Crown discoloration after endodontic obturation with different cements: a clinical study

Luciana Stadler **DEMENECH**[1]
Jéssica Vavassori **DE-FREITAS**[1]
Carla Castiglia **GONZAGA**[1]
Denise Piotto **LEONARDI**[1]
Flares **BARATTO-FILHO**[2]
Flávia Sens Fagundes **TOMAZINHO**[1]
Marilisa Carneiro **LEÃO GABARDO**[1]

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ABSTRACT

Introduction: The aim of this study was to evaluate the crown discoloration after root canal filling with different endodontic cements clinically. **Methods:** Thirty-two teeth were endodontically treated and filled with AH Plus (AHP), Endofill (END), MTA Fillapex (MTA), or Sealer 26 (SEA), divided into eight patients per group. Color recording was performed with a spectrophotometer before the intervention (T_0) and at 30 (T_1) and 90 days post-intervention (T_2). The evaluations were done in the center of the dental crown and color variation (ΔE) was calculated by means of the Commission International de IEclairage (CIE) L*a*b. The data were subjected to repeated measures ANOVA and Tukeys test (alpha=5%). Results: There was no statistically significant difference in color variation between the cements (AHP ΔE=4.11; END ΔE=6.34; SEA ΔE=8.77, and MTA ΔE=12.15), $p>0.05$. However, there was a difference between the periods tested (T1 ΔE=5.65; T2 ΔE=10.02). **Conclusions:** All tested endodontic cements altered the color of dental crowns.

Keywords: Spectrophotometry. Tooth Discoloration. Root Canal Filling Materials.

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[1] Universidade Positivo, Escola de Ciências da Saúde (Curitiba/PR, Brazil).

[2] Universidade da região de Joinville (Univille), Departamento de Odontologia (Joinville/SC, Brazil).

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Contact address: Flares Baratto-Filho
E-mail: fbaratto1@gmail.com

Introduction

The growing concern for aesthetic issues in dentistry cannot be neglected, even in the case of endodontics. Changes in the color of dental crowns are determined by trauma, cavities, and restorations.[1] In addition, endodontic treatment, including access, instrumentation, and obturation, can result in color changes in the crown.[2]

In the obturation phase, sealers may induce color change, especially if residues are left in the pulp chamber above the gingival margin.[3] This is due to the presence of unreacted components during sealer manipulation or corrosion of some of its components when interacting with dentin.[3,4] Removing any excess sealer and gutta percha above the canal orifice can assist in minimizing aesthetic damage after treatment.[5]

Root canal sealer remnants in the pulp chamber, after root canal obturation, may affect the dentin and modify the appearance of the crown, due to the properties of light transmission and reflectance.[6] Spectrophotometry has been used to reduce the subjectivity of coronal color change evaluation.[6-8] These devices can detect small color differences not captured by the human eye by measuring the reflectance wavelength and transmittance.[7,9]

Though there is a variety of commercial brands with different compositions, endodontic sealers must be biologically compatible while maintaining aesthetic aspects. There is a scarcity of clinical studies comparing the effect of these materials on the color alteration of the crown. Therefore, the aim of this research was to evaluate, clinically, the influence of endodontic sealers, and to quantify the time required for the occurrence of color change of the dental crown. The null hypothesis of this research was that no endodontic sealer caused visible color change.

Material and Methods

This research was approved by the Research Ethics Committee (number 1,585,083). Thirty-two patients of both sexes, aged 18 years or older, who required endodontic treatment in anterior teeth (incisors or canines), upper or lower, were included. Patients who agreed to participate signed a free and informed consent form.

The subjects who had teeth with previous endodontic treatment, facets or prosthetic crowns, cavities and extensive restorations, cracks and coronal fractures, and teeth with pre-existing coronal color change were excluded. They were divided into four groups (n=8) and randomized to the endodontic sealer to be used: Endofill (Dentsply, Petrópolis, Brazil) - END, Sealer 26 (Dentsply, Petrópolis, Brazil) - SEA, AH Plus (Dentsply Detrey GmbH, Konstanz, Germany) - AHP, and MTA Fillapex (Angelus, Londrina, Brazil) - MTA.

