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IN VITRO EVALUATION OF THE ADHESION OF FOUR DIFFERENT ROOT CANAL SEALERS TO ROOT DENTIN

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ABSTRACT

The aim of this study was to assess the adhesion for four different classes of endodontic root canal sealers (AH Plus, Sealapex, TotalFill BC and GuttaFlow Bioseal) to the root dentin by evaluating their push out bond strength (POBS).

Material and methods: This study was conducted on 48 extracted human mandibular premolars with single root and single canal. After decoronatation and preparation of the canals with ProTaper files up to X 4, the samples were divided into four groups (n=12) according to the sealer used: AH Plus, Sealapex, TotalFill BC and GuttaFlow Bioseal sealers. The samples were obturated by utilizing the lateral compaction technique and kept in an incubator for one week. The roots were set in self-curing acrylic resin and sectioned transversely to obtain 2 mm-thick slices from the apical, middle, and coronal thirds. The interfacial bonding strength was evaluated by POBS test conducted on a universal testing machine in apical to coronal direction. The results were statistically evaluated using a one-way ANOVA and post hoc Tukey analysis, with a significance level set at $p < 0.05$.

Results: AH plus sealer exhibits a considerably higher POBS in the apical, middle and coronal thirds than other sealers. Sealapex, total fill, and Gutta flow bioseal do not exhibit any statistically significant differences.

Conclusions: AH plus sealer demonstrated a higher POBS in comparison to other sealers (Seal apex, total fill, Gutta flow bioseal). The POBS to root dentin was not significantly different between Sealapex, total fill, and Gutta flow bioseal.

KEY WORDS: GuttaFlow bioseal, Sealapex, TotalFill BC, push-out bond strength, polydimethylsiloxane-guttapercha sealer.

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INTRODUCTION

Successful endodontic treatment involves not only shaping and cleaning all root canals but also sealing them with biocompatible, non-resorbable materials to create an impermeable barrier against bacteria, ensuring long-term success. [1]

Root canal obturation involves using gutta-percha as the core filling material and a sealer to fill the gaps between the root canal wall and the GP.[2] Many studies have demonstrated a clear link between the success of treatment and bacterial microleakage after root canal obturation.[3] Therefore, the root canal sealer should ideally form a bond with both the core material and root dentine to ensure a bacterial-tight seal obturation.[4]

Several root canal sealers were developed to meet optimal sealer criteria for improved root canal therapy outcomes.[5] AH Plus (Dentsply DeTrey GmbH, Konstanz, Germany) is an epoxy resin sealer with excellent bonding strength to dentin, making it widely used.[6] AH Plus also has a low viscosity, which makes it easy to place in the RC and helps to ensure that it fills all small spaces.[7] It is still regarded as the standard sealer that new sealers are evaluated against.[8] Sealapex (Kerrdental, Brea, CA, USA) is a calcium hydroxide-based sealer known for its low cytotoxicity, antibacterial properties, and excellent ability to stimulate the healing of periapical tissue.[9]

Calcium silicate-based sealers have recently been introduced due to their superior sealability and biocompatibility. Total fill BC sealer (FKG, La Chaux-de-Fonds, Switzerland) is a pre-mixed bioceramic sealer, which was known for its biocompatibility, antibacterial activity. [10-11]

Another recently introduced bioceramic silicone-based sealers is GuttaFlow bioseal (Coltène/Whaledent AG, Altstätten, Switzerland). It was developed to integrate the filling properties of GP with the bioactive characteristics of calcium silicates in a single formulation, offering multiple advantages such as excellent sealing ability, superior adaptation to root canal walls, and minimized solubility.[12]

The current literature reveals a lack of data evaluated the use of GuttaFlow Bioseal and its bond strength; thus, the study's objective was to assess the POBS of AH Plus, Sealapex, TotalFill BC, and GuttaFlow Bioseal.

