Tooth Discoloration Resulting from a Nano Zinc Oxide-Eugenol Sealer

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**ABSTRACT**

**Introduction:** A desirable quality of any endodontic sealer is its ability to be tooth color friendly. Therefore, the aim of the present study was to evaluate the tooth discoloration potential of a nano zinc oxide-eugenol (NZOE) sealer. **Methods and Materials:** In order to evaluate tooth discoloration, the pulp chamber of 60 human maxillary central and lateral incisors were filled with one of the sealers, naming AH-26 (resin-based sealer), Pulpdent sealer (ZOE-based) and a NZOE experimental sealer. Color measurements were assessed at the baseline (before placement of sealers) (T0), 24 h (T1) and 72 h (T2), 1-week (T3), and 1-month (T4) after the placement of sealers using the Easy Shade spectrophotometer. Data were analyzed in SPSS software using one-way ANOVA, and repeated measured ANOVA.

**Results:** No significant differences were observed when the paired comparison test was performed (P>0.05). **Conclusion:** The tested NZOE sealer had similar tooth discoloration potential in comparison with AH-26 and ZOE sealer.

**Keywords:** Nano Particle; Root Canal Sealer; Spectrophotometry; Tooth Discoloration; Zinc-Oxide Eugenol

**Introduction**

Sealing the root canal system after cleaning and shaping, is one of the essentials of endodontic treatment [1]. The presence of sealer is necessary regardless of the type of core material because it creates a strong fluid-tight seal [2]. Besides functional and biological characteristics, one of the principal properties of a sealer is its ability to prevent tooth discoloration [3]. The discoloration caused by endodontic materials including sealers used in endodontic treatment, is a common clinical problem [4]. Some of the main reasons for tooth discoloration are the presence of blood, necrotic tissues and endodontic materials. Studies evaluating the effect of root canal sealers on tooth crown discoloration have concluded that all the sealers used in endodontics have discoloration potential to some extent [3, 5].

The most commonly used sealers in root canal treatment are zinc-oxide eugenol (ZOE)-based sealers. Studies have shown that these sealers have a long history of successful use because of many positive properties such as profound antimicrobial activity [3]; however, one of the disadvantages of ZOE sealers, is tooth discoloration potential [6, 7]. On the other hand, resin-based sealers offer the advantage of adhering to the root canal walls and being free of eugenol. Many studies conducted on discoloration potential of sealers have insisted on the high discoloration potential of resin sealers [3]. It has been shown that AH-26 causes severe discoloration of tooth structures, which is attributed to the silver ions in its composition [8].

Recently, nanotechnology is extensively used in manufacturing dental materials [9]. The chief aim in this context is to prepare materials with better mechanical properties, lower resistance to abrasion and more favorable optical and esthetic...
properties [10]. Some other advantages of nanoparticles which have drawn attention in endodontics are penetration into dentinal tubules, antibacterial activity and low microleakage property [10, 11].

A new endodontic sealer with nano-sized ZOE powder particles (NZOE) has been developed in the Dental Material Research Center, Mashhad University of Medical Sciences, Mashhad, Iran. This sealer is similar to various ZOE-based sealers, but with different sizes of ZOE nanoparticles [12]. This sealer exhibit cytocompatibility [13] and antibacterial activity [11] with satisfactory sealing ability [12].

Tooth color assessment can be performed by visual color evaluation with shade guides [14], determination of dentine color changes in longitudinal tooth sections [15], digital imaging [16] and colorimeters and spectrophotometers [17]. Spectrophotometers is the reference method because of its high sensitivity, repeatability and data stability [18].

The aim of the present in vitro study, was to compare the tooth discoloration caused by NZOE, to two common endodontic sealers AH-26 (resin-based sealer), Pulpdent sealer (ZOE-based).

