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Original Article

Comparison of the apical seal obtained by Adseal, Proseal, and AH26 sealers in root canal obturation with lateral compaction technique

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ABSTRACT

Background: Root canal obturation is an important step in endodontic treatment, which is performed aiming to three-dimensionally seal the canal and prevent microleakage, reentry, and proliferation of microorganisms in the root canal system. On the other hand, microleakage eventually leads to root canal treatment failure. Sealing ability is an important property of endodontic sealers. This *in vitro* study aimed to compare the quality of apical seals obtained by three endodontic sealers.

Materials and Methods: This *in vitro* experimental study evaluated 48 extracted single-canal maxillary incisors. Hard- and soft-tissue residues were removed and the teeth were immersed in 5.25% of sodium hypochlorite for disinfection. The teeth were decoronated at the cementoenamel junction with a diamond disc such that 10 mm of root length remained. Canal patency was ensured using a #10 K-file. The canals were then instrumented with ProTaper rotary system. The canals were randomly divided into three experimental groups for the application of Adseal, Proseal, and AH26 sealers, and positive and negative control groups. Sealers were applied in the canals using lateral compaction technique. The external root surfaces were then coated with two layers of nail varnish except for the apical 3 mm. The amount of microleakage was quantified using the dye-penetration technique. The Tukey's test was used to compare the microleakage between the experimental and control groups. The Kruskal–Wallis test was applied to compare the microleakage of experimental groups ($P < 0.05$).

Results: The amount of microleakage in canals filled with Adseal, Proseal, and AH26 sealers with lateral compaction technique was 2.33 ± 0.64, 2.2 ± 0.81, and 2.22 ± 0.71 μm, respectively. No significant difference was noted among the three sealers regarding microleakage ($P = 0.84$). However, the amount of microleakage in the sealer groups was significantly lower than that in the control group ($P < 0.001$).

Conclusion: The application of Adseal, Proseal, and AH26 had equal efficacy for the provision of optimal apical seal in filling of root canals with lateral compaction technique. The application of sealers yielded a significantly superior apical seal compared with the control group.

Key Words: Epoxy resin AH-26, gutta-percha, root canal obturation

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INTRODUCTION

The main goal of root canal therapy is to eliminate the microorganisms from the root canal system. A successful endodontic treatment depends on efficient cleaning and shaping, and filling of the root canals. On the other hand, the root canals should be hermetically sealed following cleaning and shaping to prevent the colonization of oral microorganisms and reinfection of periapical tissues or the root canal space.[1,2]

Endodontic sealers are applied to prevent leakage of the periapical exudate into the unfilled areas of the root canal system.[3]

Several materials and methods have been proposed to create a hermetic apical seal in the root canal system. Root-filling materials should be able to completely fill the root canal space.[4] Apical seal is highly important and can increase the success of endodontic treatment by up to 96.5%.[1] Gutta-percha alone cannot fill the root canal space and the use of sealers is imperative to efficiently fill the gaps.[4-6]

An optimal hermetic seal cannot be achieved without the use of sealers because gutta-percha cannot chemically bond to dentin. In other words, the application of a sealer with the ability to bond to dentin and gutta-percha is imperative for a hermetic seal.[7] Sealers play a more important role than the root-filling materials, and the root-filling materials mainly serve as a carrier for the sealers.[8,9]

A wide range of endodontic sealers is commercially available, which makes it difficult for dental clinicians and endodontists to select an ideal sealer.[10,11] AH26 is the most commonly used epoxy resin-based sealer with reportedly excellent sealing ability.[12] The optimal properties of this sealer include favorable antimicrobial properties, adhesion, long working time, easy mixing, radiopacity, and optimal sealing ability while its disadvantages include risk of tooth discoloration, relative insolubility in solvents, relative toxicity of the unmixed material, and partial solubility in oral fluids. This sealer has 4–5 h of working time and 24–48 h of setting time.[12,13] Adseal is a resin-based sealer supplied in two separate tubes. It is prepared by mixing bismuth phosphate and zinc oxide with vinyl polymer.[14] Adseal is a permanent endodontic sealer with a reasonable price. It is heat cure and has optimal biocompatibility. It can be mixed easily, has optimal radiopacity, and is not dissolved in tissue fluids. Its working time is 23 min, its setting time is 45 min, and its film thickness is 33 μm.[15] This sealer has optimal radiopacity and sealing ability, is insoluble in tissue fluids, and does not cause tooth discoloration.[15] Proseal is another commonly used resin-based sealer, which is popular in the Iranian market due to its reasonable price. It has low shrinkage and optimal radiopacity and flow. According to the manufacturer, Dia-Proseal contains calcium hydroxide, which increases its pH. The high pH value of this sealer is highly important for its disinfecting property. The high pH of this sealer can neutralize the acids secreted by osteoclasts and degrade the bacterial membrane and its protein structure.[16] However, it should be gently mixed. Its working time is 1 h and its setting time is 7 h. A yellow paste and a white catalyst are well mixed in 1:1 ratio for 10–20 s. On the other hand, it can be prepared fast, easily, and with minimal waste.[17]