MATERIALS AND METHODS

This study received approval from the Research Ethics Committee of the Faculty of Dentistry, Mansoura University (Protocol ID: M0104023RC). The required sample size performed using G*Power 3.1 software (Heinrich Heine University, Dusseldorf, Germany). In order to achieve a power of 80% and an alpha value of 0.05, 12 teeth were utilized for each experimental group.

Teeth selection

The study used forty-eight single-rooted human mandibular premolars, obtained from the Faculty of Dentistry's outpatient clinic, Mansoura University, for orthodontic purpose or periodontal problems. The selected teeth had to meet **inclusion criteria**, meaning they had:

1. Single root
2. Single straight root canal
3. Mature apices

Each tooth was submerged in a 5.25% sodium hypochlorite solution to ensure effective disinfection.

Teeth preparation and obturation

Prior to instrumentation procedures, the crowns of all teeth were carefully eliminated to the level of cementoenamel junction by utilizing a diamond-coated disk with coolant to get 14 mm root length. The working length was determined by measuring the length of K-file #15 (Mani Inc., Tochigi, Japan) at the apical foramen subtracting 1 mm. A radiograph was taken to verify the accuracy of the working length. ProTaper Universal Nickel Titanium Rotary System (Dentsply Sirona, Charlotte

NC, USA) was used to shape all root canals up to F4 (0.40/0.06), using a crown-down technique. Irrigation was performed with 5 ml of concentrated 5.25% NaOCl after each file, and the apical patency was assessed using a K-file size 15.

After the completion of instrumentation, the final rinse was (5ml concentration 5.25% NaOCl, washing with 5ml of saline followed by 5ml of EDTA 17% for 1 minute finally canals were rinsed with sterile saline). The samples were distributed to four groups in a random manner, with each group consisting of 12 teeth (n = 12) according to sealer type that was used:

- Group I (AH plus sealer),
- Group II (Sealapex),
- Group III (Total fill bioceramic sealer),
- Group IV (Guttaflow bioseal sealer).

Absorbent paper points (Meta Biomed, Cheongju, Korea) were used to dry all prepared canals. The endodontic sealers specific to each group were prepared in following the manufacturer's recommendations. Obturation was done by using the cold lateral compaction technique with size F4 GP as a master cone in all samples.

In group I & II; AH Plus (G1) and SealApex (G2) were mixed and applied into the canals using a lentulospiral (Mani, INC, Japan), then the master cone was coated with a layer of the sealer and was carefully seated to its entire working length. **In group III & IV**; TotalFill (G3) and GuttaFlow Bioseal (G4) were injected into the canals using special tips provided by the manufacturers, then the master cone was inserted to the full working length.

To ensure comprehensive canal filling, a size #30 spreader was employed up to 2 mm less than the working length, followed by auxiliary GP cones sized 25/0.02. Using a heated instrument, any excess gutta percha at the canal orifice was eliminated followed by vertical condensation using hand plugger. Any excess sealer was removed using an alcohol-soaked cotton pellet. All samples were then incubated at 37ºC for one week to give sealers time to completely set.

Bond strength evaluation using Push out test

After incubation, the samples were placed vertically in self-cure acrylic resin in a plastic mold. The roots were then divided into three equal thirds (apical, middle and coronal), and from the center of each third, a 2-mm thick segment was cut horizontally. This was done using Isomet 4000 precision micro-saw device (Buehler, USA) equipped with a 0.6 mm thick diamond disc, operating at 2500 rpm.

A stainless-steel cylindrical plunger was used to apply load to the filling material. This plunger is attached to the upper section of an Instron universal testing machine (model 3345; High Wycombe, England) and has diameters of 0.9 mm for the coronal samples, 0.7 mm for the middle samples, and 0.5 mm for the apical samples.

