Evaluation of Sealing Ability of Three Root Canal Sealers: An In Vitro Study

Shivangi Trivedi, Swati Chhabra, Abhishek Bansal, Naveent Kukreja, Nitu Mishra, Aparna Trivedi, Parwan Gill, Dinraj Kulkarni

Abstract

Aim: To evaluate the sealing ability of three different types of sealers using confocal laser microscopy.

Materials and methods: Sixty extracted single-root premolars were selected and divided into three groups (20 teeth in each group) according to the type of sealer used, namely, mineral trioxide aggregate (MTA) Fillapex, AH Plus, and Bio C Sealer. Root canal preparation and obturation were done in all the samples. Roots were dissected transversely in apical plane. Percentage of gap from region to canal circumference was calculated using a confocal laser microscope. Samples were subjected to statistical analysis.

Results: High dye penetration was seen with AH Plus compared to MTA Fillapex and least with Bio C Sealer. The AH Plus is the best sealer with respect to seal ability of all the three.

Conclusion: This study helps to appraise the sealing ability of the different types of sealers using confocal laser microscopy which is useful for the success of root canal treatment.

Clinical significance: As sealer has to seal voids, foramina, and canals, it should have good penetration for the success of root canal treatment.

Keywords: AH Plus, Bio C Sealer, MTA Fillapex, Root canals.

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Introduction

For ideal root canal treatment, several factors are responsible such as proper instrumentation, biomechanical preparation, obturation as well as postendodontic restoration. Thus, the main purpose of RCT is to put an end to microbial existence and to prevent reinfection of root canal. This will bring out proper sealing along with successful obturation, which acts synergistically to create hermetic seal.1

Improper filling of canal can result in fluid movement into the defects, which may cause inflammatory reactions compromising the success of treatment.2 Also the root canal ramifications, such as lateral, secondary, and accessory canals, connect root canal with the periodontal ligament and apical foramen.3

Root canal sealers are used in combination with gutta-percha for filling of root canals. Sealers obliterate the discrepancies like grooves and lateral depressions that cannot be filled with gutta-percha. Gutta-percha is impermeable; thus, leakage occurs at the sealer to gutta-percha and sealer to tooth interface.4

Root canal sealers have the following main functions:

- Sealing off voids, patent accessory canals, and multiple foramina.
- Forming a bond between the core of filling material and root canal wall, and
- Acting as lubricant, making the placement of filling core easier and enshrining the remaining microorganism.5

The capability of root canal sealers to seal root canal is reinforced by minimizing the amount of sealer and assessing good adaptation and penetration of the sealer into the root dentin.

Thickness of sealer and its adaptation to root dentin is the main function of sealer’s physical and chemical properties.6 Flow is an important property that shows its capability to penetrate into small irregularities and ramifications of the root canal and also the dentinal tubules. Along with flow, the antimicrobial effectiveness of root canal sealers aids in disinfection of root canal system.3

Some of the main factors for choice of sealer are:

- Its ability to form sound seal
- Well tolerated by periradicular tissue
- Easy to manipulate7

Different types of root canal sealers are available, with each one having their own merits and demerits. However, they are selected according to their sealing ability, adhesive properties, biocompatibility, and antimicrobial efficacy. Some of them are:

1-4,7Department of Conservative Dentistry and Endodontics, Maharishi Markandeswar College of Dental Sciences and Research Mullana, Ambala, Haryana, India
3Department of Oral Pathology and Microbiology, Modern Dental College and Research Centre, Indore, Madhya Pradesh, India
6Department of Prosthodontics, Crown and Bridge and Implantology, Modern Dental College and Research Centre, Indore, Madhya Pradesh, India
8Department of Oral and Maxillofacial Pathology, M.A. Rangoonwala Dental College and Research Centre, Pune, Maharashtra, India

Corresponding Author: Aparna Trivedi, Department of Prosthodontics, Crown and Bridge and Implantology, Modern Dental College and Research Centre, Indore, Madhya Pradesh, India, Phone: +91 9406732918, e-mail: dr90aparnatrivedi@gmail.com


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• ZnO based
• Epoxy resin based
• Glass ionomer based
• Calcium hydroxide based
• Bioceramic based
• MTA based

According to Meryon, zinc oxide eugenol-based sealers are cytotoxic, which may be due to the toxic effect of zinc ions. Eugenol is not only toxic but also neurotoxic. Thus, exclusion of eugenol helps in reducing toxicity.

