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Comparative Analysis of Marginal Adaptation of Different Root Canal Sealers Using Scanning Electron Microscope

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Abstract

Aims: The present study aimed to evaluate and examine the degree of marginal adaptation of several root canal sealers using a scanning electron microscope (AH Plus, MTA-Fillapex, Total-Fill, and GuttaFlow Bioseal) to root dentine.

Methods and Material: Forty extracted mandibular premolars with completely formed apices and a single root were selected. The root canals were instrumented after the decoronation of teeth. The samples (n = 10) were divided randomly into four groups. Group (1) was sealed with a resin-based sealer (AH Plus), Group (2) with an MTA-based sealer (MTA-Fillapex), Group (3) with a bioceramic sealer (TotalFill BC), and Group (4) with a silicone-based sealer (GuttaFlow Bioseal). After horizontally slicing samples with a diamond disk, marginal adaptability was evaluated using SEM.

One-way ANOVA test and the multiple Post hoc test of Tukey was reliant on the statistical analysis of the data.

Results: TotalFill BC has shown significantly higher marginal adaptation than MTA-Fillapex and GuttaFlow Bioseal ($P < 0.05$). There is no significant difference between apical and coronal sections in the four tested groups under SEM ($P < 0.05$).

Conclusions: Total fill BC outperformed the other tested sealers in terms of marginal adaptability.

Key-words: AH Plus; GuttaFlow Bioseal; Marginal Adaptation; Scanning Electron Microscope; Total fill BC.

Introduction:

A successful endodontic procedure requires complete removal of the diseased pulp, effective cleaning of the root canal, and correct biomechanical preparation and obturation[1]. Since most treatment failures were due to inadequate obturation, insufficiently filled gaps may serve as a breeding ground for bacteria[2]. Producing a hermetic fluid seal is the main aim of endodontic obturation. The most widely utilized solid core material for root canal obturations is gutta-percha with sealer[3]. Gutta-percha, on the other hand, does not integrate with the dentine of the tooth's roots. Furthermore, microleakage at the sealer-core or sealer-dentine junction is a leading cause of root canal treatment failure over time[4].

The marginal adaptability of a root canal filling material is crucial for ensuring the long-term stability of treatment outcomes. Gutta-percha and sealer should be utilized to fill the canal with a homogenous mass that matches the canal walls. If there is no sealer involved, the filling material will not be able to adapt to the canal walls, resulting in gaps[5, 6]. A good sealer should stick well, seal well, be compatible with tissue, not dissolve in tissue fluids, and kill bacteria. It is necessary for a root canal sealer to have the ability to form a reliable connection between the filler material and the canal walls[7]. There are several different types of endodontic sealants, including those with a zinc oxide-eugenol base, a calcium hydroxide base, a resin base, a glass ionomer base, a silicon base, a bioceramic base, and an MTA base[8].

AH-Plus (Dentsply DeTrey, Konstanz, Germany) is a widely used sealer because it has such desirable qualities as high dentine adhesion and optimum sealability[9]. MTA-Fillapex is an MTA-based sealer (Angelus, Londrina-Parana, Brazil) that consists of MTA, bismuth oxide, salicylate resins, pigments, and silica nanoparticles in a two-paste system. In addition to being highly biocompatible with the surrounding tissue, this sealer is noted for its excellent sealing efficacy, bactericidal activity, and low solubility[10].

Total Fill BC sealer (FKG, La Chaux-de-Fonds, Switzerland) is a pre-mixed calcium silicate-based sealer. When Total Fill BC root canal sealer cures, it forms hydroxyapatite and chemically bonds to dentine[11]. GuttaFlow Bioseal (Coltène/Whaledent, Langenau, Germany). Guttaflow Bioseal has a bioactive characteristic and a slight setting expansion that guarantees a maximum seal. GuttaFlow Bioseal has been found to have excellent penetration to dentine and good physicochemical qualities in terms of setting time, solubility, radiopacity, and flow[12].