The plunger tip was placed perpendicular to the sample surface to ensure that it only touched the filling material, thereby avoiding any stress on the adjacent dentine. The dislodging force was exerted in the apical coronal direction (the narrower diameter of the root canal facing upward) to avoid any restriction that may have resulted from the taper of the RC. The bonding strength was measured in megapascals (MPa) using the formula: Load divided by the adhesion surface area. The surface area of adhesion of each segment was determined using the formula: $[(r^1+r^2) / 2] \times\pi\times h$, where h is the segment's thickness, measured in millimeters, r^1 and r^2 represent the lesser and larger radii, respectively, and π is the constant 3.14.

Statistical analysis

The POBS values obtained from samples of the four groups were compared using statistical methods. The Shapiro-Wilk test confirmed that the data followed a normal distribution curve ($p<0.05$). Thus, A one-way analysis of variance (ANOVA) was conducted to compare the mean values across the groups. When ANOVA revealed a statistically significant difference, a Tukey's post hoc test was conducted for further analysis of the results. The statistically significant was established at $p < 0.05$. The analyses were performed using GraphPad Prism software (Version 10.0; GraphPad Software, San Diego, California, USA).

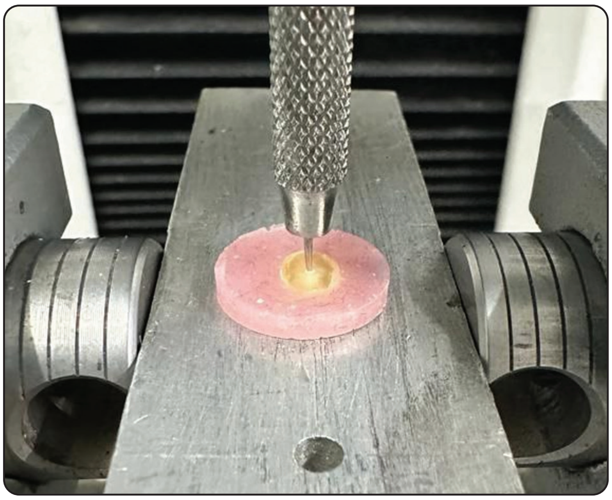

Fig. (1) Close view of the plunger.

RESULTS

The POBS for all samples was calculated in megapascals (MPa) in cervical, middle and apical thirds. High values indicated high bonding strength between root dentin and the filling material. The data were presented as mean values along with their corresponding standard deviations (SD).

- **Inter-group comparison (Comparison between tested groups according to radicular regions):**

The AH plus sealer demonstrated significantly higher dislodgement resistance in the cervical, middle, and apical regions compared to the other three groups. There is no statically significant difference between Seal apex, total fill, Gutta flow bioseal.

The mean ± standard deviation (SD) of the POBS, measured in megapascals (MPa), across the various groups.

Site	AH plus Mean ±SD	Seal apex Mean ±SD	Total fill Mean ±SD	Gutta flow bioseal Mean ±SD	Test of Significance
Coronal	5.565±0.994 (Aa)	2.052± 0.449 (Ab)	2.941±0.909 (Ab)	2.327±0.995 (Ab)	P value < 0.0001**
Middle	6.669±0.889 (Ba)	3.176±0.932 (Bb)	3.410±0.855 (Ab)	2.788±0.960 (Ab)	P value < 0.0001**
Apical	6.955±1.279 (Ba)	3.583±0.772 (Bb)	3.106±0.703 (Ab)	3.604±0.381 (Bb)	P value < 0.0001**

*Values marked with **different small** letters denote significance within the same row (P<0.05), while values with different **capital** letters indicate significance within the same column (P<0.05).*

- **Intragroup comparison (Comparison between the POBS values for each third of the root):**

AH plus, Seal apex sealers showed statistically significant greater POBS values at the apical and middle thirds than the cervical third.

The POBS of Total fill sealer in apical, middle, and coronal samples did not show any significant differences.

Gutta flow bioseal sealer had considerably higher values of POBS at apical section in comparison to coronal samples. When comparing the samples from the cervical and middle thirds, no statistically significant differences were found.