The main advantage of epoxy resin-based sealers is their reduced solubility and better apical seal. Calcium hydroxide-based sealers stimulate periapical tissues to facilitate healing and also for its antimicrobial effects. However, in terms of microleakage, calcium hydroxide-based sealers are not superior to other groups of sealers. Glass ionomer-based sealers are technically less demanding than traditional methods, has an inherent potential for providing a more stable apical seal, and also may prevent root fracture due to their bonding properties. The MTA-based sealers are new endodontic materials, which are based on physiochemical properties of MTA. They develop a biocompatible sealer with ideal physical, chemical, or mechanical properties, which are due to their alkaline pH, and calcium ion releasing ability. These sealers are biocompatible, stimulate mineralization, and also boost apatite-like crystalline deposits along the apical and middle third of the enamel wall. These sealers have sealing abilities similar to the epoxy-resin-based sealer.

There has been regular research for alternative sealer that bonds to dentin along with the filling materials. More long-term data are needed to figure out whether the recently developed sealer will be used in parallel or mechanical properties, which are due to their alkaline pH, and calcium ion releasing ability. These sealers are biocompatible, stimulate mineralization, and also boost apatite-like crystalline deposits along the apical and middle third of the enamel wall. These sealers have sealing abilities similar to the epoxy-resin-based sealer.

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**Materials and Methods**

The following materials were used in the study:

- Freshly extracted single-root premolars
- 0.2% thymol: disinfectant
- NaOCl: for irrigation between each file change
- EDTA: final irrigation
- Distilled water: to clean fractured fragment
- Sealers: MTA-Fillapex, AH Plus, and Bio C Sealer
- Rhodamine B dye: for labeling sealers

**Armamentarium Used**

The following armamentarium were used in the study:

- Contra-angle handpiece and low-speed diamond disk: to decoronate the sample
- K-file: size 10, 35, and 60
- Gates glidden-drill: size 4, 3, and 2
- Paper points: for drying canal
- GP master cone: for obturation
- Spreader
- Intraoral periapical radiograph films
- Incubator: to keep samples
- Confocal laser microscope

This *in vitro* study was conducted in the Department of Conservative Dentistry and Endodontics of Maharishi Markandeshwar College of Dental Sciences and Research, Mullana, Ambala, Haryana.

**Selection of Samples**

Sixty extracted single-root premolars were selected after being radiographed buccolingually and mesiodistally. The samples were collected from the Department of Oral surgery, Maharishi Markandeshwar College of Dental Sciences and Research, Mullana to be used in this *in vitro* study.

Inclusion criteria were single straight root canal and completely formed apex with patent foramina.

Exclusion criteria were obstruction within the canal system and internal/external resorption.

**Preparation of Samples**

The teeth were cleaned and tissue remnants from the root surfaces were removed by using the ultrasonic tips. The samples were then disinfected with 0.2% thymol and stored in distilled water. The sample was divided into three groups of 20 each based on the sealer used. Group I: MTA-Fillapex, Group II: Bio C Sealer, and Group III: AH Plus. The teeth were radiographed to confirm the presence of a single and straight canal. Selected teeth were decoronated at 16 mm from apex (for standardization of length of all sample size). After extirpation of pulp, 10 K file was introduced into the canal until it was visible at the apical foramen. Working length was calculated by subtracting 1.0 mm from the measurement.

