Comparative Assessment of the Bonding Strength of Four Types of Endodontic Sealers Using Push-Out Test.

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ABSTRACT

Background: The bonding strength between the endodontic sealer and the dentine is critical for preserving the endodontic filling material’s integrity and sealing ability. Therefore, the current study aims to use a push-out bond strength test to compare and evaluate the intra-radicular bonding strength of four endodontic sealers (AH-Plus, ADseal, MTA-Fillapex, and TotalFill BC) to the root canal walls and gutta-percha.

Methodology: A straight palatal root from 40 extracted maxillary first molars teeth was utilized in this study. The root samples were splinted into four groups (n=10) according to the obturation material employed. By using a ProTaper Next NiTi-rotary system, the specimens were instrumented up to size 40/.06. In all experimental groups, obturation was completed using a single-cone technique. Each sample had a 2 mm thick slice taken from the root’s coronal, middle, and apical areas. A universal-testing machine and a stainless-steel plunger at 0.5 mm/min speed in an apical-coronal orientation were used to assess sealers’ bonding strength. The obtained data were analyzed using the One-Way ANOVA repeated measure and Bonferroni tests.

Result: TotalFill BC had a significantly higher push-out bond strength mean value than the other kinds of sealers employed in this study. In addition, the coronal level had the greatest mean values.
Conclusion: Root samples filled with gutta-percha and bioceramic sealer had a considerably greater bond strength than the other tested groups. The coronal area had the highest bond strength values in root segment location.

Keywords: Bioceramic, Resin, MTA Sealers, Push-out bond strength, Endodontics.

Introduction

Successful root canal treatment relies on thorough debridement of the root canal system, the elimination of pathogenic microorganisms, and finally, complete sealing of the root canal space to block any bacterial spread from the oral environment to the apical tissue (1). Therefore, it prevents further apical irritation from either incomplete elimination of bacteria and their products or communication between apical tissues and the oral cavity, thereby reducing periapical inflammation (2).

An endodontic sealer is required to fill the gaps and voids between the principal material and the root canal walls and act as a lubricant, creating a fluid-tight seal (3).

The AH Plus sealer is an epoxy-amine resin-based formula provided in a paste-paste system (Dentsply, DeTrey, GmbH, Konstanz, Germany). The epoxy resin, calcium-tungstate, zirconium oxide, aerosol iron oxide, and silicone oil are included in this product. It has strong physical properties, low solubility, dimensional stability, acceptable micro-retention to dentine, and biocompatibility (4).

The Adseal-sealer (Meta Biomed Co., Cheongju, Korea) is an epoxy-oligomer resin-based sealer that is easily mixed and provided as a paste-paste system with a dual syringe. It consists of an epoxy-oligomer resin as the base, ethylene glycol salicylate, and the poly-butane-diol amino-benzoate as the catalysts, calcium phosphate, and bismuth sub-carbonate. It has good physical properties, apical sealing capacity, appropriate biologic function, and root dentin micro-retention (5).

The MTA-Fillapex (Angelus, Londrina, PR., Brazil) is an MTA-based sealer that comes in a dual syringe paste-paste system and is made up of resins, bismuth oxide, silica nanoparticles, and pigments. MTA is present in 13.2% of the MTA Fillapex paste: paste formula. MTA which is well known for its biocompatibility, produces a remarkable hermetic seal in which the MTA particles expand, preventing micro-infiltration (6).

The TotalFill BC (FKG Dentaire, La-Chaux-de-Fonds, Switzerland) sealer principally consists of di-calcium and tri-calcium silicate, calcium hydroxide, monobasic calcium phosphate, zirconium oxide, tantalum oxide, fillers, and thickeners. According to manufacturers’ instructions, it is injectable, premixed, radiopaque, shrinkage-free, insoluble, and hydrophilic,
implying that the moisture in the dentinal tubules is required to initiate and accomplish the setting process (7).

Sealer bond strength is a remarkable feature that improves the effectiveness of endodontic therapy. It is, however, still controversial, and further studies are required to evaluate and compare the bonding strength of different sealers.

**Method**

**Sample Collection and Selection**

Forty extracted maxillary first molar human teeth with straight palatal roots and patients aged 20 to 36 years old were collected from different dental and health facilities, as authorized by the Research-Ethics Committee of Mustansiriyah University College of Dentistry No. (MUOPR2). The following criteria used for teeth selection (8):

1. Straight palatal roots straight.
2. No root caries or resorptions.
3. The apical foramen well developed and located.
4. Roots with an initial size of # 20 k were utilized.

**Sample Preparation**

To ensure uniformity, the length of the palatal root was evaluated with a digital caliper and marked at 11 mm from the root's end; the root was then sectioned perpendicular to its long axis with a diamond disc (Nyon, Switzerland) in a straight hand-piece with water coolant (9).