Color registration was performed with the VITA Easyshade® intraoral spectrophotometer (VITA Zahnfabrik, Bad Säckingen, Germany) at three different times: before beginning endodontic treatment (T_0), at 30 days (T_1), and at 90 days (T_2) after the completion of treatment.

The endodontic treatment was performed by only one operator, specialist in Endodontics, with five years of experience. Initially, crown prophylaxis with a rubber cup and pumice stone was performed to remove debris and/or extrinsic stains. The T_0 measurement was registered at that time. The teeth were submitted to local anesthesia and absolute isolation. Coronal access was done with 1012HL diamond (KG Sorensen®, Cotia, Brazil) or 1014HL (KG Sorensen®, Cotia, Brazil) spherical drills; for the convenience and contour shapes, inactive 3080 (KG Sorensen®, Cotia, Brazil) and 3082 (KG Sorensen®, Cotia, Brazil) were used. Next, it was verified with inspection by exploratory probe no. 5 (SS White Duflex, Rio de Janeiro, Brazil) that the ceiling of the pulp chamber was completely removed. During the biomechanical preparation, 2.5% sodium hypochlorite (NaOCl) (Biodinâmica, Ibiporã, Brazil) was used as an irrigating solution. After preparation, the teeth were irrigated with 17% ethylenediaminetetraacetic acid (EDTA) (Biodinâmica, Ibiporã, Brazil) for five minutes and then again with 3 ml of 2.5% NaOCl before being dried with sterile absorbent paper points (Tanariman Industrial Ltda., Manacapuru, Brazil).

The selection of the master cone was performed according to the diameter after preparation, and the choice of the endodontic sealer to be used was made randomly. The handling of each sealer was done according to the manufacturer's instructions. Table 1 shows the chemical composition of the seal-

ers used in this study. All teeth were obturated using the Modified Tagger's Hybrid Technique. Removal of the obturation material was standardized at 2 mm below the cementoenamel junction for all teeth. Then, the pulp chamber was cleaned with 70% alcohol (Rioquímica, São José do Rio Preto, Brazil) and dried with a cotton pellet. A seal with glass-ionomer cement was performed with Vidrion R® (SS White, Rio de Janeiro, Brazil) until the last color measurement. After the registration of T_2, patients were sent to obtain final tooth restoration with composite resin.

The VITA EasyShade Compact® spectrophotometer (VITA Zahnfabrik, Bad Säckingen, Germany) was used in "single tooth" mode for all evaluations (T0, T_1, and T_2). The active point of the spectrophotometer was positioned in the center of the crown due to the size of this anatomical structure. For data collection, measurements were performed three times and the mean of the *Commission International de l'Eclairage* (CIE) parameter L*a*b was calculated.[10]

The values of L*, a* and b* were used to calculate the color changes (ΔE) using the following formula:

$\Delta E = [(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$, where L * is the color value (luminosity) and a* and b* represent the chromatic hue, in which red is +a, green is -a, yellow is +b, and blue is -b. The values of ΔE were calculated as follows: ΔE1, color difference between T0 and T1; ΔE2, color difference between T0 and T2. A ΔE value between 1 and 3.7 was considered as acceptable, and values greater than 3.7 were clinically perceptible.[11,12]

All analyzes were done using Statistical Package for Social Sciences (IBM® SPSS® Inc., Chicago, USA), version 24.0. Analyzes of repeated measures ANOVA and Tukey's test were considered with a significance level of 5%.

Results

Statistical analysis showed significant difference to the time factor (p=0.02), and to the interaction sealer-time (p=0.04). The same did not occur to the sealer (p=0.10).

