Original Article

Tooth Discoloration after Using a Premixed Mineral Trioxide Aggregate–Based Endodontic Sealer (Endoseal MTA)

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Abstract

Introduction: Introduction: The present study aimed to evaluate the coronal discoloration of human teeth induced by using a new Endoseal MTA compared to an AH Plus Sealer. **Methods:** A total of 40 premolars extracted for orthodontic reasons were used in the present study. Then, the teeth were incised in the coronal third of the root 3 mm below the cementoenamel junction. Samples were randomly allocated to two experimental groups (group 1: AH Plus sealer, group 2: Endoseal MTA) and 6 teeth as the negative control group. The color evaluation was determined at four different times: before placing sealers (T0), 1 month (T1), 3 months (T2), and 6 months (T_3) after that with an intraoral spectrophotometer. Data were analyzed using Multivariate Test and Hotelling's Trace. A *P*-value <0.05 was considered statistically significant. **Results:** The Endoseal group showed discoloration after 1 and 3 months of the placement of sealer as AH Plus sealer. Also, discoloration of the AH Plus group was higher than that of the Endoseal group after 3 months; however, it was not significant (*P*>0.05). Furthermore, discoloration of the Endoseal group was significantly higher than that of the AH Plus group after 6 months (*P*<0.05). Discoloration tended to decrease until 6 months in both groups. **Conclusion:** The Endoseal group indicated discoloration which is comparable to AH Plus in 1 and 3 months; however, discoloration in the AH Plus group decreased compared to the Endoeseal MTA group after 6 months.

Keywords: AH Plus, Mineral Trioxide Aggregate, Root Canal Sealer, Tooth Discoloration

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Introduction

Endodontic sealers are essential for root canal treatment. In addition to possessing proper biological and functional properties, sealers should not cause tooth discoloration.

Discoloration after root canal treatment is a common cosmetic concern for both the patient and the dentist, especially for the anterior teeth (1, 2). Tooth

discoloration creates a wide range of cosmetic problems which will be very costly and time-consuming to treat (3). Bleaching is not usually successful for iatrogenic discolorations (4).

The main reasons for intrinsic discoloration related to endodontic treatment include degradation of the necrotic pulp tissue, hemorrhage within the pulp chamber and endodontic medicaments and fillers (1, 5-7). It has been determined that most endodontic sealers can discolor the teeth due to the properties of the structural particles (4). Color sequencing may occur within a few weeks if these materials fail to be removed from the pulp chamber after obturation (8). This discoloration often appears in the cervical and middle thirds of the crown (6). The discoloration is usually exacerbated by penetration into the dentinal tubules (9). The ways to reduce discoloration include the complete removal of sealer residues from the pulp chamber and filler cut-off from the pulp chamber. Despite considering the above-mentioned items, parts of the sealer may remain in the walls. Therefore, using sealers with less discoloration potential is essential to control the coronal discoloration after root canal therapy (9).

The AH Plus sealer has been introduced as a gold standard sealer with excellent properties. AH Plus has improved in terms of properties such as the non-release of aldehyde form during the chemical set-up of this sealer compared to that of AH 26 sealer (10). In addition, tooth discoloration was subsequently reduced due to the removal of silver from the formula (11).

MTA, which is mainly composed of calcium silicate and bismuth oxide, was first introduced as a root-end filling material due to its desirable properties such as biocompatibility, bioactivity, and good sealing. It is used for perforation, pulp cap, and regeneration (12-14). Using MTA has been considered in the structure of endodontic sealers due to these desirable properties, called bioceramic-based sealers such as ProRoot Endo sealer, CPM sealer, and MTA fillapex. (15)

Endosteal MTA (Maruchi, Wonju, Korea) is a new mineral trioxide aggregate–based endodontic sealer obtained from pozzolan cement that has been introduced recently. Studies have shown that this sealer has physical properties comparable to MTA and higher biocompatibility than that of AH Plus (16, 17). However, the main disadvantage of MTA-based sealers is the discoloration due to the release of ferrous iron (18). Therefore, studying the discoloration nature of this sealer is essential since studies are limited in this regard. To the best of our knowledge, a limited number of articles have been published on the effect of endoseal MTA sealer on the discoloration of the crown. In the present study, the 6-month effect of this sealer on crown discoloration was investigated compared to a resin-based sealer. Table I shows Chemical composition of endodontic sealers used in the present study

The visual evaluation of tooth color is performed using dental shade guides (8, 19), discoloration of dentin in the longitudinal section of the teeth (20), the digital image (1), the colorimeter, and the spectrophotometer. Among these, the spectrophotometer is a reference method (21) due to its high sensitivity, information stability, and repeatability (22).

