioceramic sealer. (15)

Bioceramic sealer composed of tricalcium silicates, dicalcium silicate, calcium aluminate, zirconium oxide, and a thickening agent. The small size of its constituent particles, along with its water affinity and low contact angle, enables it to spread easily over dentinal walls within the canal and penetrate lateral micro-canals. This results in the formation of a strong chemical bond between the sealer and the dentinal walls. (16)

The setting reaction of bioceramic sealer is moisture-activated, producing a final set consisting of calcium silicate hydrate gel and calcium hydroxide. The calcium hydroxide interacts with phosphate ions from the dentin to form hydroxyapatite and water. The water generated continues to react with the calcium silicate, leading to the precipitation of additional gel-like calcium silicate hydrate. (17)

AH Plus is an epoxy-based paste-paste system containing various radiopaque fillers. Its creep capacity and extended setting time enhance its penetration into micro-irregularities, resulting in improved mechanical interlocking between the sealer and root dentin. (18)

In the present study dye penetration was checked in all the groups. The statistical analysis showed the highest dye penetration in group 1 (AH plus sealer), followed by MTA Fillapex, and the lowest dye penetration in group 3 (bioceramic sealer). The mean linear dye penetration of AH Plus sealer was 2.68mm, of MTA Fillapex was 1.52mm and of bioceramic sealer was 1.39mm.

The overall lowest mean values for Group 3 (bioceramic sealer) may be attributed to the aforementioned near-ideal sealer properties and some drawbacks of the sealer used in Groups 1 and 2. These results are supported by studies done comparing bond strength. (19,20)

The limitation of the study was that the study was carried out on extracted teeth, thus may not simulate in-vivo conditions. Apical dye leakage was taken as a true indication of the apical seal. Apical leakage was studied using an artificial dye; the dye may not represent the exact ingress of apical fluids in the canal. Linear dye penetration was evaluated in two dimensions, whereas the root canal is a three-dimensional entity.

6. CONCLUSION

The study concluded that bioceramic sealer offers superior sealing ability compared to other sealers. However, further research is needed to fully harness its excellent biological properties in clinical applications. Additional in vitro, ex vivo, and in vivo studies are required to assess the performance of this material, validate its use in endodontic therapy, and explore its potential for retreatment.

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Conflicts of interest

There are no conflicts of interest.

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