For the sealer factor, AHP (4.11) had the lowest ΔE, without difference to END (6.34), Sealer 26 (8.74) and MTA (12.15). Considering the time factor, T_2 (10.02) was statistically greater than T_1 (5.65). Table 2 shows the mean chromatic change for each group at different time intervals and the pairwise comparisons.

Table 1. Cements used in the research with their respective information about the manufacturer and composition.

Cement (manufacturer)	Composition
AH Plus® (Dentsply Detrey GmbH, Konstanz, Germany)	"Paste A: bisphenol-A epoxy resin, bisphenol-F epoxy resin, calcium tungstate, zirconium oxide, silica, iron oxide pigments. Paste B: dibenzyl diamine, amino adamantane, tricyclodecane thiamine, calcium tungstate, zirconium oxide, silica, silicon oil".
Endofill® (Dentsply, Petrópolis, Brazil)	"Powder: zinc oxide, hydrogenated resin, bismuth subcarbonate, barium sulphate and sodium borate. Liquid: eugenol, sweet almond oil and butylated hydroxytoluene (BHT)".
MTA Fillapex® (Angelus, Londrina, Brazil)	Resin salicylate, resin diluent, natural resin, bismuth oxide, nanoparticle silica, MTA and pigments.
Sealer 26® (Dentsply Herpo, Petrópolis, Brazil)	"Po: bismuth trioxide, calcium hydroxide, hexamethylenetetramine, titanium dioxide. Resin: bisphenol epoxy."

Table 2. Mean values of ΔE and (standard deviation) of the groups studied.

Group	ΔL T_1	ΔL T_2	Δa T_1	Δa T_2	Δb T_1	Δb T_2	ΔE T_1	ΔE T_2
AHP	-0.90±3.93^a	-1.57±4.44^a	-0.30±0.93^a	-0.26±1.06^a	-0.07±1.86^a	-0.16±1.54^a	3.78 ± 1.90^a	4.34 ± 2.15^a
END	-1.65±6.28^a	4.75±5.09^{ab}	-0.03±0.96^a	-0.65±2.01^a	0.27±2.58^a	1.89±5.67^a	5.04 ± 4.59^a	7.63 ± 5.08^{ab}
MTA	-1.86±5.52^a	4.98±20.43^b	0.63±1.04^a	-0.17±0.52^a	1.10±3.01^a	0.38±6.12^a	5.20 ± 3.92^a	19.09 ± 17.18^b
SEA	-1.54±9.42^a	-1.91±8.31^a	1.02±1.89^a	1.32±1.53^a	4.31±7.38^a	5.36±8.51^a	8.47 ± 9.83^{ab}	9.00 ± 9.49^{ab}

Note: Equal letters do not differ statistically. AHP = AH Plus, END = Endofill, MTA = MTA Fillapex, SEA = Sealer 26.

All groups had a ΔE>3.7 (clinically perceptible). In T_1, there was no statistically significant difference between all the sealers. But, in T_2, a statistical difference was observed only between AHP and MTA.

Discussion

Here was proposed a clinical analysis of tooth crown color change after root canal filling with different endodontic sealers and rejected the null hypothesis, as the tested materials promoted chromatic alterations.

The development and use of materials that do not cause color change is essential when treatment is performed on teeth where esthetic is a concern. Studies have reported that the procedures and materials used during endodontic treatment may have negative aesthetic impacts.[2,3,7,13-17] Stages such as access, preparation, irrigation, intracanal medication, and obturation may result in intrinsic or internalized discoloration, or a combination of both.[2,13] To minimize discoloration due to inadequate removal of the coronal pulp, usually due to inappropriate access, the accesses of all teeth were checked with an exploratory probe no. 5. In addition, to avoid possible confounding variables, irrigation solutions and a single session protocol were standardized.