The present in vitro study aimed to evaluate the coronal discoloration of human teeth induced by using a new Endoseal MTA sealer by intraoral spectrophotometer compared to the AH Plus sealer.

Materials and Methods

The present experimental trial was approved by the Human Research Ethics Committee of Mazandaran University of Medical Sciences, Iran (IR.MAZUMS.REC.95.2610). A total of 40 mandibular and maxillary premolars with similar anatomy that were extracted for orthodontic reasons were selected for this study. All the teeth were radiographically examined and teeth were excluded by pulp chamber recession, decay, repair, fractures, and noticeable clinical discolorations. At first, the external stains, calculus, and soft tissue were cleaned using a rubber cup and pumice, and then teeth samples were kept in distilled water until testing. Then teeth were incised in the coronal third of the root 3 mm below the cementoenamel junction (CEJ) and the apical parts were discarded. A cubic access hole 5 mm wide and 5 mm high was prepared by diamond fissure bur (Teeskavan, Iran) on the apical surfaces of the teeth and then the pulp chamber was chemically and mechanically cleaned with H-File (No. #35-80) and 2.5% Hypochlorite (Golrang, Iran) as a detergent and finally washed with normal saline.

The specimens were divided into two groups (n=17) by the simple random sampling method: Group 1 AH Plus sealer (Dentsply, De Trey, Konstanz, Germany) and Group 2 Endoseal MTA (Maruchi, Wonju, Korea); also 6 samples were considered as negative controls. The sealers were prepared according to the manufacturer's instructions and placed inside the pulp chamber in the cervical access. The amount of sealer was sufficient to completely cover axial walls in thickness of 1 mm. Table I presents the chemical composition of sealers used in this study. After the sealer setting, apical access cavities were covered by self-curing glass-ionomer cement (Fuji, Japan). The control group was only instrumented and remained unfilled. The samples were mounted on

cuboids made up of silicone impression putty and then incubated for 6 months at 37°C and 100% humidity. During the study course, the samples were stored in distilled water to simulate clinical conditions.

Table I**:** Chemical composition of endodontic sealers used in the present study

Sealer	Manufacturer	Composition
Endoseal MTA	Maruchi, Wonju, Korea	Calcium silicates, Calcium aluminates, Calcium aluminoferrite, Calcium sulfates, Radiopacifier, Thickening agents
AH Plus	Dentsply, De Trey, Konstanz, Germany	Paste A: Bisphenol-A epoxy resin, Bisphenol-F epoxy resin, Calcium tungstate, Zirconium oxide, Silica, Iron oxide pigments Paste B: Dibenzyldiamine, Amino adamantane, Tricyclodecane-diamine, Calcium tungstate, Zirconium oxide, Silica, Silicone oil

Table II**:** Mean ΔE (SD) values of experimental groups in all experimental periods

Group	Number	1st Month (Δ E1, T0-T1)	3rd Month (Δ E2, T0-T2)	6th Month (Δ E3, T0-T3)
Endoseal MTA	17	5.222(0.408)	6.647(0.528)	6.160(0.516)
AH Plus	17	5.509(0.716)	8.080(0.829)	4.479(0.505)
Control	6	0.526(0.199)	0.576(0.198)	0.625(0.214)

Color measurement

An intraoral spectrophotometer (VITA Easyshade® compact: VITA Zahnfabrik, BadSäckingen, Germany) was used to determine the color changes at the same time, place conditions, and natural light. The device was calibrated before each measurement. Determining the color of the teeth was performed within four intervals as follows: before the placement of sealers (T0), 1 month (T1), 3 months (T2), and 6 months (T3) after that. The device was placed perpendicular to the buccal surface of the teeth in the middle one-third region, and each sample was measured three times for the parameters of CIE L (degree of darkness and lightness related to value in the Munsell color system), a (color coefficients related to hue in the Munsell color system), b (color coefficients related chroma in the Munsell color system).

