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Evaluation of residual sealer in dentinal tubules after retreatment of canals obturated with two types of sealers

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Abstract

Objective: This study compared the retrievability of an epoxy resin-based sealer (AH26) and an MTA-based sealer (EndoSeal MTA) following root canal retreatment.

Methods: Twenty-six extracted single-rooted human maxillary central incisors were prepared up to size F3 using the Denco Super Files III rotary system. The teeth were randomly assigned to two groups and obturated with either AH26 or EndoSeal MTA sealers, employing a single-cone technique for all samples. After one week of storage in distilled water, the filling materials were removed by Denco super files III rotary system. The residual sealer was evaluated using scanning electron microscopy (SEM) at x800 and x2000 magnifications. The statistical analysis was done by Two-way ANOVA, and a P-value less than 0.05 was considered significant.

Results: Under the two magnifications, both the type of utilized sealer and the root section assessed had a significant effect on the percentage of remaining sealer ($P < 0.05$), but the interaction was not significant ($P > 0.05$). The overall percentage of residual sealer was significantly lower in the EndoSeal MTA group compared to the AH26 groups as assessed under x800 ($P = 0.08$) and x2000 ($P = 0.012$) magnifications. In each group, the percentage of residual sealer was significantly greater in the apical than in the coronal third.

Conclusions: The residual sealer in the AH26 group was greater than that in the EndoSeal MTA in all three root sections. The apical third section showed more sealer than the coronal section, irrespective of the sealer type used.

Keywords: Epoxy resin sealer, Mineral trioxide aggregate, Resin cement, Retreatment, Root canal filling material, Scanning electron microscopy

Introduction

The presence of residual filling materials after endodontic retreatment impedes the complete removal of necrotic tissue and bacteria, and thus predisposing the tooth to the development and persistence of periapical lesions (1). Previous studies reported that the success rate of non-surgical root canal (NSRC) retreatments range from 62 to 91% (2). The presence of

remaining filling materials inside the canal after retreatment may allow bacteria to accumulate and cause infection (3). Furthermore, incomplete removal of remaining filling materials can prevent the delivery of irrigating solutions to the root canal system and potentially jeopardize periapical health (4,5, 6). Residual sealers serve as a mechanical barrier between intracanal disinfectants and bacteria, particularly in challenging areas like the dentinal tubules. These bacteria are the main cause of periapical lesion development and persistence (7, 8). Therefore, the ability to retrieve root-filling materials is crucial for successful endodontic retreatment (9).

Various sealers are available for root canal therapy (RCT), including epoxy resin-based and MTA-based sealers. Epoxy resin-based sealers, such as AH26

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(Dentsply, Konstanz, Germany), are noted for their strong adhesion to dentin. (10). A significant quantity of these sealers remains in the root canal system after retreatment (11). In addition, their deep penetration into the root canal makes the removal process challenging (12). Epoxy resin-based sealers are accepted as the gold standard by endodontists (13).

MTA-based sealers are known for their ability to stimulate hard tissue formation, making them suitable for a variety of endodontic applications. EndoSeal MTA (Maruchi, Wonju, Korea), which is based on Mineral Trioxide Aggregate (MTA) (14), offers appropriate sealing properties and biocompatibility (15) and promotes biomineralization within dentinal tubules (16). Nonetheless, its retrievability remains a concern, and attempts to develop an ideal sealer are more focused on sealing ability than on the retrievability of the sealer.

Previous studies have acknowledged the challenges in achieving complete eradication of filling materials; however, most of the existing literature has focused on eliminating gutta-percha remnants (17). There is still a lack of sufficient evidence regarding retreating canals obturated with the EndoSeal MTA sealer. Therefore, the purpose of this study was to compare the retrievability of MTA-based and epoxy resin-based sealers following root canal retreatment.

Materials and methods

Study design and sample preparation

Ethical approval for this study was obtained from the Research Center of the Islamic Azad University Dental Branch, with the reference number IR.IAU.DENTAL.REC.1400.066.

This study included 26 extracted human maxillary central incisors. The teeth underwent radiographic and visual examinations to discard those with calcification, open apices, extremely wide or multiple canals, cracks, fractures, previous root canal treatment, or a curvature greater than 10°.