DISCUSSION

The adhesion between obturation materials and dentin is essential for ensuring long term success of endodontic therapy. Enhanced sealer adhesive capabilities to root dentin can reduce the chance of microleakage, prolong the clinical lifespan of the tooth following endodontic therapy, promote periapical healing, and prevent reinfection. [13,14,15,16] For this reason, the current in-vitro research was conducted to compare the bonding strength (dislodgment resistance) of four different classes of RC sealers (AH Plus, Sealapex, TotalFill BC and GuttaFlow Bioseal) to root dentin.

Various tests, including push-out, pull-out, and micro-tensile, have been employed to assess the bonding strength. However, the PBS test offers several advantages, such as a lower standard deviation, reduced technique sensitivity, ease of performance.

In the POBS test, the pluggers were chosen with a certain diameter and positioned in a manner that ensures contact only with the core material, causing it to be displaced downward;[17] without touching the walls of the canals. This ensured support of the dentin during loading process and resulted in reproducible and accurate measurements.[18] The examined samples were positioned in an apical to coronal orientation to prevent any potential interference caused by canal tapering, wedging, or constriction.

In present study, the results revealed that AH Plus exhibited a significantly superior dentine bonding compared to other endodontic sealers (Seal apex, total fill, Gutta flow bioseal).

This may be explained by the chemical bond formed to root dentine**,** AH Plus is an epoxy resin-based sealer that contains epoxy resins that react with the exposed amine groups in collagen present in dentin to form a strong covalent bond. In addition to, AH plus exhibits minimal volumetric shrinkage during polymerization, generates low stress, and offers outstanding dimensional stability.[13,14,16,18,19,20] Also the good flowability and sealer penetration could attribute to the enhanced bonding to root dentine, where AH Plus demonstrates a low viscosity, allowing it to effectively infiltrate microscopic irregularities and intricate network of dentinal tubules. This improves its mechanical adhesion to dentin.[21]

In present study, Total Fill BC Sealer exhibits lower POBS in comparison to AH Plus. This phenomena may be due to the micromechanical contact in between RC wall and the CSBS, aided by the formation of tag-like structures. Additionally, there is a chemical reaction that forms a "mineral infiltration zone" which creates a less strong attachment to the dentin compared to epoxy resins.[22]

The study findings indicate that the bonding strength of Sealapex was inferior to that of AH Plus, consistent with the findings of **Wennberg and Ørstavik**. [23] This is likely because self-cured calcium hydroxide sealers have low tensile cohesion strength.[24,25]

GuttaFlow Bioseal sealer had inferior bond strength in comparsion to that of AH Plus. The justification for the outcomes of GuttaFlow Bioseal sealer may be attributed to its composition, which includes silicone and gutta-percha particles. Studies have shown that both GP and silicone lack adhesion to the dentin surface. [26,27,28] The inclusion of silicone in GuttaFlow Bioseal resulted in inadequate wetting on the root dentin surface, likely due to the generation of significant surface tension forces that limit the distribution of these materials.

In present study, the evaluated sealers (AH Plus, Seal Apex, and Gutta Flow Bioseal) showed a higher bonding strength to apical root dentin compared with middle and coronal root dentin. This may arise from a greater sealer penetration into the dentinal tubules and stronger adaption of the GP cone to the shape of the root canal in apical third. This finding aligns with the conclusions of Uppalapati et al. and Sly et al., who reported that bonding strength rises from the coronal to the apical area.[29,30]

CONCLUSIONS

AH plus sealer demonstrated a higher POBS in comparison to other sealers (Seal apex, total fill, Gutta flow bioseal). The POBS to root dentin is not significantly different between Sealapex, total fill, and Gutta flow bioseal. The bonding strength values of apical root dentin were greater than those of middle and coronal root dentin in the AH plus sealer, Seal apex, and Gutta flow bioseal groups.

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