Multiple methods to evaluate color change induced by endodontic sealers have been proposed, such as a visual technique[2] and digital photo analysis.[14] The CIE system, used here, is recognized by ISO Standards10 and is an accurate method for calculating color change.[6,18-20]

Despite the limitations of the present study, clinically perceptible chromatic changes in the crown (ΔE>3.7) were observed with the use of all the sealers. Because there was no statistical difference between the sealers tested, the color change of the crown cannot be attributed exclusively to a single component of the various sealers. There may be other related constituents, which raises the need for further studies to investigate this phenomenon.

Some theories are accepted to explain the alterations, such as the diffusion of endodontic material through the dentinal tubules; as the enamel is translucent, the cervical region of the crown would have more evident color change.[3] It can also be said that the discoloration of the crown over time is related to the color change of the sealer itself.[15]

Regarding the color stability, the literature is controversial. Results pointed out that sealers can potentially stain the tooth structure to different degrees.[21] Contrary, Ioannidis et al.[6] concluded that not all endodontic sealers cause clinically detectable color change, and they further stated that AH 26, GuttaFlow, and Epiphany did not change the color of the crown over a six-month period.

In the present study, the sealer that caused the greatest color change was the MTA Fillapex; despite having biological characteristics superior to other endodontic sealers,[22,23] it is already known to cause tooth discoloration. Otherwise, it was suggested that, in terms of aesthetics, this material results in minimal color alterations.[12] To the radiopacifier bismuth oxide present in MTA is attributed such discoloration.[16,24] Marciano et al,[25] postulated that the grayish discoloration found in bovine teeth occurred due to the reaction between the collagen, which is present in dentin matrix, with bismuth oxide present in withe MTA analyzed. Additionally, a comparative study regarding the chemical composition of white and gray MTA revealed that the major difference appeared in the concentrations of carborundum (Al_2O_3), periclase (MgO), and FeO, with the observed values of these oxides being considerably lower in the withe material.[26] In addition, Kohli et al.[17] believed that an interaction between the irrigating solution (NaOCl or chlorhexidine) and bismuth oxide may cause a discoloration of this material. This was also confirmed by other authors.[27,28]

Time was a determinant in the difference of the evaluated teeth, as the Endofill and MTA Fillapex sealers showed a significant difference over time. Parsons et al.[3] and Arman et al.[29] concluded that tooth discoloration over a period of one to three months was minimal or absent, but discoloration became more evident over a nine to 12-month period. However, in the present study, a clinically visible alteration was observed after 30 days.Other results revealed that at one year, ΔE values were significantly lower with MTA Fillapex compared to the other groups (Pulpispad and AH26).[30]

These results can be attributed to the study model, as this was a clinical rather than an in vitro. Regarding the color change induced by zinc oxide and eugenol-based sealers, the instability of chemical bond

between ZnO and eugenol may lead to increased chromogenic potential.[30] An oxidation due to eugenol release, even after the final setting reaction, can cause dental structures discoloration over time[3].Despite a clinically visible color change, AHP Plus showed the best results of all the sealers tested. There are controversies in the literature regarding the results with this material. Also, in the study developed by Kohli et al.[17] the AH Plus did not induce a noticeable color change when left in the pulp chamber over a period of six months. Forghani et al.[5] found that both sealers, MTA Fillapex and AH Plus, led to clinically perceptible color changes in vitro, but there was no statistically significant difference between them.

Authors argue that AH Plus sealer has zirconium oxide as the radiographic contrast agent and filler, a light color, that does not undergo the chemical reactions when compared to bismuth, and the color keeps stable over extended periods of time.[31] Other laboratory findings indicate that a progressive discoloration occurs with the use of this sealer,[7,32] and contrary, a reduction in color variation occurs.[5,33]

Conclusion

In conclusion, within the limitations of this study, all the endodontic sealers caused clinically perceptible chromatic changes in the dental crown. However, the AH Plus presented less changes in dental crown.

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