The aim of this study was to assess the degree of marginal adaptation of different root canal sealers (AH Plus, MTA-Fillapex, Total-Fill, and GuttaFlow Bioseal) to root dentine using a scanning electron microscope

Materials and Methods:

Before performing the study, ethical approval was acquired from the institutional ethics committee board of the College of Dentistry, Mustansiriyah University (Approval Number and Date: REC111 on 15/04/2022). Using G power with the four groups gave us a sample size of 40 teeth.

Forty recently extracted human mandibular premolars were selected with a single root. The age of patients ranged from (18-25) years old, and teeth with fully developed apices, devoid of cavities, surface resorptions, and fractures. Curved roots, unusual canal morphology, and pulpal

calcifications were all ruled out in the study. Using a diamond disk (Komet, Germany) and water irrigation crowns were decoronated to create root sections 13 mm long from the apex. Canal patency was assessed using a K-file of size 10 (Dentsply Maillefer, Switzerland). To check the working length, insert a file into the canal until the tip of the file is visible at the apex. To get the working length, subtract one millimeter from this length. Using EdgeFile X7, the root canals were sequentially extended up to a size of 40 with a taper of 0.04 (Edge Endo, Albuquerque, New Mexico, USA). In this stage, the irrigation solution was 5 ml of 2.5% NaOCl (Promida, Turkiye) between file usage[13].

The root canals were irrigated with two milliliters of 17% EDTA (PD, Switzerland) acid for one minute, followed by five milliliters of 2.5% NaOCl to remove the smear layer, and then three milliliters of normal saline. All irrigating solutions were administered with a 30-gauge needle placed within two millimeters of the whole working length, and the root canals were dried with paper points.

All canals were dried after instrumentation, and the teeth were allocated randomly into four groups (n = 10) depending on the sealer used. The teeth in Group 1 were obturated using gutta-percha (40/0.04) and a resin-based sealant (AH Plus). Group 2 - teeth were obturated using a mineral trioxide aggregate-based sealer and gutta percha (40/0.04). (MTA Fillapex). Teeth in Group 3 were obturated with gutta-percha (40/0.04) and a bioceramic sealer (Total-Fill BC sealer). Group 4 obturated teeth with gutta-percha (40/0.04) and silicone-based sealant (GuttaFlow Bioseal).

All the sealers were operated following the manufacturer's instructions. All samples were radiographed (mesiodistal & buccolingual) to ensure the quality of obturation. Then the obturation material was removed 1 mm from the orifice. Cavit G was used to fill the cavities, and then the teeth were stored for seven days in moisturized condition with 100% humidity and 37°C temperature. Transverse sections were taken at 2 and 4 mm, and 9 and 11 mm distances from the apex using a diamond disc (Komet, USA) installed on a slow-speed handpiece with water cooling. Two sections with a 2-mm thickness from the apical and coronal third of each root were examined under a SEM[3,14].

After mounting the samples with an aluminum stub, positioning them in a vacuum chamber, gold sputtering, and then a scanning electron microscope was used for measurement. Gaps found between the sealer and the dentine of root interfaces were photographed at the coronal and apical sections of the root at magnifications of 150 and 2000 (figure 1 and figure 2), respectively. The greatest and smallest gap in microns (μ) was measured for each section[15].

All calculations and computations of statistics were done using SPSS version 22 (IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp). A one-way ANOVA was used to assess variations in marginal adaptability among geographic regions. To make pairwise comparisons between the groups at the 95% confidence level, we used Tukey's multiple post hoc test.

Results:

The results revealed that Total Fill BC sealer had the best Marginal adaptation compared to other groups (lowest gap width) [Table 1]. TotalFill BC has shown significantly higher marginal adaptation than MTA-Fillapex and GuttaFlow Bioseal (P <

0.05). A non-significant difference was found between AH Plus and other groups (P > 0.05). There is no significant difference between apical and coronal sections in the four tested groups under SEM (P < 0.05).