This *in vitro* study aimed to compare the apical seal obtained by AH26, Adseal, and Proseal.

MATERIALS AND METHODS

In this *in vitro* experimental study, 48 extracted human single-canal maxillary central incisors were collected from dental clinics in Babol City.[18] Periapical radiographs were obtained and those with severe root curvature, root fracture or cracks, immature roots, very long or very short roots, and calcified root canals were excluded from the study. The soft- and hard-tissue resides and calculus were removed, and the teeth were immersed in 5.25% sodium hypochlorite solution (Golrang, Iran) for 1 h for disinfection. They were then rinsed with water and kept in sterile 0.9% saline at room temperature until the experiment. The teeth were decoronated at the cementoenamel junction perpendicular to the longitudinal axis of the tooth using a diamond disc and high-speed handpiece under water coolant such that 10 mm of root length remained. The canal patency was ensured using a #10 K-file (Dentsply, Switzerland). For this purpose, a #10 hand K-file was introduced into the root canal until its tip was visible at the apex; 1 mm was subtracted from this length to determine the working length. The root canals were cleaned and shaped by one operator from the apex to the cementoenamel junction using a ProTaper system with single-length technique and the following sequence of files: SX (to prepare the coronal third), S1, S2, F1, F2, and F3, operating at 350 rpm. A #10 hand K-file was used to maintain patency

after using each ProTaper file. After using each file, the canal was rinsed with 0.1 mL of 2.5% sodium hypochlorite (Golrang, Iran). The canals were then dried with paper points, and the teeth were randomly divided into three experimental groups (n = 12) and two control groups (n = 6).

AH26 (Dentsply, Germany), Proseal (Diadent, Korea), and Adseal (Meta, Korea) were mixed according to the manufacturer's instructions. The canals in Group 1 were filled with gutta-percha and Adseal sealer with lateral compaction technique. The canals in Group 2 were filled with gutta-percha and Proseal sealer with lateral compaction technique and the canals in Group 3 were filled with gutta-percha and AH26 sealer with lateral compaction technique. To ensure the absence of voids, the filled root canals were radiographed. The entire external surface of the roots, except for the apical 3 mm, was coated with two layers of nail varnish to provide external seal. In the coronal part of the roots, class I cavities were created by a carbide bur and high-speed handpiece and filled with amalgam. The cavity margins were well burnished by a burnisher and the coronal seal was provided as such.

The negative control group included instrumented, but not filled, root canals. The external tooth surfaces were coated with two layers of nail varnish. In the positive control group, the entire external surface of the teeth, except for the apical 3 mm, was coated with two layers of nail varnish, and the canals were filled with gutta-percha alone without the application of sealer using lateral compaction technique [Figure 1].

In the positive control group, the canals were filled with gutta-percha alone while the root canals remained empty in the negative control group.

Figure 1: The teeth were filled with gutta-percha and different sealers in the experimental groups.

The experimental groups, as well as the positive and negative control groups, were incubated at 37°C and 100% humidity for 24 h. Next, the quality of the coronal seal was evaluated using the dye penetration method. For this purpose, the teeth were immersed in Indian ink for 72 h such that the entire tooth surface was immersed in ink. After this time period, the teeth were removed from the ink and immersed in water for 1 h. The nail varnish was wiped off by acetone [Figure 2]. Next, a buccolingual groove was created on the teeth along the longitudinal axis of the roots and extended to the center of the canal using a diamond disc. The teeth were then split in half using a spatula. The sounder half was inspected under a stereomicroscope at ×20 to determine the dye penetration depth [Figures 3-6]. The maximum linear dye penetration depth along the gutta-percha was measured using a computer and digital camera (Moticam 2000, Japan) and the respective software (Motic Images Plus 2.0 mL) and reported in micrometers. The length from the most coronal point of dye penetration to the apical constriction was measured.

