Original Article

Colorimetric Comparison of Tooth Color Change Following the Use of Two Endodontic Sealers: An Ex-Vivo Study

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Abstract

Background and Aim: Tooth discoloration induced by endodontic sealers is an undesired outcome of endodontic treatment that affects the esthetic appearance of the teeth, which is important especially in the anterior region. The aim of the present study was to compare the coronal discoloration caused by two frequently used resin-based sealers namely EasySeal and AdSeal.

Materials and Methods: For this experimental ex-vivo study, 75 intact human maxillary central incisors were employed. Access cavities were prepared and the coronal portion of the root canals was instrumented in all teeth. The samples were randomly divided into experimental and control groups (n=15); group A (EasySeal), group B (AdSeal), positive control group (amalgam), negative control group 1 (gutta-percha), and control group 2 (distilled water). The access cavity was sealed by self-cure glass ionomer. Color measurements were carried out using a spectrophotometer at the following time intervals: before the sealer placement (T_0), and 1 week (T_1), 1 month (T_2) and 3 months (T_3) after sealer placement. The acquired data were analyzed using the Kruskal-Wallis, Mann-Whitney U, and Wilcoxon signed-rank tests.

Results: The teeth filled by EasySeal showed a significantly higher discoloration than those filled with AdSeal at T_2 (P=0.01) and T_3 (P=0.05). However, there was no statistically significant difference between EasySeal and AdSeal at T_1 (P=0.09).

Conclusion: The results of the present study suggest that both EasySeal and AdSeal cause considerable coronal discoloration. However, EasySeal causes greater coronal discoloration than AdSeal.

Key Words: Tooth Discoloration, Root Canal Obturation, Root Canal Filling Materials, Esthetics, Dental, Spectrophotometry

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Introduction

Root canal sealers are often used in conjunction with gutta-percha for obturation of the root canal system to establish a fluid-tight seal (1). Aside from the biological and functional properties, one of the foremost features of sealers is not to cause discoloration (2). Despite the constant developments, tooth discoloration caused by endodontic materials such as sealers is still considered as a common undesirable consequence of endodontic treatment (3). Tooth discoloration may also be present prior to root

canal treatment due to pulpal bleeding or necrosis, aging or dystrophic calcification after dental trauma (4,5). With the increasing esthetic demands of patients, especially when anterior teeth are involved, preventing discoloration after endodontic treatment has become a principal issue (6,7). In a study conducted by Dugas et al, it was shown that about 10% of patients were unsatisfied with the esthetic appearance and color of their endodontically treated teeth (8).

Several studies have demonstrated that root canal sealers including zinc oxide eugenol, epoxy-based sealers, calcium hydroxide, and tricalcium phosphate have the potential to cause mild to severe coronal discoloration (9-13) that can be due to the penetration of sealer into the dentinal tubules (9,10) or filling material remnants in the pulp chamber (11). The discoloration related to sealers is time-dependent and associated with the presence of chemically unreacted or corroded components such as heavy metal additives or phenolic compounds. (11,14)

Various methods have been proposed for evaluation and measurement of coronal discoloration of teeth. Tooth color assessment can be performed by visual color assessment with shade guides under standard lighting conditions according to the Munsell color system (11) or by evaluating dentin color changes in longitudinal sections of pulp chambers (12). Computerized analysis of digital photos in Adobe Photoshop, (13) digital colorimeters and spectrophotometers (15) enable the objective evaluation of chromatic alterations. Due to their high sensitivity, repeatability and data stability, spectrophotometers are regarded as the reference method in color science and are comprehensively applied for quantitative color measurements. (16-19)

Most of the studies which were conducted on discoloration induced by endodontic sealers have shown the considerable discoloration potential of resin-based sealers. (2) Despite the significance of prevention of discoloration caused by endodontic sealers in the esthetic zone, there remains a paucity of information on the association of two commonly used epoxy resin-based sealers, AdSeal (MetaBiomed, Cheongju, South Korea) and EasySeal (Komet dental, Brasseler GmbH & Co., Lemgo, Germany), and tooth discoloration. Therefore, this study aimed to obtain data which will help to address these research gaps. Considering all the above, the aim of the present study was to compare the coronal discoloration induced by two commonly used resin-based endodontic sealers, AdSeal and EasySeal. The null hypothesis (H_0) was that there would be no difference between AdSeal and EasySeal regarding coronal discoloration.