**Root Canal Preparation**

Root canal preparation was done using the step-down technique. Coronal third was flared by using Gates glidden drills of size 4, 3, and 2. Apical third was prepared using K-files of size 35, i.e., master apical file size. Then step back was done in 1 mm increments upto the file size of 60. In between each file canals were irrigated with 5.25% NaOCl. Final irrigation was done with EDTA for 3 minutes to remove the smear layer. Irrigation was done with distilled water and the canals were dried with paper points.

**Obturation**

Samples were randomly divided into three groups according to the type of sealer used. Canals were obturated using cold lateral compaction technique. A 35 GP size master cone was placed in each canal. All sealers are prepared according to the manufacturers’ instructions. Each sealer was labelled using rhodamine B dye. The GP master cone was coated with sealer and inserted into the canal. The root canals were filled with accessory gutta-percha points and compacted laterally with the fine sized finger spreader. Gutta-percha cones were seared off at the canal orifice. The radiographs were taken at buccal and mesial aspects to assess the quality of root canal filling. All the samples were kept into the incubator at 37°C in 100% humidity for 10 days to allow the sealer to set. For each sample epoxy resin was used and sectioning was done at apical terminus of the filling with copius coolant irrigation.

**Confocal Laser Analysis**

Each cross section was examined under confocal laser scanning microscopy. Images were recorded at 100x magnification using fluorescent mode with laser emission at wavelength 546–674 nm and excitation at 543 nm. and the sealer–dentin interface was evaluated (Figs 1 and 2). Sealer penetration was calculated after importing the image into the IOB software. By this, the root canal circumference and the sealer penetration into the dentinal tubules...
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were measured. Then the canal walls where the sealer penetrated into the dentinal tubules were outlined and measured using the same method. Ruler tool of the IOB software was used to measure the depth of sealer penetration. During this measurement, the canal was taken as the starting point and the data points were averaged to obtain a single measure for each section. Subsequently the percentage of the root canal sealer penetration in that section was established.

**Statistical Analysis**

The data collected was subjected to statistical analysis. Analysis of variance was used to analyze the sealing ability of the different types of sealers. Significant value was set at 0.05. Tukey test (*post hoc* test) was used to compare between the groups (divided according to the type of sealer used).

**Results**

The standard deviation of MTA-Fillapex, Bio C Sealer, and AH Plus are 42.5, 47, and 73.3, respectively. AH Plus and Bio C Sealers showed significant result, while MTA Fillapex showed nonsignificant result (*p* > 0.001; Table 1). When comparison was done between the groups, significant correlation was seen between AH Plus (A) vs Bio C Sealer (C) and MTA-Fillapex (B) vs Bio C Sealer (C) and nonsignificant between AH Plus (A) vs MTA-Fillapex (B) (Figs 1 to 3 and Table 2). Statistically significant differences were obtained in the sealing ability of the three groups (*p* < 0.001). However, while comparing the sealing ability of different groups (intergroup comparison), the comparison between groups A and B was nonsignificant (*p* = 0.946), while the comparison between groups A and C and groups B and C was highly significant (*p* < 0.001).

**Discussion**

The goal of our study was to compare the sealability of all the three sealers. All procedures were performed by the same operator to avoid intraoperator discrepancies. Only teeth with straight root canals were used because they can offer a more standardized method for evaluation of apical leakage. However, using a single-cone technique for root canal filling allowed observing the sealability of the sealers in more critical situation than that offered by the lateral condensation technique as it is possible to speculate that the single-master cone needs a greater interaction with the sealer to promote the sealing. Rhodamine B dye was used because it does not suffer discoloration by calcium hydroxide-based materials as seen with methylene blue.

We choose the AH Plus sealer because it is used frequently in clinical work and is usually chosen as the control in studies on the properties of new sealers because of its good flowability, proper film thickness, and viscosity. The most critical area of the prepared root canal is the 2–3 mm of apical third, hence we choose it.

The AH Plus is an epoxy-resin-based sealer. It is used because of its reduced solubility, better apical seal, microretention to root canal dentin, and less shrinkage.