The measures of central dispersion including the mean and standard deviation of linear microleakage (dye penetration depth) in the root canals in different groups were calculated and reported. Since the linear microleakage data were normally distributed (confirmed by the Kolmogorov–Smirnov test), one-way ANOVA was applied to compare the microleakage among the groups. Since the result of one-way ANOVA was significant, pairwise comparisons were carried out using the Tukey's test. The microleakage in the three experimental groups was compared using the nonparametric Kruskal–Wallis test. The level of significance was set at 0.05.

RESULTS

The Kolmogorov–Smirnov test revealed that the microleakage data were normally distributed in the groups (P = 0.2 for Adseal, P = 0.2 for Proseal, P = 0.2 for AH26, and P = 0.2 for the positive control group). The mean amount of microleakage (dye penetration depth) was 2.33 ± 0.64 µm in Adseal, 2.2 ± 0.81 µm in Proseal, 2.22 ± 0.71 µm in AH26, and 8.24 ± 0.78 µm in the positive control group [Table 1]. One-way ANOVA showed a significant difference among the four groups in the amount of linear microleakage (P < 0.001). The

Table 1: Measures of central dispersion for the amount of linear microleakage (μm) in root canals filled with gutta-percha and different sealers

Group	*n*	Mean	SD	SE	95% CI of the mean		Minimum	Maximum
					Lower bound	Upper bound		
Adseal	12	2.33	0.64	0.18	1.93	2.73	1.45	3.45
Proseal	12	2.2	0.81	0.23	1.69	2.72	1.29	3.84
AH26	12	2.22	0.71	0.2	1.77	2.67	1.15	3.25
Positive control	6	8.24	0.78	0.32	7.42	9.07	7.46	9.43

SD: Standard deviation; SE: Standard error; CI: Confidence interval

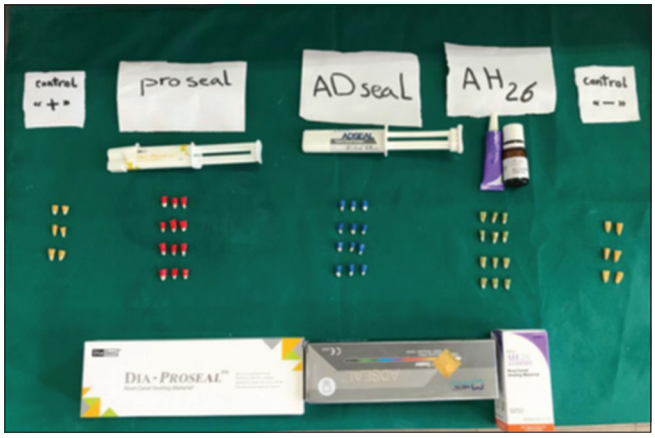

Figure 2: The teeth were coated with two layers of nail varnish except for the apical 3 mm. In the negative control group, the samples were coated with two layers of nail varnish.

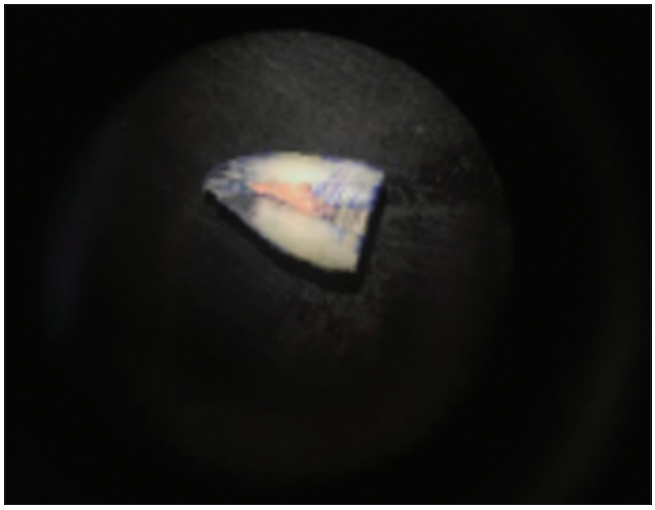

Figure 3: Stereomicroscopic image of a tooth filled with gutta-percha and AH26 sealer.