Subsequently, the crown of each specimen was cut using a diamond disc to obtain a standard length of 10 mm from the incisal edge to the anatomical apex (17). The working length (WL) of a #10 K-file (Mani, Japan) was set 1 mm shorter than this length. All canals were prepared with Denco super files III rotary system (Shenzhen Denco Medical, China) up to size F3 (18) according to the manufacturer's instructions. Canals were irrigated with 2 ml of 2.5% sodium hypochlorite (NaOCl; Marvaban, Iran) for 1 minute after using each file. After that, 5 ml of 17% ethylenediamide tetraacetic

acid (EDTA; Marvaban, Iran) was used to remove the smear layer. The final irrigation was performed with 2.5% NaOCl for 30 seconds. The canals were then dried with paper points.

Sample allocation

The teeth were randomly divided into two groups (n=13) based on the type of sealer used:

Group 1: In this group, an epoxy-resin-based sealer (AH26; Dentsply, Konstanz, Germany) was used for sealing the canal.

Group 2: The teeth in this group were sealed with a calcium silicate-based sealer (EndoSeal MTA; Maruchi, Wonju, Korea).

Both groups were obturated using 0.06 tapered gutta-percha (DiaDent, Chungcheongbuk-do, Korea) and the single cone (SC) technique. In the AH26 group, a small amount of sealer was applied on a 25 mm lentulo spiral filler (Spiral Paste Filler; Henry Schein Inc., Melville, NY, USA) and introduced into the canal via a handpiece set 1 mm shorter than the WL (19). In the EndoSeal MTA group, canals were filled using a special syringe. Subsequently, the master cone was inserted, cut at the orifice level, and compacted with a plugger (20).

After obtaining periapical radiographs of the buccolingual and mesiodistal dimensions, the samples were kept in an incubator (Behdad, Tehran, Iran) at 37°C and 100% humidity for one week (21).

Endodontic retreatment

Once the sealer had fully set, the filling materials were removed using the Denco super files III rotary system, and the irrigation process used for the initial RCT was repeated. The removal process began with the SX rotary file (19/variable taper) used up to half of the WL, progressing with S1 (17/variable taper) and S2 (20/variable taper) files up to two-thirds of the WL using a brushing motion. The F1 (20/apical taper 7%), F2 (25/apical taper 8%), and F3 (30/apical taper 9%) files were then employed up to the full WL with a gentle pecking motion at 2 NCm torque and 300 rpm (22). The procedure was considered complete when no visible filling material remained on the final file. Patency was maintained using small-sized K-files.

Assessing residual sealer percentage

Each tooth was then bisected longitudinally and buccolingually, and grooves were made at 9 mm (coronal), 6 mm (middle), and 3 mm (apical) from the apex. Afterward, a gold coating was applied to each sample (23). Scanning electron microscopy (SEM)

Table 1. Mean and standard deviation (SD) of the percentage of residual sealer at different sections in the study groups under ×800 magnification

Magnification	Sealer	Coronal	Middle	Apical	Total	P-value
×800	AH26 (%)	14.8223 ± 9.60	13.1181 ± 4.42	14.5835 ± 6.05	14.17 ± 6.69	0.02
	EndoSeal MTA (%)	6.7596 ± 4.11	8.7512 ± 4.96	9.9912 ± 5.78	8.49 ± 4.94	
	total	10.75 ± 6.85 ^a	10.93 ± 4.69 ^a	12.28 ± 5.9 ^b		
	P-value	0.047				

Table 2. Mean percentage of residual sealer after retreatment in both study groups when evaluated at different sections and under ×2000 magnification

Magnification	Sealer	Coronal	Middle	Apical	Total	P-value
×2000	AH26 (%)	14.2235 ± 6.68	14.1327 ± 5.71	15.6312 ± 6.57	14.62 ± 6.32	0.089
	EndoSeal MTA (%)	9.0069 ± 4.61	11.2054 ± 4.31	12.1581 ± 5.27	10.73 ± 4.73	
	total	11.61 ± 5.64 ^a	12.66 ± 5.01 ^{ab}	13.89 ± 5.92 ^b		
	P-value	0.012				

(Philips XL-30 ESEM) was used to photograph each root third at ×800 and ×2000 magnifications (24). The size of the remaining materials was measured with Image J software (National Institutes of Health, USA) (25). This analysis focused on sealer particles measuring 5-6 µm and residual gutta-percha pieces measuring 20-30 µm (26). The percentage of remaining sealer was calculated using the following formula:

$$\frac{\text{Area of residual sealer after retreatment}}{\text{Area of initial filling material after retreatment}} \times 100$$

Data analysis

Data were analysed using SPSS V.16 (SPSS Inc., IL, USA) and compared using two-way ANOVA. A P-value less than 0.05 was considered statistically significant.