Discussion:

This research used single-cone obturation to imitate the most general approach used in clinical scenarios and to preserve group homogeneity[16]. With any single-cone obturation approach, matching the master cone to the preparation is critical. Furthermore, because of the predictability of form associated with constant taper, a genuine single cone approach should be achieved using a constant tapered preparation such as a 0.04 or 0.06. A variable taper approach is not advised since its lack of shape prediction (and hence repeatability) results in a less-than-ideal cone fit. In this investigation, root canals were instrumented using an EdgeFile X7 system with a constant 0.04 taper.

To ensure that the smear layer was removed for better sealer adhesion, the irrigation protocol used in this study included 17% EDTA solution after the instrumentation was finished. Distilled water was then used as the final rinse to wash out any remaining irrigation chemicals that might affect the setting reaction of the used sealers, particularly the resin-based ones[16].

In the current study, Total Fill BC RCS had the highest marginal adaptability, followed by AH Plus and GuttaFlow Bioseal, and MTA Fillapex had the lowest marginal adaptability.

The BC sealer finding is consistent with earlier investigations that found BC sealer to be more adaptable than AH Plus [16,17,18]. TotalFill BC's superior adaptability can be attributed to the size of the cement's particles which are very fine and have hydrophilic properties. The sealer may easily spread out across the root canal dentine walls and into the lateral micro-canals because of the sealer's low contact angle. Bioceramic-based root canal sealers also have a chemical adherence to the dentine walls of the canals[19]. Establishing a mineral infiltration zone, which at the interaction of calcium silicate and dentine creates structures like tags, has also resulted in more significant marginal adaption for Total Fill BC root canal sealer. Calcite crystals are created when the tissue's carbon dioxide and the calcium ion in this zone react. These crystals lead to a decrease in gaps and leakage, as well as improved adaptability.[20,21,22]. However, this result disagreed with the previous study [23,13].

AH Plus exhibited a good adaptation regarding other sealers (GuttaFlow Bioseal, MTA-Fillapex), and these results were consistent with earlier research[24,25]. AH plus is highly adaptable because it chemically attaches to root dentin by opening the epoxide ring and reacting with any accessible amino groups in collagen to generate covalent connections between the resin and collagen[25].

GuttaFlow Bioseal sealer demonstrated greater marginal adaptability than MTA Fillapex, although the difference was not statistically significant. The lowest marginal adaptation showed by MTA Fillapex, like the findings of other studies[3,24,25,] can be due to inadequate micro tags created at this sealer's setting. MTA Fillapex sealer is an MTA-based sealer, but it also contains resin; therefore, the discrepancy in the results may be attributable to the incomplete polymerization of the two materials. However, when the sealer polymerizes, its viscosity rises, slowing the molecular mobility and reaction rate.

Coronal and apical sections from the same group showed no statistically significant difference, possibly due to the standardization

of selection, instrumentation, and obturation of the tested samples.

Conclusion

Within the limits of this investigation, Total fill BC sealer showed the best marginal adaptation among the tested sealers, followed by AH Plus sealer.

Conflict of Interest: The authors declare that there was no conflict of interest.

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Table 1: Tukey HSD test for multiple comparisons between groups at coronal and apical levels.

(I) group	(J) group	Coronal		Apical	
		Std. Error	P-Value	Std. Error	P-Value
Group 1 AH PLUS	Group2	1.4715	0.054	1.0792	0.059
	Group3	1.4715	0.200	1.0792	0.079
	Group4	1.4715	0.200	1.0792	0.700
Group 2 MTA Fillapex	Group1	1.4715	0.054	1.0792	0.059
	Group3	1.4715	0.000	1.0792	0.000
	Group4	1.4715	0.336	1.0792	0.430
Group 3 Totalfill BC	Group1	1.4715	0.200	1.0792	0.079
	Group2	1.4715	0.000	1.0792	0.000
	Group4	1.4715	0.001	1.0792	0.005
Group 4 Guttaflow Bioseal	Group1	1.4715	0.200	1.0792	0.700
	Group2	1.4715	0.336	1.0792	0.430
	Group3	1.4715	0.001	1.0792	0.005