Materials and Methods

The research protocol was approved by the Vice Chancellor of Research of Mashhad University of Medical Sciences (Grant No.: 920816). Sixty sound extracted maxillary central and lateral incisors, without any caries, cracks, fractures or restorations, were selected. First the tooth surfaces were polished to remove extrinsic discoloration. Then the tooth roots were separated from the crowns at cervical thirds of the roots. The pulp tissue and the pulp horns, if any, were removed by #4 and then 1/4 round burs (Brasseler USA, Savannah, GA, USA) installed on a slow-speed handpiece (Figure 1A). The canals were irrigated with sodium hypochlorite and normal saline at the end. The samples were randomly divided into three groups (n=20) according to the experimental sealers: Pulp Canal Sealer (SybronEndo, Orange, CA, USA), AH-26 sealer (Dentsply, De Trey, Konstanz, Germany) and NZOE. At the beginning of the procedures, the tooth color was determined with the use of Spectrophotometer (VITA Easyshade; VITA Zahnfabrik, Bäd Sackingen, Germany) (Figure 1B) twice and the mean value was recorded as the baseline value.

Each sealer was mixed properly based on the standard protocol. AH-26 sealer was mixed at a powder-to-liquid ratio of 1:3 to achieve a homogeneous mix. A 1:1 powder-to-liquid ratio was used for pulp canal and NZOE sealers with adequate mixing. Each sealer was placed into the pulp chamber via the cervical access and was properly sealed with self-cure glass-ionomer (Fuji I LC, GC Corporation, Tokyo, Japan) (Figure 1C). The samples were incubated at 37°C under saturated moisture. Also the specimens were preserved in humid environment during color assessment in order to simulate the clinical situation considering that tooth dehydration may affect its optical properties reversibly [19].

Color measurement

The chromatic alterations were assessed by an intraoral Spectrophotometer (VITA Easyshade; VITA Zahnfabrik, Bäd Sackingen, Germany). All the measurements were carried out between 9 and 11 in the morning under identical light conditions in similar environment to minimize the environmental factors effect.

Color measurement was performed at the baseline (before placement of sealers) (T₀), 24 h (T₁) and 72 h (T₂), 1-week (T₃), and 1-month (T₄) after the placement of sealers. The measurements were repeated twice for each specimen and the mean CIE parameters including L (the degree of darkness and lightness related to value in the Mansell color system), a (color coefficients related to hue in the Mansell color system), b (color coefficients related chroma in the Mansell color system) were recorded. In the color environment, based on this measurement the parameter depends on the color intensity on the green and red axes and the b parameter depends on the color intensity on the blue and yellow axes [4].

Color changes (ΔE) for each time intervals were calculated with the following formula:

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

\[\Delta E_0: \text{colour difference between } T_0 \text{ and } T_1\]
\[\Delta E_1: \text{colour difference between } T_0 \text{ and } T_2\]
\[\Delta E_2: \text{colour difference between } T_0 \text{ and } T_3\]
\[\Delta E_3: \text{colour difference between } T_0 \text{ and } T_4\]

Standard threshold of ΔE is 3.7 (ΔE<3.7) (17). Data were analyzed with SPSS software version 16 (SPSS version 16, Chicago, IL, USA). The one-way ANOVA and repeated measured ANOVA tests were used for statistical analyses.

Results

Table 1 presents the means ΔE and standard deviations (SD) of tooth discoloration values of each sealer at different time intervals. Discoloration caused by all three sealers in all measurement points was more than standard threshold (ΔE>3.7) but with no significant difference compared one another (P=0.112). The severity of discoloration at T₁ and T₄ was: AH-26>NZOE>Pulp Canal Sealer. This sequence altered to NZOE>AH-26> Pulp Canal Sealer at T₂. At T₃ the discoloration was as follows: NZOE>Pulp Canal Sealer>AH-26. After 3 days (until the 30th day; the end of the experiment), tooth discoloration was progressive for AH-26, but tends to decrease for NZOE (Figure 2) but these difference were not significance (P=0.992).
Tooth discoloration of a nano sealer

Discussion

This study evaluated the tooth discoloration tendency of a nano-particle ZOE sealer in comparison with AH-26 and Pulp Canal sealer. It is important to make persistent efforts to manufacture a sealer that has all the ideal properties reported by Grossman [1]. NZOE sealer was recently manufactured in Mashhad Faculty of Dentistry through assistance from the Department of Physics, Faculty of Basic Sciences, Ferdowsi University of Mashhad. This sealer have shown suitable physical and antimicrobial properties [11-13] and the present study showed that its discoloration potential was comparable to AH-26 and Pulp Canal Sealer.