The MTA Fillapex is a bioceramic and resin sealer. It is biocompatible and encourages apatite-like crystalline deposits along the apical and middle third of the canal walls.

The Bio C is a novel bioceramic, nonresin sealer, which stimulates tissue regeneration.

The flow, setting time, and solubility of all three sealers are shown in Table 3.

The present study showed high dye penetration with respect to AH Plus followed by MTA Fillapex and then Bio C Sealer.

Many researchers concluded that AH Plus shows more dye penetration. Gandolfi et al. found that AH Plus demonstrated better sealing ability than that of MTA. Almeida et al. concluded that AH Plus permitted less dye leakage than pulp canal sealer. Al Haddad et al. found that AH Plus exhibits the least number of gap-containing regions than MTA Fillapex. Tyagi et al. found better penetration of it into the microirregularities. Viapiana found that AH Plus exhibits higher percentage of root canal filling than Bio C Sealer.

Superior adaptation of AH Plus is due to its ability to bond to root dentin chemically by reacting with the exposed amino groups in collagen to form covalent bonds between the epoxy resin and collagen. The AH Plus sealer is slightly acidic and might result in self-etching when in contact with dentin, unlike the alkaline bioceramic-based sealers, thereby enhancing interfacial bonding and adaptation.

According to Hubbe et al., AH Plus is a thixotropic fluid that undergoes transformation of its internal structure, which promotes the alternation of the flow speed accounting for the abrupt flow after a certain time. Al-Haddad et al. stated that hydrophobicity of this sealer facilitates the permeation of resin into open dentinal tubules and creates efficient microretention when 17% EDTA was used as the final irrigant.

Many researchers found that AH Plus shows less dye penetration. Candeiro et al. proved that AH Plus has lower flow rate compared...
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Table 1: Sealing ability of all three sealers

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean (μm)</th>
<th>Std deviation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH Plus (A)</td>
<td>8</td>
<td>463.432</td>
<td>73.37712</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTA Fillapex (B)</td>
<td>8</td>
<td>454.556</td>
<td>42.55236</td>
<td>46.982</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bio C Sealer (C)</td>
<td>8</td>
<td>224.037</td>
<td>47.06769</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An ideal root canal sealer should possess perfect combination of sealing ability and biocompatibility. Significant difference was found between the sealing ability of AH Plus, MTA Fillapex, and Bio C Sealers.

Understanding of the current concepts in the usage of different sealers in endodontic therapy and their comparison is essential in order to draw some clinical inferences.

Further investigations are needed for Bio C Sealer.

Table 2: Comparison of sealing ability of all three groups

<table>
<thead>
<tr>
<th>Comparison between groups</th>
<th>Mean difference</th>
<th>p value</th>
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<tbody>
<tr>
<td>AH Plus (A) vs MTA Fillapex (B)</td>
<td>8.87625</td>
<td>0.946</td>
</tr>
<tr>
<td>AH Plus (A) vs Bio C Sealer (C)</td>
<td>239.39500</td>
<td>0.001</td>
</tr>
<tr>
<td>MTA Fillapex (B) vs Bio C Sealer (C)</td>
<td>230.51875</td>
<td>0.001</td>
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</tbody>
</table>

Table 3: Flow, setting time, and solubility of three sealers

<table>
<thead>
<tr>
<th></th>
<th>AH Plus</th>
<th>MTA Fillapex</th>
<th>Bio C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (mm)</td>
<td>36.76 ± 3.04</td>
<td>28.73</td>
<td>23.46</td>
</tr>
<tr>
<td>Setting time (minutes)</td>
<td>5.79 ± 4.95</td>
<td>130 ±10</td>
<td>&lt;240</td>
</tr>
<tr>
<td>Solubility (%)</td>
<td>0.75 ± 0.41</td>
<td>0.1</td>
<td>2.86</td>
</tr>
</tbody>
</table>

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References