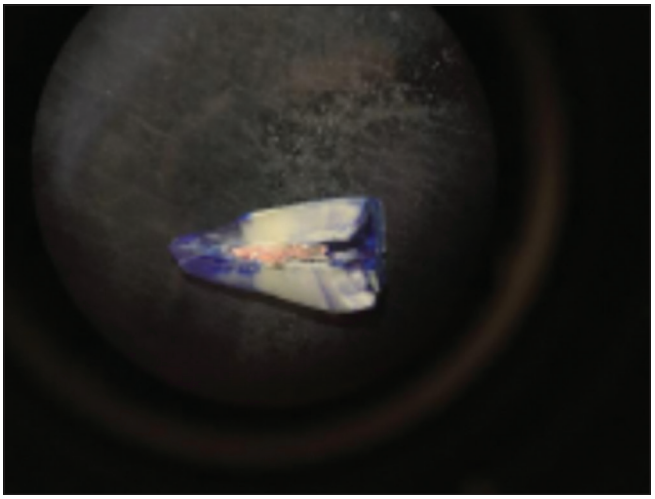

Figure 4: Stereomicroscopic image of a tooth filled with gutta-percha and Adseal sealer.

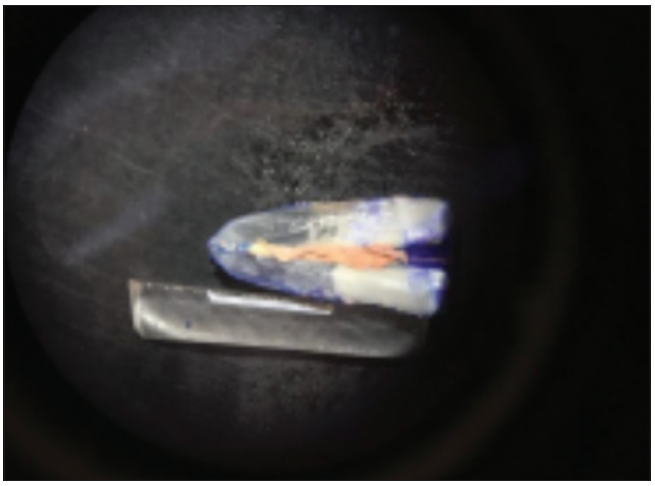

Figure 5: Stereomicroscopic image of a tooth filled with gutta-percha and Proseal sealer.

maximum value was noted in the positive control and the minimum value was noted in the Proseal group.

Pairwise comparisons of the groups regarding linear microleakage by Tukey's test revealed significant differences between Adseal and positive control ($P < 0.001$), Proseal and positive control ($P < 0.001$), and AH26 and positive control ($P < 0.001$). However, no significant difference was noted between Adseal and Proseal ($P = 0.97$), Adseal and AH26 ($P = 0.98$), or Proseal and AH26 [$P = 1.0$, Table 2].

The microleakage of root canals filled with Adseal, Proseal, and AH26 was compared using nonparametric Kruskal–Wallis test, which revealed no

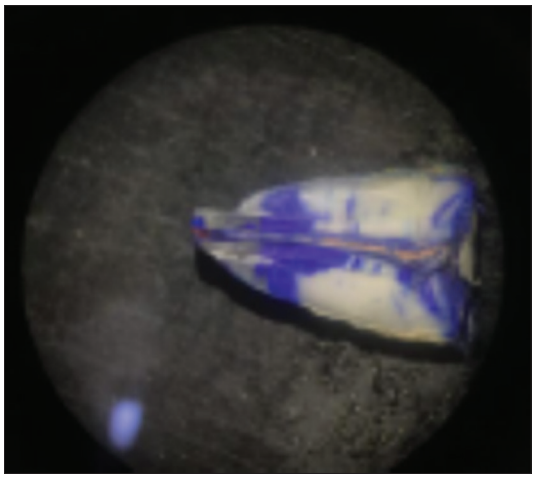

Figure 6: Stereomicroscopic image of a positive control tooth.

significant difference in this respect among the three groups ($P = 0.84$).

DISCUSSION

The current results revealed no significant difference in the mean amount of linear microleakage in the root canals filled with Adseal, Proseal, and AH26.