Materials and Methods

Specimen preparation:

This study was approved by the Ethics committee of Islamic Azad University Faculty of Dentistry, Iran (12.31.2015.898). In this ex-vivo experimental study, 75 sound human maxillary incisors were obtained which were free from caries, restorations, cracks, enamel defects or pathological discoloration. Rubber cups with pumice paste were used to polish the teeth and remove the stains and debris from the tooth surface. Samples were initially kept in saline until further use.

The sample size in each group (n=15) was calculated by using the Power and Precision software (ver.15.0; Englewood, NJ, USA) based on a previous study by considering α=0.05, β=0.2, standard deviation of color change (ΔE)=1.5 and the least significant difference of ΔE=1.6. (20)

Access cavity preparation was performed using high-speed diamond bur and low-speed round-end burs followed by the removal of the pulp chamber roof and pulp horns using the safe-end bur installed on a high-speed hand-piece. The specimens were sectioned 3 mm below their cementoenamel junction in the coronal third of the root using high-speed diamond disc under water coolant. (21)

Coronal preparation of the root canals was done by Orifice Shaper-SX (ProTaper, Dentsply, Switzerland). The canals were irrigated with 17% EDTA and 5.25% sodium hypochlorite each for 1 min to remove the smear layer

followed by a final rinse with sterile distilled water and final drying with paper points. (22)

The specimens were randomly assigned to experimental and control groups: group 1 (EasySeal, n=15), group 2 (AdSeal, n=15), positive control group (amalgam, n=15), negative control group 1 (gutta-percha, n=15) and negative control group 2 (distilled water, n=15). The chemical composition of sealers used in each experimental group is mentioned in Table 1. Sealers were prepared according to the manufacturers' instructions.

The thermoplastic technique was employed for the obturation of root canals using gutta-percha (Meta Biomed, Cheongju, South Korea) and different sealers for each experimental group. Excess gutta-percha was removed at the level of 1 mm under the root canal orifice, and sealer remnants were cleared from the pulp chamber using a cotton pellet. Finally, the access cavity was sealed by self-cure glass ionomer (GC Fuji II, Tokyo, Japan). The pulp chambers in the positive control group were filled with amalgam (GS-80 SDI, Victoria, Australia). In the negative control group 1, the teeth were obturated with thermoplasticized gutta-percha 1 mm under their cementoenamel junction, and the access cavities were sealed by self-cure glass ionomer while the samples in the negative control group 2 were rinsed with distilled water and sealed with self-cure glass ionomer. The teeth were stored in an incubator at 37°C and 90% humidity to simulate the clinical setting and minimize the color change caused by tooth dehydration. (23)

Color measurement:

The chromatic alterations of specimens were assessed by a spectrophotometer (MHT Spectroshade micro, Verona, Italy) at 4 time points: prior to sealer placement (baseline: T_0), and 1 week (T_1), 1 month (T_2) and 3 months (T_3) after sealer placement. The measurements were performed between 11 am-1 pm under similar lighting conditions. For standardization purposes, all color readings were done by the same operator. A mounting index made of putty silicone impression material (Coltene, Altstätten, Switzerland) was used to ensure the customization and reproducibility of each crown's position, creating 1 cm of space between the spectrophotometer and the labial surface of the teeth. According to the manufacturer's instructions, the spectrophotometer was calibrated prior to each reading. Color measurement was done using the Commission Internationale de l'eclairage L*a*b* (CIE L*a*b*) system where L* is the color value (the degree of darkness and lightness), and *a** and *b** represent chroma (in which red is +a, green is -a, yellow is +b and blue is -b).