In the present study, in order to evaluate the effect of sealer on tooth discoloration, the sealers were placed in the pulp chambers of maxillary incisors. In a similar study, Zare Jahromi et al. [20] placed AH-26 and ZOE sealers in the pulp chambers of maxillary incisors in order to evaluate the discoloration caused by these sealers. But some other studies selected premolar teeth for evaluation of sealer discoloration [21-23].

Like almost all earlier studies on tooth discoloration caused by sealers [14, 16, 17, 24], apical access was used and the occlusal surface was kept intact, in order to prevent changes in optical properties of samples due to restorative materials, microleakage and tooth structure loss. In this study the smear layer was not removed similar to routine clinical set-up.

In the present study, tooth discoloration was evaluated by spectrophotometry using Easy Shade device. Overall, within the limitation of this study, NZOE sealer caused tooth discoloration comparable to the two other sealers. In a study by van der Burgt et al. [23], ZOE sealer resulted in significant discoloration of teeth after 7 days. They also reported that AH-26 resulted in severe grayish tooth discoloration. Parsons et al. [14] reported that AH-26 and Pulp Canal sealer resulted in significant discoloration of tooth crowns. They attributed this severe discoloration to the presence of silver ions. In the study by Gurel [25] the pulp canal sealer resulted in severe tooth discoloration. In addition, in a study by Partovi et al. [22], discoloration by ZOE sealer was more severe than that by AH-26 sealer at all time intervals. In the present study, NZOE sealer resulted in less discoloration than AH-26 sealer on days 1 and 30. In the study carried out by Zare Jahromi et al. [20] discoloration by ZOE sealer was less than AH-26 after 4 months. In the present study, too, a decreasing trend in discoloration was observed with the NZOE sealer, i.e. with the passage of time and after 3 days, discoloration began to decrease and was less than AH-26 after 30 days. However, there were no significant differences in discoloration caused by NZOE compared to AH-26 and Pulp Canal Sealer.

Finally, in order to make an absolute conclusion, more evaluation on the discoloration potential of this new sealer must be done with a larger sample size and a longer time period.

| Table 1. Mean (SD) of ΔE value of sealers in all experimental intervals |
|---------------------------------------------------------------|
| Sealer (N) | 1st day ΔE | 3rd day ΔE | 7th day ΔE | 1st month ΔE |
|-----------|------------|----------|----------|-------------|
| AH-26 (20)| 15.60 (14.33) | 11.33 (9.69) | 11.62 (9.08) | 13.77 (16.01) |
| Pulp Canal Sealer (20)| 9.99 (6.62) | 9.99 (8.01) | 12.11 (8.30) | 10.50 (7.94) |
| Nano Sealer (20)| 10.34 (6.00) | 15.66 (11.23) | 13.29 (7.66) | 12.28 (7.32) |
Conclusion

Based on the results of the present study, it can be concluded that nano zinc oxide–eugenol sealers cause similar tooth discoloration comparable to that caused by AH-26 and pulp canal sealers.

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Conflict of Interest: ‘None declared’.

References

1. Flores DS, Rached FJ, Jr., Versiani MA, Guedes DF, Sousa-Neto MD, Pecora JD. Evaluation of physicochemical properties of four root canal sealers. Int Endod J. 2011;44(2):126-35.
2. Schilder H. Filling root canals in three dimensions. 1967. J Endod. 2006;32(4):281-90.
3. Tour Savadkouhi S, Fazlyab M. Discoloration Potential of Endodontic Sealers: A Brief Review. Iran Endod J. 2016;11(4):250-4.
4. Ioannidis K, Beltes P, Lambrianidis T, Kapagiannidis D, Karagiannis V. Crown discoloration induced by endodontic sealers: spectrophotometric measurement of Commission International de l’Eclairage’s L*, a*, b* chromatic parameters. Oper Dent. 2013;38(3):E1-12.
5. Lenherr P, Allgayer N, Weiher R, Filippi A, Attin T, Krastl G. Tooth discoloration induced by endodontic materials: a laboratory study. Int Endod J. 2012;45(10):942-9.
6. Jalalzadeh SM, Mamavi A, Abedi H, Mashouf RY, Moaresi A, Karapanou V. Bacterial microleakage and post space timing for two endodontic sealers: an in vitro study. J Mass Dent Soc. 2010;59(2):34-7.
7. Kazemi RB, Safavi KE, Spangberg LS. Dimensional changes of endodontic sealers. Oral Surg Oral Med Oral Pathol. 1993;76(6):766-71.
8. Krastl G, Allgayer N, Lenherr P, Filippi A, Taneja P, Weiher R. Tooth discoloration induced by endodontic materials: a literature review. Dent Traumatol. 2013;29(1):2-7.
9. Gomes-Filho JE, Silva FO, Watanabe S, Cintra LT, Tendoro KV, Dalto LG, Pacanaro SV, Lodi CS, de Melo FF. Tissue reaction to silver nanoparticles dispersion as an alternative irrigating solution. J Endod. 2010;36(10):1698-702.
10. Saunders SA. Current practicality of nanotechnology in dentistry. Part I: Focus on nanocomposite restoratives and biomimetics. Clin Cosmet Investig Dent. 2009;1:47-61.
11. Javidi M, Afkhami F, Zarei M, Ghavzini K, Rajabi O. Efficacy of a combined nanoparticulate/calcium hydroxide root canal medication on elimination of Enterococcus faecalis. Aust Endod J. 2014;40(2):61-5.
12. Javidi M, Zarei M, Naghavi N, Mortazavi M, Nejat AH. Zinc oxide nano-particles as sealer in endodontics and its sealing ability. Contemp Clin Dent. 2014;5(1):20-4.
13. Javidi M, Zarei M, Omidi S, Ghorbani A, Gharechahi M, Shayani Rad M. Cytotoxicity of a New Nano Zinc-Oxide Eugenol Sealer on Murine Fibroblasts. Iran Endod J. 2015;10(4):231-5.
14. Parsons JR, Walton RE, Ricks-Williamson L. In vitro longitudinal assessment of coronal discoloration from endodontic sealers. J Endod. 2001;27(11):699-702.
15. Davis MC, Walton RE, Rivera EM. Sealer distribution in coronal dentin. J Endod. 2002;28(6):464-6.
16. Zarei M, Shahrani F, Vatanpour M. Comparison between gutta-percha and Resilon retreatment. J Oral Sci. 2009;51(2):181-5.
17. Ioannidis K, Mistakidis I, Beltes P, Karagiannis V. Spectrophotometric analysis of crown discoloration induced by MTA- and ZnOE-based sealers. J Appl Oral Sci. 2013;21(2):138-44.
18. Lehmann KM, Igiel C, Schmidtmann I, Scheller H. Four color-measuring devices compared with a spectrophotometric reference system. J Dent. 2010;38 Suppl 2:e55-70.
19. Faria-Junior NB, Tanomaru-Filho M, Berbert FL, Guerreiro-Tanomaru JM. Antibiofilm activity, pH and solubility of endodontic sealers. Int Endod J. 2013;46(8):755-62.
20. Zare Jahromi M, Navabi AA, Ekhhtari M. Comparing Coronal Discoloration Between AH26 and ZOE Sealers. Iran Endod J. 2011;6(4):146-9.
21. Forghani M, Gharechahi M, Karimpour S. In vitro evaluation of tooth discoloration induced by mineral trioxide aggregate Fillapex and iRoot SP endodontic sealers. Aust Endod J. 2016.
22. Partovi M, Al-Havvaz AH, Soleimani B. In vitro computer analysis of crown discoloration from commonly used endodontic sealers. Aust Endod J. 2006;32(3):116-9.
23. van der Burgt TP, Mullaney TP, Plasschaert AJ. Tooth discoloration induced by endodontic sealers. Oral Surg Oral Med Oral Pathol. 1986;61(1):84-9.
24. El Sayed MA, Etemadi H. Coronal discoloration effect of three endodontic sealers: An in vitro spectrophotometric analysis. J Conserv Dent. 2013;16(4):347-51.
25. Gurel MA, Helvacioglu Kivanc B, Ekici A, Alacam T. Evaluation of crown discoloration induced by endodontic sealers and colour change ratio determination after bleaching. Aust Endod J. 2016.