![Figure (1) Confirmation of root length.](image)

By subtracting 1 mm from the 11 mm measurement, the working length was determined (10). The forty samples were randomly splinted into four groups (n=10) depending on the obturation substances as follows: Group1: AH-Plus-sealer (Dentsply, DeTrey, GmbH, Germany). Group2: Adseal-sealer (Meta Biomed Co, Cheongju, Korea). Group3: MTA-Fillapex-sealer (Angelus, Londrina, PR, Brazil). Group4: TotalFill BC-sealer (FKG Dentaire, La Chaux-de-Fonds, Switzerland).

The ProTaper NEXT rotary system was utilized with endodontic motor (Rooter, FKG Dentaire) to prepare root canals in all sample groups at 300 rpm speed and a torque of 2 Ncm up
to size 40/06 using a crown-down method. The final irrigation regimen was conducted with 17% EDTA 1 mL, followed by 2.5% sodium hypochlorite 3 mL for 1 min. Then, the utterly prepared canal was rinsed with 5 ml of normal saline to remove any irrigation residue before drying with matching paper points (11).

Following the achievement of the instrumentation phase, the root canals for all study groups were obturated with gutta-percha size #40/06. (ProTaper Next, Dentsply, Switzerland) and sealer using a single cone method. To admit the sealers to be set, all samples were stored for seven days in an incubator device at 100% humidity and 37°C (12).

![Figure (2) Radiographic X-ray](image)

Following the storage period, the roots have been immersed in a transparent acrylic resin before being molded into resin blocks using silicone molds (25 mm height and 10 mm diameter) (13). Then, the molded sample was sliced horizontally into three parts of 2 ± 0.1 mm thickness (Apical, Middle, and Coronal). To guarantee that the load was applied in an apical-coronal orientation, each segment was marked with an indelible marker on its apical side (8). Each sample’s slice thickness was calibrated using a digital caliper, then inspected for any irregularities before being stored in a plastic container (10).

![Figure (3): (A) sample slices; (B) Verification of slice thickness.](image)

**Push-Out Bonding Strength Test**

A push-out bonding strength test was conducted by applying a compressive force to the apical surface of each slice using a cylindrical plunger connected to a Universal Testing-Machine at 0.5 mm/min speed until the initial dislodgment of filling material (14). The plunger pin diameters utilized at each apical, middle, and coronal level were 0.4 mm, 0.55 mm, and 0.7 mm, respectively.
The failure modes of the bond are shown in (Table 3). The data were statistically assessed utilizing one-way analysis of variance (ANOVA) repeated measure and post hoc tests (Bonferroni). Analysis was performed on IBM SPSS, ver. 21 software. The selected level of significance was \( p < 0.05 \). Partial Eta Square (Effect Size) is Small (0.01-0.059), Medium (0.06-0.139), and Large \( \geq 0.14 \) (15, 16).

**Results**

The data distribution was tested using the Shapiro–Wilk test and was normally distributed \( (P > 0.05) \). The results of mean values, minimum (Min.), maximum (Max.), and standard deviations (SD) of the push-out bond strength of endodontic sealers at the root levels, are shown in (Table 1).

**Table (1): Descriptive statistics of push-out bonding strength by root levels and sealer groups.**

<table>
<thead>
<tr>
<th>Groups</th>
<th>N0.</th>
<th>Middle</th>
<th>Apical</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH Plus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>2.320</td>
<td>1.960</td>
<td>1.830</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.650</td>
<td>3.530</td>
<td>3.210</td>
</tr>
<tr>
<td>Mean</td>
<td>2.953</td>
<td>2.704</td>
<td>2.474</td>
</tr>
<tr>
<td>( \pm SD )</td>
<td>0.399</td>
<td>0.471</td>
<td>0.388</td>
</tr>
<tr>
<td>ADseal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>1.320</td>
<td>1.170</td>
<td>0.910</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.320</td>
<td>1.960</td>
<td>1.830</td>
</tr>
<tr>
<td>Mean</td>
<td>1.791</td>
<td>1.489</td>
<td>1.278</td>
</tr>
<tr>
<td>( \pm SD )</td>
<td>0.280</td>
<td>0.251</td>
<td>0.291</td>
</tr>
<tr>
<td>MTA Fillapex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>0.990</td>
<td>0.780</td>
<td>0.450</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.660</td>
<td>1.570</td>
<td>1.370</td>
</tr>
<tr>
<td>Mean</td>
<td>1.356</td>
<td>1.212</td>
<td>1.002</td>
</tr>
<tr>
<td>( \pm SD )</td>
<td>0.248</td>
<td>0.292</td>
<td>0.291</td>
</tr>
<tr>
<td>TotalFill BC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>3.320</td>
<td>3.140</td>
<td>2.750</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.980</td>
<td>3.920</td>
<td>3.670</td>
</tr>
<tr>
<td>Mean</td>
<td>3.584</td>
<td>3.491</td>
<td>3.210</td>
</tr>
<tr>
<td>( \pm SD )</td>
<td>0.260</td>
<td>0.288</td>
<td>0.307</td>
</tr>
</tbody>
</table>

The TotalFill had the highest mean values at all levels. The MTA-Fillapex, on the other hand, exhibited the lowest mean values. The coronal level had the greatest mean of push-out bonding-strength value in all groups, followed by the middle, and lastly, the apical level had the least value.