The L*a*b values were used to calculate the color change (ΔE) at different time points according to the following formula:

$\Delta E=\sqrt{([\Delta L]^2+[\Delta a]^2+[\Delta b]^2)}$

$\Delta L= L1-L0$

$\Delta a= a1-a0$

$\Delta b= b1-b0$

ΔL,ΔE,Δa and Δb values represent differences from baseline at each assessment time point.

Statistical analysis:

The significance of change in the mean ΔE over time was assessed using the Kruskal-Wallis test, Mann-Whitney U test, and Wilcoxon signed-rank test. All analyses were carried out using SPSS software (ver.16.0; SPSS Inc., Chicago, IL, USA). The significance level was set at $\alpha=0.05$.

Results

The mean and standard deviation of ΔE at different time points in the groups are shown in Table **2**. The positive control group exhibited immediate severe discoloration, which was significantly higher than the experimental and other control groups (P=0.01). The negative control group showed the least coronal discoloration during all evaluation periods as demonstrated in Figure 1. At T_1, both EasySeal and AdSeal groups showed significantly higher ΔE compared with the control groups (P=0.01) but there was no significant difference between them (P=0.9). The severity of discoloration at T_1 was: amalgam > AdSeal = EasySeal > distilled water = gutta-percha without sealer. This sequence changed to amalgam = EasySeal > AdSeal > gutta-percha without sealer = distilled

Table 1. Manufacturer and chemical composition of sealers

Groups	Material	Manufacturer	Composition
Group A	EasySeal	Komet Dental, Brasseler GmbH & Co., Lemgo, Germany	**Paste 1:** 4-[-2-(4-hydroxyphenyl) propan-2-yl] phenol-epichlorohydrine resin, tricalcium phosphate, diphenylolpropane-diglycidyl ether, barium sulfate; **Paste 2:** polyalkoxyalkylamine-copolymer, 5-amino-1,3,3-trimethylcyclohexanmethylamine, nanodispersed silicon dioxide, water, barium sulfate, tricalcium phosphate, polyhexamethylene biguanides-hydrochloride
Group B	**AdSeal**	**MetaBiomed, Cheongju, South Korea**	**Base: Bisphenol A diglycidyl ether –bisphenol A copolymer, Zirconium oxide, Calcium phosphate, Bismuth subcarbonate Catalyst: Poly(1,4-butanediol)bis(4-aminobenzoate), Bismuth subcarbonate, Triethanolamine, Calcium phosphate, Zirconium oxide, Calcium oxide polymer**

Table 2. Median ± interquartile range of tooth discoloration (ΔE) in experimental and control groups during the study period

Groups	*n*	1st week ($\Delta E_{1,T0-T1}$)	1st month ($\Delta E_{2,\ T2-T0}$)	3rd month ($\Delta E_{3,\ T3-T0}$)
EasySeal	15	4.30±1.70	7.20±2.40	7.11±3.10
AdSeal	15	4.30±2.10	4.10±2.10	5.73±1.81
Amalgam	15	6.66±0.78	5.80±0.37	8.10±0.59
Distilled water	15	3.22±0.34	3.36±0.71	3.70±0.45
Gutta-percha	15	2.95±0.22	3.15±0.59	3.78±0.49