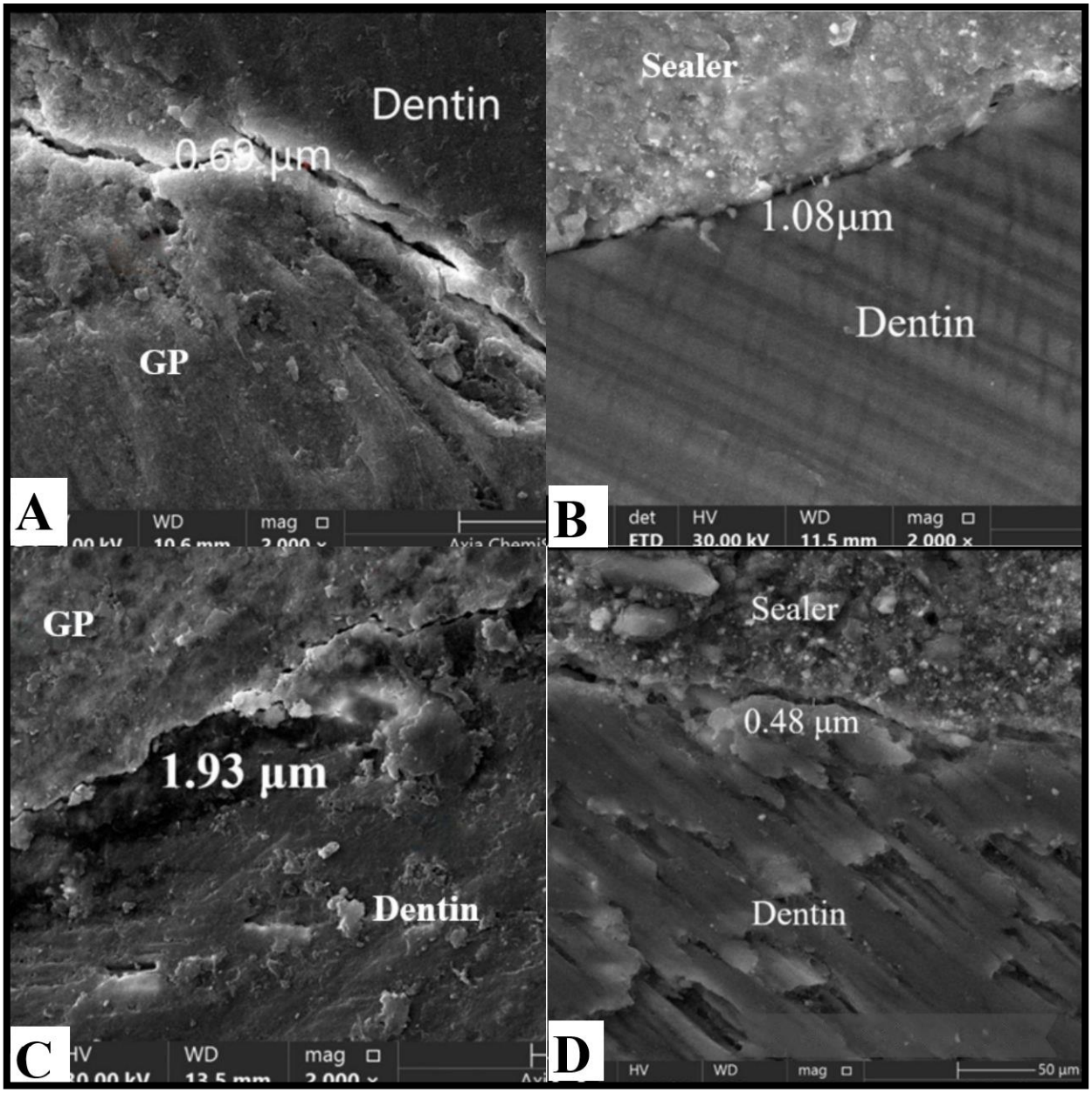

Figure 1 Coronal sections under SEM x2000 (A): AH Plus; (B): MTA-Fillapex; (C): TotalFill BC; (D) GuttaFlow Bioseal.