Color changes (ΔE) were calculated for each period by the following formula:

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2}$$

ΔE1=color distinction between T0 and T1

ΔE2=color distinction between T0 and T2

ΔE3=color distinction between T0 and T3

The standard threshold of ΔE is 3.7 (ΔE<3.7) (23). Data were analyzed using SPSS software version 16 (SPSS version 16, Chicago, IL, USA). Multivariate tests and MANOVA (Hotelling's Trace) were used for statistical analyses.

Results

Table II shows the mean ΔE and SD in the sealers at different intervals. Table III compares the rate of color change in study groups at different times. The control group indicated no discoloration at these intervals. The discoloration in all measurements was higher than the standard limit (ΔE> 3.7) and was significantly different compared to that of the control group (*P*-value<0.05). No significant difference was observed in ΔE value between two sealers at 2 intervals (1 month and 3 months) (*P*> 0.05) as follows in T1: AH Plus = Endoseal, T2: AH Plus

> Endoseal, and it was significant in one interval (6 months) T3: Endoseal> AH Plus

ΔE1(P-value=0/07) ΔE2 (*P*-value=0/15) ΔE3 (*P*-value=0/02).

Table III: Comparison of color change in experimental groups at different times

	Group	CI 95%	*P*-Value
	Endoseal MTA	5.22(4.35-6.09)	0.07
ΔE1	AH Plus	5.50(3.99-7.02)	
	Control	0.629(0.22-1.05)	
ΔE2	AH Plus	6.64(5.52-7.76)	0.15
	Endoseal MTA	8.075(6.32-9.83)	
	Control	0.878(0.671-1.086)	
ΔE3	AH Plus	6.155(5.06-7.25)	0.02
	Endoseal MTA	4.475(3.40-5.55)	
	Control	0.9539072-1.166	

Discussion

The present study examined the coronal discoloration of a new Endoseal MTA-based sealer compared with the AH Plus sealer. Recent efforts have focused on achieving proper biocompatibility and bioactivity properties of MTA, as well as the ability to set this substance in wet conditions for applying in the structure of endodontic sealers. Coronal discoloration was one of the disadvantages of MTA, which has even been reported in white types. Endoseal MTA was a newly introduced Calcium Silicate MTA-based sealer derived from pozzolan cement (16, 24). This sealer contained a premixed substance enclosed in an airtight syringe which could be directly used in the root canal (16).

According to the manufacturer's instructions, Endoseal MTA indicated a very good flow capability which could increase the sealing ability and bond strength due to the sealer penetration into dentinal tubules, anatomical anomalies, and minor canals. The self-setting feature was another clinical advantage of this sealer (25).

Other studies on MTA derived from pozzolan cement have reported characteristics such as low cytotoxicity, hard tissue-inducing bioactivity, as well as minimal discoloration (24, 26), and low apical leakage (27).

Limited information is available on the potential of Endoseal discoloration. Until now, a limited number of articles have been published on the discoloration effect of endoseal MTA sealer on crown color change. The present study indicated that the discoloration potential of this sealer is higher than that of the AH Plus sealer after 6 months.

The AH Plus was a widely used resin-based sealer that was replaced with AH26 due to its good sealing ability and no discoloration properties (28).

In this study, the samples were placed in the tubes including distilled water during the test to preserve the moisture, as dehydration would reduce the non-vital tooth translucency (29). Hence, it changed the color of the tooth. The methods of selecting, preparing, and maintaining the teeth were in line with the proposed method in the study of Forghani et al.(9) on the crown of premolar teeth since finding a healthy premolar tooth extracted for orthodontic treatment is normally more convenient, and the large volume of the pulp chamber is provided for the sealer placement.

Apical access was used in this study similar to previous studies (9, 23), and kept the occlusal surface intact to prevent the negative effects of cutting, micro-leakage, and restorative materials on the optical property.

Exposure of a large volume of sealer to the pulp chamber walls may increase the potential of discoloration sealers; however, the residue of sealer inside the pulp chamber was the cause of discoloration of the tooth after root canal treatment (9).