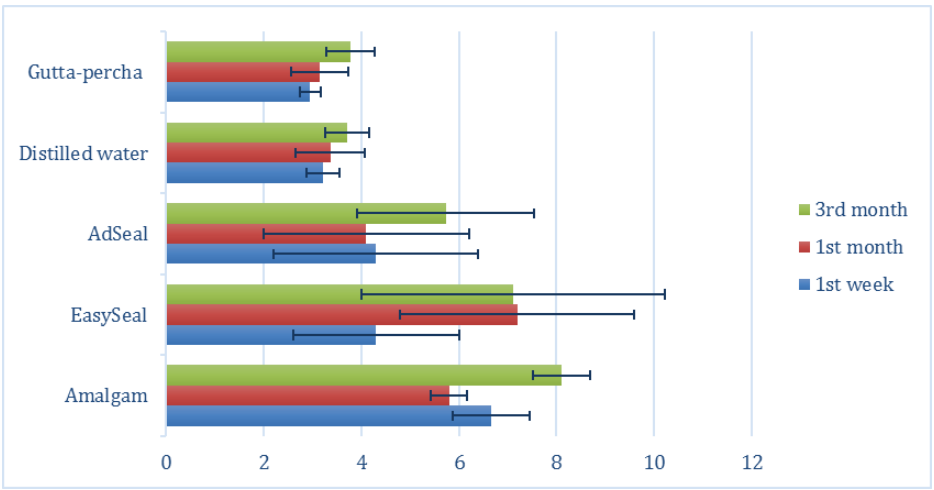

Figure 1. Comparison of color change among different groups

water at T_2 and T_3. The discoloration in EasySeal group increased over time (P=0.01) unlike the AdSeal group (P=0.08).

Discussion

Sealer-induced tooth discoloration is one of the most frequently stated problems of endodontic treatment, especially in the maxillary anterior teeth (3,6,7). It seems to be due to the penetration of sealer into the dentinal tubules and the corrosion of its heavy metal additives such as silver and formation of metallic oxides (11). Adseal and Easyseal are both widely used epoxy resin-based sealers with the same indications for use. Although a previous study reported that no discoloration was caused by AdSeal, (24) the discoloration potential of Easyseal is still poorly understood. Therefore, this study was performed to assess the discoloration potential of these two sealers.

The results of the current study demonstrated that both AdSeal and EasySeal, at all time points, led to significant tooth discoloration compared with the negative control group. However, EasySeal showed significantly higher discoloration potential than AdSeal at the follow-up times of T_2 and T_3. This finding broadly supports the work of other studies in this area linking endodontic sealers to tooth discoloration (25-27). However, when comparing our result with those of older studies, it must be pointed out that, unlike ours, the vast majority of studies (22,23,26,27) on this subject filled the pulp chamber of the teeth with sealers which is not a well-suited approach for clinical usage.

Another crucial finding was that EasySeal, unlike AdSeal, produced a significant discoloration over a 3-month period. A similar conclusion was reached by Burgt et al (10). This differs from the findings presented by Parson et al, who reported a non-apparent or mild coronal discoloration within 3 months (11). This controversy may be due to the method of tooth preparation. In our study, similar to Burgt et al, the smear layer was removed with EDTA and NaOCl (10). On the other hand, in the study conducted by Parson et al, no effort was made to remove the smear layer (11). Another possible explanation might be that Parson et al. used a visual evaluation method for assessing the color change; whereas, in the present study a spectrophotometer, which is a highly accurate and objective color-measuring instrument (11,28,29) and CIE L*a*b* color system were employed.

A possible explanation for the inconsistency in discoloration potential of these two sealers might be that in EasySeal, barium sulfate is used as a radio-opacifier which has been proven to have significant discoloration effect when used in combination with calcium hydroxide (Ultracal XS) (30). AdSeal, on the other hand, contains zirconium oxide as a radio-opacifier which has a long-term color stability. (2)

These findings, while preliminary, would seem to suggest the use of AdSeal in endodontic treatment of esthetically demanding regions. However, the generalizability of these results is subject to certain limitations. For instance, the small sample size of this study did not allow a precise conclusion about the advantage of one sealer over the other. Nevertheless, it is worth emphasizing that obtaining sound and caries-free extracted teeth is quite difficult. An additional possible source of error in this study might be the limited time of follow-up. Considering these limitations, further studies are required in order to confirm these results.

Conclusion

The evidence from this study suggests that use of AdSeal in areas of esthetic demand might have some advantages over the use of EasySeal. Our results have provided further evidence for the association of endodontic sealers with tooth discoloration. However, given the small sample size, the results of this study should therefore be interpreted with considerable caution. Despite this, considering the scarcity of freshly extracted maxillary incisors, our findings could be a useful aid in clinical decision making but should be validated by a larger sample size. It is also worth noting that findings obtained from in vitro conditions may not represent the actual tooth discoloration potential of endodontic sealers in the clinical setting; therefore, further studies, which take clinical settings into studies,

which take clinical settings into account, will need to be undertaken.

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The authors deny any conflict of interests in the matter of the present study.

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