**Table (2): ANOVA test among root levels by sealer groups.**

<table>
<thead>
<tr>
<th>Multivariate Tests</th>
<th>F</th>
<th>( \text{df} )</th>
<th>( \text{p} )</th>
</tr>
</thead>
</table>

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ANOVA test revealed a statistically significant difference between each sealer group's root levels (coronal, middle, and apical), with a (P < 0.05). The partial Eta square revealed that the ADseal group had the largest effect size (0.687), followed by AH-Plus and TotalFill. In contrast, the MTA-Fillapex had the smallest effect size (0.524).

Table (3): The Bond Failure Modes

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mode of failure (N / %)</th>
<th>Adhesive Failure</th>
<th>Cohesive Failure</th>
<th>Mixed Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N.</td>
<td>%</td>
<td>N.</td>
</tr>
<tr>
<td>AH Plus</td>
<td></td>
<td>6</td>
<td>20%</td>
<td>3</td>
</tr>
<tr>
<td>ADseal</td>
<td></td>
<td>7</td>
<td>23.3%</td>
<td>5</td>
</tr>
<tr>
<td>MTA Fillapex</td>
<td></td>
<td>1</td>
<td>60%</td>
<td>0</td>
</tr>
<tr>
<td>Total Fill</td>
<td></td>
<td>1</td>
<td>3.4%</td>
<td>1</td>
</tr>
</tbody>
</table>

N. = samples number, % = percentage.

Discussion

Under the circumstances of the current study, the findings established a significant difference among all sealer groups (AH-Plus, ADseal, MTA-Fillapex, and TotalFill) at each apical, middle, and coronal level of samples, except for ADseal and MTA-Fillapex groups at the
middle and apical levels, together with the middle and the coronal levels of the TotalFill group revealed a non-significant difference. **Accordingly, both null hypotheses were rejected.**

The bioceramic-based sealer group (TotalFill) had a considerably greatest push-out bonding strength value than other kinds of endodontic-sealers involved in study groups. Concurrently, the MTA-Fillapex had the weakest push-out bonding strength of any group tested. The construction of a chemical bind (through the synthesis of hydroxyapatite during the setting mode) with dentine walls by the 'mineral infiltration zone' can explain the TotalFill sealer’s greatest bond strength. In addition, its hydrophilic properties and low contact angle, which allow it to spread more easily over root-canal walls, providing adaptation and an outstanding hermetic seal (17). These findings corroborated the conclusions of (17,18,19).

By comparison, among TotalFill and AH-plus sealers, the TotalFill group had greater push-out values with a significant difference at each root level. This corresponded to (19,20). Conversely, this conclusion contradicted with (21, 22).

Furthermore, when comparing TotalFill to ADseal sealer, the results validated that the TotalFill had greater bonding strength with a significant difference at all root levels. This result concurred with (18). Nevertheless, this finding disagreed with (21, 22).

In correlation, both ADseal and AH-Plus, in turn, are epoxy-resin sealers. However, once comparing to ADseal, the AH-Plus held a greater push-out value with a significant difference at each level of the root sample. Thus, the configuration of a covalent bond via an open epoxide-ring among each exposed amino group in collagen may explain AH Plus's high bonding strength (23, 24).

The MTA-Fillapex demonstrated the least push-out value, with a statistically significant difference among all samples groups at all root levels except middle and apical levels, which showed a non-significant difference with the ADseal. This result corroborated the conclusions of (21, 25). In contrast, it was opposed to (26).

In the term of root level, this study detected that the coronal level had the greatest mean values of all root levels tested, followed by middle level, which does have the second highest mean values. As opposed to, the apical level had the smallest values. These results corroborated the previous study's findings (27). However, it conflicts with (28, 29).

**Conclusion**

Within the limitations of this study, the TotalFill bioceramic sealer showed promising results as a root canal sealer. It exhibited greater resistance to push-out test than MTA-Fillapex and epoxy resin-based sealers (AH-Plus, ADseal) with gutta-percha as a root canal filling.

**Conflict of interest:** None.
Financial disclosure

This study did not get any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES


