Spectrophotometric analysis of crown discoloration induced by endodontic sealers and fluoride varnish as sealer after 6 months

Original Article

Zakiyeh donyavi[1], Zahra Khamverdi[2], Maryam Farhadian[3], Hadiseh Abbaspourrokni[4], Zahra pakseresht[5*]

[1] Assistant professor, Department of endodontics, School of Dentistry, Alborz University of Medical Sciences, Karaj, Iran
[2] Professor, Dental Research Center, Department of Restorative Dentistry, School of Dentistry, Hamadan University of Medical Sciences, Hamadan, Iran
[3] Assistant professor, Department of Biostatistics, school of public Health and Research center for Health sciences, Hamadan University of Medical Sciences, Hamadan, Iran
[4] Assistant professor, Department of endodontics, School of Dentistry, Sari University of Medical Sciences, Mazandaran, Iran
[5] Assistant professor, Department of Endodontics, School of Dentistry, Gilan University of Medical Sciences, Rasht, Iran

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Corresponding Author:
Zahra Pakseresht, Assistant professor
Address:
Department of Endodontics, School of Dentistry, Gilan University of Medical Sciences, Rasht, Iran
Email: z.pakseresht@yahoo.com
Telephone: +98914 189 7599

Abstract

Introduction:
This study aimed to assess tooth discoloration at 6 months following the use of 5% fluoride varnish (Duraflur), AH 26, zinc oxide eugenol (ZOE)-based sealer and mineral trioxide aggregate (MTA)-based sealer in extracted premolars.

Materials and methods:
In this in vitro, experimental study, 75 freshly-extracted human premolars with completely formed roots underwent root canal treatment. AH 26, 5% fluoride varnish (Duraflur), Endofill and MTA Fillapex were applied in the canals along with gutta-percha in groups 1 to 4 (n=15). No sealer was used in the control group (n=15). The color parameters and color change (ΔE) of tooth crowns were assessed immediately after filling (T1) and at 3 and 6 months, postoperatively using a spectrophotometer.

Results:
MTA Fillapex (6.16±3.72) and Endofill (1.93±4.70) yielded the highest and the lowest ΔE, respectively at 3 months. Endofill (7.07±2.60) and MTA Fillapex (7.00±3.40) yielded the maximum and fluoride varnish (6.54±1.33) and AH 26 (5.76±2) yielded the minimum ΔE at 6 months.

Conclusion:
Tooth discoloration caused by the use of 5% fluoride varnish as endodontic sealer was comparable to that of MTA Fillapex and less than that of Endofill and AH 26.

Key words:
•Canals sealer •Fluoride Varnish •Spectrophotometry

Introduction

Coronal discoloration caused by endodontic sealers is a common occurrence that adversely affects esthetics following endodontic treatment (1). Intrinsic coronal discoloration may be present prior to endodontic treatment due to intrapulpal bleeding, necrosis, dystrophic calcification following trauma or old age (2,3). The main cause of tooth discoloration at the middle and cervical thirds of the crown following endodontic treatment is presence of root filling materials such as sealer in contact with coronal dentin and the pulp chamber (4-6). The main constituents of sealers such as eugenol, phenol and silver are responsible for coronal discoloration (7,8). Tooth discoloration as the result of sealer application occurs due to the penetration of sealer constituents into dentinal tubules during or after the setting of sealer (9). The penetration depth of sealer and the severity of resultant discoloration depend on dentin thickness and quality of sealer (5).

The extent and severity of tooth discoloration caused by endodontic sealers depend on the substantivity of sealer constituents (1,10). AH 26 sealer undergoes chemical reactions in the root canal system and releases bismuth, which causes a brown to green discoloration. Corrosion of silver present in the composition of some sealers causes greyish to black discoloration. Modified AH Plus contains zirconium oxide for opacity, which also causes tooth discoloration in long-term (11). Sealers containing zinc oxide eugenol (ZOE) and epoxy resin-based sealers can also cause moderate to severe coronal discoloration (6). Mineral trioxide aggregate (MTA)-based sealers also cause tooth discoloration despite favorable properties such as biocompatibility and induction of hard tissue formation (12-14). MTA-based sealers such as MTA-Fillapex cause grayish discoloration of dentin since they contain tricalcium silicate, bismuth oxide and dicalcium silicate (9). The grayish color of MTA is also responsible for tooth discoloration. Moreover, metal oxides such as manganese and iron oxide cause tooth discoloration (14).

Fluoride varnish is used for caries prevention and coating of avulsed teeth following their delayed replantation. It is also effective for treatment of dentin hypersensitivity (11,15). Fluoride varnish was recently used as a root filling material for primary teeth in combination with ZOE and calcium hydroxide (16). Its advantages include inhibition of Enterococcus faecalis more efficiently than calcium hydroxide and the ability to obstruct the dentinal tubules (15). Rao et al, (15) Parirokh et al, (16) and Forghani et al. (17) showed that the biocompatibility of fluoride varnish is comparable to that of AH 26.

Insignificant cytotoxicity and optimal sealing ability of fluoride varnish when used as endodontic sealer have been previously documented (17). However, its discoloration potential also needs to be evaluated prior to its widespread use as an endodontic sealer. Thus, this study aimed to assess tooth discoloration following the use of 5% fluoride varnish sealer compared to a MTA-based sealer, AH 26 and a ZOE-based sealer. The null hypothesis was that there would be no significant difference among different sealers in terms of tooth discoloration.

Materials and Methods

This in vitro, experimental study was conducted on 75 freshly-extracted human premolar teeth with completely formed roots. The study was approved in the ethics committee of Hamadan University of Medical Sciences (IR.UMSHA.REC.1396.173). The teeth were single-canal and had no discoloration, caries, cracks or fracture. Those with cracks, restorations, fracture or caries were excluded. To ensure absence of cracks, the teeth were evaluated under a stereomicroscope at x20 magnification. The teeth selected for this study had been extracted within the past 3 months. The soft tissue residues and calculus were removed by a curette and scalpel and the teeth were then immersed in 10% formalin for disinfection.

They were transferred to distilled water 24 hours prior to root canal treatment. Root canal treatment was then performed. The sealers tested in this study were Endofill, MTA Fillapex, AH 26 and 5% fluoride varnish (Table 1). The teeth were immersed in sodium hypochlorite for 15 minutes to eliminate organic residues (9). Access cavity was prepared and working length was determined using a #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). The canals were then instrumented to the working length using ProTaper nickel-titanium rotary instruments (Dentsplay Maillefer, Ballaigues, Switzerland) up to

F3 under irrigation with sodium hypochlorite and 17% EDTA (Asia Chemi Teb Co., Tehran, Iran). The teeth were randomly divided into 5 groups (n=15) in according the sealer used as follows: G1: without sealer(control),
G2: Endofill, G3: MTA Fillapex, G4: AH 26 and G5: 5% fluoride varnish.

Table 1. Root canal sealers used in this study and their composition

Group	Sealer	Composition
1	AH 26 (Dentsply DeTrey, Konstanz, Germany)	Epoxy-amine resin-based root canal sealer, opaquer-zirconium oxide.
2	MTA Fillapex (Angelus, Londria, Brazil)	Resins (salicylate, diluting, natural), bismuth trioxide, nanoparticulate silica, mineral trioxide aggregate, pigments.
3	Endofill (Produits Dentaires SA, Vevey, Switzerland)	Zinc oxide, hydrogenated resin, barium sulfate, eugenol.
4	5% fluoride varnish (Duraflur; Pharmascience, Montreal, Quebec, Canada)	Fluoride, alcohol and resin based solution

Root canals in the 4 sealer groups were dried with paper points and were then filled with gutta-percha and the respective sealer using lateral compaction technique. Excess sealer in contact with the external root surface was thoroughly removed. However, the sealer in the coronal pulp chamber was thoroughly removed. All teeth were then restored and sealed with composite resin. A spectrophotometer (Easyshade, Advance, Bad Säckingen, Germany) was used for colorimetry immediately after filling of teeth (T1) and after 3 (T3) and 6 (T6) months. The color parameters of each tooth were measured before and after the intervention, and the color parameters after the intervention were compared with the values of the same tooth before the intervention. Each parameter was measured twice and the mean value was used as the final parameter. Data were analyzed using SPSS version 20 at 0.05 level of significance. Descriptive statistics and statistical tests such as ANOVA (for multiple comparisons of the groups) and two-way repeated measures ANOVA (for intragroup comparisons and comparison of ΔE among groups with time as the repetition factor) were applied. Normal distribution of data was evaluated using the Kolmogorov-Smirnov test, which showed normal distribution of data ($P>0.05$).

Results

Table 2 shows the mean and standard deviation of ΔE in the five groups. Comparison of ΔE among the four sealer groups revealed that at 3 months, MTA Fillapex and Endofill yielded the highest and the lowest ΔE, respectively. Fluoride varnish and AH 26 ranked second and third, respectively. At 6 months, Endofill and MTA Fillapex yielded the maximum and fluoride varnish and AH 26 yielded the lowest ΔE. No significant difference was noted in ΔE1, ΔE2 or ΔE3 among Endofill, AH 26, MTA Fillapex and fluoride varnish groups ($P>0.05$).
Within-group comparison of ΔE during the three time periods of T1-T3, T1-T6 and T3-T6 with sealer as the main factor revealed no significant difference in the control, MTA Fillapex and fluoride varnish groups ($P>0.05$).
However, the difference in ΔE during the three time periods of T1-T3, T1-T6 and T3-T6 was significant among the AH 26, MTA Fillapex, fluoride varnish and control groups ($P<0.05$). Endofill group showed greater color change over time. Repeated measures ANOVA revealed that differences in ΔE among different groups over time were not significant but ΔE significantly changed over time.

Table 2. Comparison of the mean ΔE among the groups studied at different time periods

Sealer/Time	ΔE1(T1-T3) Mean± SD	ΔE2(T1-T6) Mean± SD	ΔE3(T3-T6) Mean± SD	P value*	Pvalue**
Control	6.25±4.11a	6.66±3.42a	6.06±4.02a	0.894	Group: 0.795 Time: 0.011 Group×Time: 0.383
Endofill	4.70±1.93b	7.07±2.60	6.69±3.97a	0.043	
MTA Fillapex	6.16±3.72	7.00±3.40	7.53±3.78	0.298	
AH 26	4.91±1.28	5.76±2.38	6.95±3.37	0.018	
Fluoride varnish	5.89±3.19	6.54±1.33	5.51±3.65	0.544	
Pvalue***	0.495	0.686	0.628		

SD: Standard deviation

* Within-group comparison using Repeated measures ANOVA

** Inter-group comparison over time by repeated measures ANOVA

***One way ANOVA

Discussion

One important factor affecting the success of dental restorations is their color stability over time. Tooth discoloration caused by endodontic sealers is a common occurrence, adversely affecting esthetics following endodontic treatment. The aim of this study was to evaluate tooth discoloration at 6 months following the use of different sealers in root canal therapy.

The CIE L*a*b* system was used for assessment of color change in this study, which is the most commonly used system for evaluation of color parameters introduced by the International Commission Illumination de L'Eclairage (18-20). Color is described by three parameters of L*, a* and b*.

ΔE<1 is not detectable by the human eye; ΔE between 1 and 3.3 can be detected by experts and ΔE>3.3 is detectable by the lay people. ΔE>3.3 is not clinically acceptable (21,22).

Color perception varies among different individuals and even in the same person at different times. Several factors such as the lighting conditions, translucency, opacity, light reflection and scattering and the human eye characteristics can affect color perception (23)

Several methods have been proposed for the evaluation and quantification of sealer-induced discoloration, including visual technique and computer analysis of digital photos (6). Inherent objectivity and standardization difficulties may be improved by the use of a spectrophotometer. This methodology has been proven to be accurate and reliable for quantitative tooth color measurements (4). A major advantage of visual spectrophotometry is that tooth color measurement is based on the measurement of spectral reflectance, which describes the total reflection of a sample in visual spectrum (8).

in this study, spectrophotometry was considered as the reference method to determine the tooth color changes (9). ΔE<3.5 was considered as the clinically acceptable threshold of color change (9).

The findings of the current study revealed that MTA Fillapex had the highest and Endofill ZOE-based sealer had the lowest ΔE at 3 months. Fluoride varnish and AH 26 ranked second and third, respectively in terms of ΔE. At 6 months, the highest ΔE was noted in Endofill and MTA Fillapex and the lowest ΔE was noted in fluoride varnish and AH 26 sealer groups. Within-group comparison of ΔE during T1-T3, T1-T6 and T3-T6 regarding the type of sealer showed no significant difference among the control, MTA Fill apex and fluoride varnish groups (P>0.05). However, the difference in ΔE during the three time periods of T1-T3, T1-T6 and T3-T6 was significant among the AH 26, MTA Fillapex, fluoride varnish and control groups (P<0.05). Endofill group showed greater color change over time. The reason may be the fact that AH 26 sealer undergoes chemical reactions in the root canal and releases bismuth, which causes brown to green discoloration. Also, corrosion of silver in the composition of sealers causes a greyish to black discoloration (11).

ZOE sealers cause fast and severe discoloration in tooth crown due to the weak and unstable chemical bond between zinc oxide and eugenol, which is susceptible to self-oxidation even after completion of setting reactions of eugenol. As the result, its color becomes darker over time (1,4). A previous study showed that MTA Fillapex caused fast and severe tooth discoloration at one week after its application using spectrophotometry (24).This finding was in agreement with our results.

Ioannidis et al. (4) evaluated coronal discoloration caused by MTA and ZOE-based sealers over a 3-month period using a spectrophotometer and concluded that ZOE-based sealers cause much greater discoloration than MTA-based sealers. They used Roth's 811 sealer, which is a zinc oxide-based sealer, and is different from the sealer used in our study. Roth's 811 sealer causes severe and fast tooth discoloration one week after application (4).

In another study, Ioannidis et al. (6) evaluated coronal discoloration due to AH 26, GuttaFlow, Roth's 811 and Epiphany sealers at 1 week, 1 month, 3 months and 6 months using a spectrophotometer and found that Roth's 811 ZOE-based sealer caused the greatest discoloration. They did not use a MTA-based sealer for the purpose of comparison; but in line with our findings, zinc-oxide sealer caused the highest color change at 6 months. Partovi et al. (8) stated that zinc-oxide-based sealers have the highest tooth discoloration potential among endodontic sealers.

Sucia et al. (9) evaluated coronal discoloration caused by 4 endodontic sealers namely EndoFill, AH Plus, Apexit and MTA Fillapex at 1 week and 3 months using a spectrophotometer and found that all sealers cause some degrees of discoloration but AH Plus and Endofill are associated with the highest degree of color change. They evaluated the color change at 3 months, which is shorter than the assessment period of 6 months in our study. Aziz et al. (25) assessed coronal discoloration caused by three endodontic sealers namely AH Plus, Apexit Plus and Sultan using spectrophotometry at 3, 7 and 10 days and concluded that AH Plus and Sultan caused the greatest color change.

Zare Jahromi et al. (5) studied coronal discoloration caused by AH 26 and ZOE sealers during 4 months by digital photography of the labial surface of 50 central incisors and concluded that AH 26 caused significantly greater discoloration that ZOE. Their results were different from our findings, which may be due to the difference in the study period and method of assessment of color change over time.

Our findings revealed that fluoride varnish used as endodontic sealer did not cause significant discoloration during the 6-month period of study. Evidence shows that fluoride varnish causes a temporary color change when applied on the enamel and dentin surfaces for caries prevention, but this discoloration resolves within 24 hours (26). Thus, it seems that application of fluoride varnish as sealer does not cause significant coronal discoloration and is comparable to MTA-based sealers.

Some previous studies evaluated the application of fluoride varnish as sealer. Rao et al, (16) and Parirokh et al. (17) evaluated the bacterial leakage of fluoride varnish and demonstrated that its sealing ability was similar to that of AH26. Thus, it has the potential for use as an endodontic sealer. Furthermore, Forghani et al. (18) evaluated the cytotoxic effects of fluoride varnish on human gingival fibroblasts when used as endodontic sealer and found that the rate of cell viability following exposure to fluoride varnish was similar to that of AH 26. Thus, fluoride varnish can be suggested as an endodontic sealer due to possession of favorable properties such as optimal biocompatibility, low bacterial leakage, acceptable antimicrobial activity, fluoride release potential and insignificant color change of tooth crown.

Autio-Gold et al. (27)stated that Duraphat fluoride varnish causes perceivable color change in restorations, which is clinically acceptable. They used a colorimeter (Chroma-meter, Minolta) for color assessment (27). However, a spectrophotometer was used in our study, which is more accurate.

Future studies are recommended to use a stereomicroscope to assess the penetration depth of sealer into the dentinal tubules and the resultant discoloration. Studies are also required on the biocompatibility and physical properties of fluoride varnish when used as endodontic sealer.

Conclusion

The coronal discoloration caused by the application of fluoride varnish as endodontic sealer was comparable to that caused by MTA Fillapex and less than that caused by Endofill ZOE-based sealer and AH 26.

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