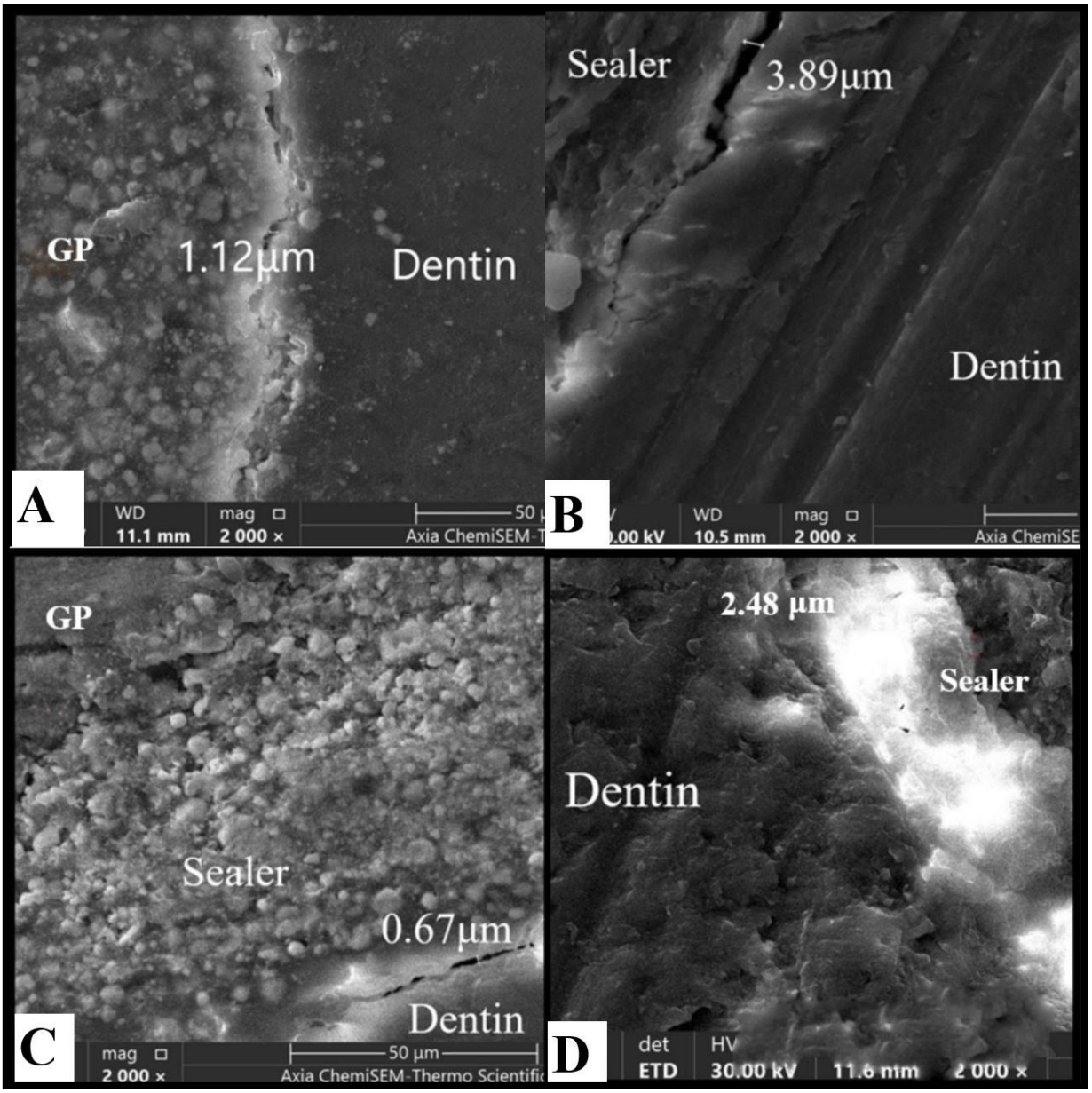

Figure 2: Apical sections under SEM x2000 (A): AH Plus; (B): MTA-Fillapex; (C): TotalFill BC; (D) GuttaFlow Bioseal.