In the present study, the Easy Shade device was used to evaluate the tooth color due to the repeatability and information stability (21). Although the deviations in the spectrophotometer references can occur along with most existing commercial devices, these differences are not included in this study because the discoloration assessment was intended in this study rather than the exact color estimate of the tooth. Since the study of long-term discoloration potential of sealers was considered in this study, the smear layer was not removed through EDTA because the presence of this layer blocks the dentinal tubule openings; therefore, the sealer particles penetrate more slowly into the dentinal tubules, consequently observing subsequent discoloration studies (8). The smear layer was not clinically eliminated from the pulp chamber, and discoloration of the tooth was observed even in the presence of the smear layer in previous studies (8).

Previous studies have shown that coronal discoloration occurred as a result of endodontic materials seven weeks or several months after obturation. Differences in the results of these studies could be ascribed to the type of employed procedure. The time required for clinical discoloration depended on many factors, such as the presence of the smear layer, the thickness of the remaining dentin, and the quantity and quality of the sealer (28). In the present study, long intervals of 1, 3, and 6 months were used since, to the best of our knowledge, no investigations have been conducted on these intervals, and the only study examining the discoloration potential of Endoseal sealer (30) had used shorter intervals.

Dae-Sung Lee et al. compared the discoloration potential of Endoseal with AH Plus and Pro root MTA within periods of 1, 2, 4, and 8 weeks. Their results showed that Endoseal had no significant change in ΔE and ΔL compared to AH Plus and the control group. As a result, Endoseal showed less discoloration compared to conventional MTA and the same discoloration with AH Plus (30), which is consistent with the results of this study. In this study, the sealers had significant discoloration compared to that of the control group.

Fergana et al. studied tooth discoloration caused by MTA Fillapex, iRoot SP, and AH Plus sealers and reported that progressive discoloration was observed in the first 3 months, and then discoloration was reduced by the end of the experiment. The discoloration induced by AH Plus was very severe in the first three months. Nevertheless, they had the lowest amount at the end of the test and no significant difference was observed between the sealers. Similar to this study, all sealers had a significant discoloration effect compared to that of the control group (9). The discoloration pattern was similar to the present study. The high levels of discoloration at baseline could be due to the high penetration capacity of the dentinal tubules, and reduction over time following the distribution of sealer particles in a larger area than dentinal tubules. Consequently, they will be less focused and less visible. In addition, the diameter of the dentinal tubules decreases near the cementoenamel junction (CEJ); however, the residual sealer should decompose into smaller components to penetrate the dentinal tubules. This collapse may cause the tooth surface to be less visible (9).

The results of AH Plus in this study were consistent with those of Elkhazian et al. (31), Meinckle et al. (32), and El Sayed and Etemadi (28). In the studies by Lenherr (33), and Lee (30), AH Plus showed minimal discoloration compared to the control group.

In the present study, the discoloration caused by endoseal MTA sealer was greater after 6 months. Several mechanisms have been proposed for MTA- induced discoloration. The first is the gray color of the material itself, which is responsible for the discoloration. To this end, white MTA was presented to endodontic markets. They also showed that metal oxides (Fe, Mn) could cause discoloration (30). Another suggestion is that discoloration can occur due to a chemical reaction between bismuth oxide (Bi2O3) and dentin. Bismuth oxide has been added to MTA for providing radiodensity. The discoloration created in MTA is due to the reduction of crystals in bismuth atoms. In some new commercial formulations, bismuth oxide has been replaced by zirconium oxide (ZrO2) and tantalum oxide. Recent studies have shown that the MTA containing zirconium oxide exhibits less discoloration than the MTA containing bismuth oxide. According to the manufacturer's instructions, Endoseal contains both bismuth and zirconium radio opacifiers (30). This may justify the standard color change observed in this sealer, while the zirconium oxide content of bismuth oxide was probably higher in the structure of this sealer. This discoloration was similar to AH Plus, and the removal of silver from the AH26 structure and the production of AH Plus to remove the color-forming nature of this sealer. The discoloration observed in the AH Plus sealer in this study suggested that, firstly, a substance other than silver caused the discoloration, which may be zirconium oxide, which is also present in the structure of AH Plus (28, 30).

Further studies are required to study the color-forming feature of these sealers.

Conclusion

In general, despite the limitations of this study, MTA-based Endoseal sealer of root canal indicated discoloration which is comparable to AH Plus in 1 and 3 months; however, discoloration in the AH Plus group decreased compared to the Endoeseal MTA group after 6 months.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the present study.

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