The application of sealer in root canals completed the process of root filling by filling the irregularities and gaps between the root filling material and canal walls. Furthermore, sealers serve as a lubricant and enable the placement of a higher number of gutta-percha points in the root canals. An *in vitro* study revealed that inadequate apical seal is responsible for 60% of treatment failures.[19]

Different sealers have been proposed for use in root canal treatment, and *in vitro* and clinical studies have reported controversial results regarding their efficacy.[20,21] For instance Salem *et al*. reported that AH26 sealer is the most effective, available sealer for prevention of microleakage.[22] Soleymani *et al*. evaluated apical microleakage of root canals following the use of AH26 and MTA Fillapex sealers in the presence of blood using the dye penetration technique. They reported that AH26 yielded minimum apical microleakage; however, the difference between the two sealers in terms of apical microleakage was not significant.[18] YaghotiKhorasani and Norozzadeh used the dye penetration technique with India ink to compare apical seal obtained by three types of endodontic sealers, namely AH26, AH Plus, and Tubliseal. They reported that although AH Plus was superior to AH26 in terms of the quality of the apical seal, the difference between the two sealers in this regard was not significant.[1]

Table 2: Pairwise comparisons of the linear amount of microleakage (μm) in root canals filled with different sealers using Tukey's test

Group 1	Group 2	Average difference	Error in the difference criterion	*P*
Adseal	Proseal	0.13	0.298	0.97
	AH26	0.11	0.298	0.98
	Positive control	5.91	0.365	0.001
Proseal	AH26	0.017	0.298	1.0
	Positive control	6.04	0.365	0.001
AH26	Positive control	6.027	0.365	0.001

In their study, AH26 sealer showed moderate microleakage, which was in line with the findings of the current study.

Khalilak Z *et al*. evaluated AH26, Endomethasone, Sealapex, and ZOE sealers and reported that the microleakage of AH26 was lower than that of other sealers but this difference did not reach statistical significance; this finding was in agreement with our results.[12]

New endodontic sealers are commonly introduced to the dental market. However, none of the available sealers in the market have the required criteria to create a hermetic seal in the root canal system.[23,24] Dia-Proseal is a new endodontic sealer. According to the manufacturer, it has advantages such as fast setting, adequate dimensional stability, provision of a hermetic seal in complex root canal systems, long storage time, and double-syringe system for faster mixing. Song *et al*. found no significant difference between Dia-Proseal and Adseal in terms of microleakage; but Adseal showed the highest microleakage values.[17]

Adseal was another sealer evaluated in this study. It is an epoxy resin-based sealer commonly used in root canal treatment due to its favorable properties.

Mozayeni *et al*. evaluated the apical microleakage of three sealing techniques using the dye penetration method and reported minimum microleakage in gutta-percha/Adseal and maximum microleakage in Resilon/Epiphany group.[2] They measured the penetration depth of methylene blue for the assessment of microleakage. They found no significant difference in microleakage of Adseal, Dia-Proseal, and AH26, but Adseal showed higher microleakage.

Hasheminia *et al*. reported that the sealing ability of Adseal was comparable to that of AH Plus and other

epoxy resin sealers.[25] The sealing ability of Adseal is explained by the fact that epoxy resin sealers do not have polymerization shrinkage and their setting reactions are imperative for their optimal adaptation to dentinal walls.[22] Epoxy resin sealers primarily contact the dentin and form a micromechanical retention that reinforces the tooth structure and prevents reinfection.[23] Song *et al*. compared the properties of Dia-Proseal with AH Plus and Adseal and showed that Dia-Proseal had the highest pH. Adseal experienced higher dimensional changes than AH Plus and Dia-Proseal. The solubility of AH Plus and Dia-Proseal sealers was the same and Adseal showed low solubility.[17] On the other hand, Mokhtari *et al*. evaluated the apical microleakage of teeth sealed with three different sealers using the dye penetration method. They reported 2.53, 2.76, and 3.03 mm of dye penetration depth following the use of AH26, Adseal, and Endofil, with no significant difference among them. This result was in agreement with our findings.[26] However, Endofil used by Mokhtari *et al*. was not used in our study; instead, we used Dia-Proseal. Both studies employed the dye penetration method to determine the amount of microleakage.

Studies on the microleakage of sealers have differences in terms of methodology, type of sealers used, and the techniques employed for assessment.[24] Obviously, all these factors can affect the results. These parameters may explain the controversy in the results of studies.

The dye penetration method is commonly used for the measurement of microleakage. The dye penetration method has disadvantages such as the smaller size of dye molecules compared with bacteria and the inability to prevent their penetration into the root canal filling material. However, this technique is highly popular due to its simplicity.[27]

In the present study, the maximum penetration depth of dye along the gutta-percha was determined using a computer and a digital camera with the respective software in micrometers. The measurement was made from the most coronal point of penetration to the apical constriction.

CONCLUSION

The Adseal, Prosal, and AH26 endodontic sealers had equal efficacy in the provision of apical seal in root canals filled with the lateral compaction technique. The application of each sealer resulted in a significantly higher apical seal compared with the control group.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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