Results

Tables 1 and 2 present the amount of residual sealer in the study groups at different sections under ×800 and ×2000 magnifications. Both the type of utilized sealer and the root section assessed had a significant effect on the percentage of remaining sealer in different root canal thirds ($P < 0.05$; Tables 1 and 2), but the interaction was not significant ($P > 0.05$).

The overall percentage of residual sealer was significantly lower in the EndoSeal MTA group compared to the AH26 groups as assessed under ×800 ($P = 0.08$) or ×2000 ($P = 0.012$) magnifications.

Post hoc Tukey's test revealed a statistically significant difference between the percentage of residual sealer in the apical and coronal thirds of each group under both magnifications ($P < 0.05$; Tables 1 and 2).

Discussion

Complete removal of filling materials from the root canal system during retreatment is crucial to prevent periapical lesions or pain. This study evaluated the amount of residual sealer after retreating canals obturated with AH26 and EndoSeal MTA sealers.

Various techniques have been proposed to evaluate the material remnants, such as micro-computed tomography (micro-CT), cone beam computed tomography (CBCT), two-dimensional radiographic images, tooth splitting and direct SEM evaluation, and examinations by a confocal microscope or a stereomicroscope (6,10,23,25,27,29).

The present study performed SEM evaluation, which is similar to studies conducted by Kakoura et al. (23) and Elsoukary et al. (28). SEM offers the advantage of simultaneously assessing multiple samples, like dentinal tubules, with excellent resolution even in the presence of smear layers. Although non-invasive micro-CT analysis remains the gold standard, it was not used in the present study due to the device's unavailability.

The epoxy resin-based AH26 sealer exhibited higher residual values than the EndoSeal MTA Sealer in this investigation. Epoxy resin sealers form a stronger bond and a higher quality interface with dentin than MTA-based sealers, potentially explaining their more challenging removal from the root canal system (29). The outcomes of this study are consistent with those of Zakie et al. (30), who compared using AH26 with MTA Fillapex and 5% fluoride varnish as the sealer. They found that the amount of sealer left in the AH26 group was higher than that in the other groups. Neelakantan

et al. (6) also noted that the MTA sealer left less residue than the resin sealer (AH plus). On the contrary, Kim et al. (17) found no significant difference in the amount of residual sealer in single and double-rooted teeth when comparing EndoSeal MTA, bioceramic sealer, and AH Plus. The discrepancy between the results of Kim et al. (17) and the present findings could be due to various factors such as using different teeth, evaluation methods, and sealers. Additionally, the authors (17) stated that the amount of residual EndoSeal MTA sealer was highest in C-shaped roots, which may be attributed to the sealer's quick setting time and the unique morphology of C-shaped roots that enhances the sealer's mechanical resistance to removal compared to that in single-rooted central incisors.

The results of the present study indicated a more significant amount of residual sealer in the apical third than in the middle and coronal thirds, although the difference was only significant between the apical and coronal sections. This finding agrees with the findings reported by Kim et al. (17), and Cornelissen et al. (30). Mechanical and chemical removal techniques are more effective for removing filling materials from the coronal and middle thirds than from the apical third. Furthermore, the remaining filling materials can be compacted into the apical third of the canal during the retreatment procedure. In addition, the complex anatomy of the apical third, including lateral canals and ramifications, hinders the complete removal of filling materials (31). Contrary to the findings of this study, Emel et al. (7) reported a greater amount of residual sealer in the coronal third of the root canals. Donnermeyer et al. (32) reported no significant differences in the amount of residual sealer among the root canal thirds. These variations may be due to the use of different sealers.

Because of its *in vitro* nature, the results of the present study cannot be fully extrapolated to the clinical setting. One limitation of the present study was that it did not use the gold-standard (micro-CT) analysis to assess the amount of residual sealer. Only evaluating teeth with a single straight canal might influence the findings of the current study. Moreover, the residual sealers in teeth with complex root canal anatomy need further investigation.

Conclusions

The amount of residual sealer after retreatment was significantly lower across all apical thirds in canals obturated with Endoseal MTA sealer compared to those obturated with AH26 sealer. Regardless of the utilized

sealer, removing residual sealer from the apical third was more difficult compared to the coronal third of root canals.

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Conflict of interest

The authors declare no conflict of interest.

Authors' contributions

SA conceived the presented idea designed the analysis, developed the theory, and performed the computation. NR performed the data analysis, model, and computational framework design. SA and NR supervised the work. TJ wrote the manuscript in consultation with SA and NR, carried out the experiment, and performed the measurements.

Ethical approval

Ethical approval for this study was obtained from the Research Center of the Islamic Azad University Dental Branch, with the reference number IR.IAU.DENTAL.REC.1400.066.

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