Evaluation of dentin discoloration caused by endodontic root canal sealers due to ultrasonic agitation

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DOI: https://doi.org/10.14436/2358-2545.11.3.046-051.oar

ABSTRACT

Introduction: Tooth discoloration is an aesthetic problem commonly reported by patients as one of the main reasons to seek a dentist. Thus, this study aimed to evaluate the dentin discoloration caused by AH Plus, MTA Fillapex, Sealer Plus and Pulp Canal Sealer EWT endodontic sealers, associated or not with ultrasonic agitation during the obturation. **Methods:** Round cavities were prepared on the palatal faces of eighty bovine teeth slabs, preserving a 2 mm of dentin thickness. The slabs were randomly separated in groups by type of sealer employed and based on the use or not of ultrasonic agitation (n = 10). The color was measured by a spectrophotometer after sealer insertion into the cavities (T0), after 7 (T1) and 180 days (T2). **Results:** Clinically detectable discoloration (ΔE > 3,7) was present in all groups at T1 and T2. Statistically significant differences were not found between T1 and T2 (P > .05). **Conclusion:** All endodontic sealers tested caused dentin discoloration after 7 days. The color-changing persisted thought the entire experimental period. Moreover, the ultrasonic agitation did not influence on the dentin discoloration caused by the endodontic sealers tested.

Keywords: Endodontics. Discoloration. Ultrasonic agitation.

How to cite: Gonçalves NB, Luna-Cruz SM, Pinheiro-Júnior EC, Gomes NV, Vasconcelos BC. Evaluation of dentin discoloration caused by endodontic root canal sealers due to ultrasonic agitation. Dental Press Endod. 2021 Sept-Dec;11(3):46-51. DOI: https://doi.org/10.14436/2358-2545.11.3.046-051.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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Submitted: December 08, 2019. Revised and accepted: August 03, 2020.

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Introduction

Aligned and bleached teeth are the current beauty standard. However, endodontically treated teeth might suffer discoloration, which might affect the patients[28] satisfaction and life quality.[10]

Several aspects of the endodontic treatment are associated with crown discoloration,[2] such as pulp necrosis, dental traumatisms, and remains of the pulp tissue, medication, or endodontic sealer within the pulp chamber.[25] The remaining of endodontic sealer within the pulp chamber figures among one of the main causes of infiltration of the dentin tubules after the endodontic treatment.[29] Such a process affects the cervical and medium thirds of the crown more frequently once in these regions the enamel is thinner and translucid, which makes the discoloration apparent.[8]

The composition of the endodontic sealers has been discussed, as such products present a radiopacifier, which contains bismuth and has been pointed as the responsible for the dentin discoloration.[17,30] Silver present in the endodontic sealer such as AH26 (Dentsply/DeTrey, Konstanz, Germany) and Pulp Canal Sealer (SybronEndo, Orange, CA, USA) has also been associated with teeth discoloration. Thus, newly developed materials present calcium tungstate and/or zirconium oxide instead of bismuth and silver. Some examples of the former are AH Plus (Dentsply/De Trey, Konstanz, Germany), Sealer Plus (MK Like Dental and Medical Products, Porto Alegre, RS, Brazil), and MTA Fillapex.[17]

Together with the development of new endodontic sealer, research has also focused on protocols and techniques to foster the endodontic therapeutic. Under this light, the use of ultrasonic agitation has been incorporated into the obturation step to promote the adaptation of the material to the root canal walls, the filing of the root canals and isthmus, as well as to improve the intratubular penetration and the antimicrobial activity of the types of sealer against *Enterococcus Faecalis*.[3] Although further investigation is needed, it has been reported that ultrasonic agitation might delay the discoloration of obturation materials.[1]

In this scenario, our study aimed to analyze ex vivo for 180 days the dentin discoloration caused by the endodontic sealer Pulp Canal Sealer EWT (PCS), AH Plus (AH), Sealer Plus (SP), and MTA Fillapex (MTAF) when ultrasonic is used or not.

Material and methods

Sample selection and preparation

This study was previously approved by Local Ethics Committee (Protocol number 2018/031). Eighty single-rooted bovine teeth were used; teeth that were too small or that presented extensive wear were excluded.

The samples were prepared according to a protocol modified from Lenherr al.[16] and Arman et al.[4] Thus, the teeth were cleaned with curettes to remove any fragments or calculus adhered to the teeth surface. Then, the crowns were cut using #7020 diamond disks (KG Sorensen, Cotia, DP, Brazil) to prepare 10 x 10 x 3.5 mm enamel-dentin slabs. A digital pachymeter digital (Mitutoyo, Suzano, SP, Brazil) was used to ensure the slabs had a standardized size. In the sequence, round cavities measuring 5 mm of diameter and 1.5 mm of depth were prepared at the center of the palatal side of the slabs using a #1052 drill (KG Sorensen, Cotia, SP, Brazil). A dental gauge caliper (Golgran, São Caetano do Sul, SP, Brazil). was used to ensure that 2 mm of dentin-enamel thickness was preserved after the cavity preparation. Moreover, one of the 4 squares of the slab was worn out to became rounded, so the specimen positioning could be standardized during the color measurement.

In the sequence, the slabs prepared were immersed into 2.5% sodium hypochlorite (Asfer Indústria Química Ltda, São Caetano do Sul, SP, Brazil) for 15 minutes. Then, the specimens were washed in distilled water for 1 minute, immersed in EDTA 17% (Asfer Indústria Química Ltda, São Caetano do Sul, SP, Brazil) for 3 minutes, then washed again in distilled water for 1 min, and finally, they were dried in filter paper.

After being prepared, the slabs were randomly assigned to 4 groups, according to endodontic sealer, and within each group, the slabs were separated according to the use of ultrasonic agitation or not. Regardless of the group, all cavities were filled following the manufacturer's instructions. Table 1 presents the composition of each material tested. The ultrasonic agitation was employed using a piezoelectrical ultra-

sonic device (PM200; EMS, Chemin de la Vuarpillière, Switzerland) set to the level 3 potency (approximately 30%) and mounted with a conical ultrasound insert (E8; Helse Ultrasonics, Santa Rosa do Viterbo, SP, Brazil). After condensation of the endodontic sealers, the inserted was placed into 1 mm of the cavity. Then, two agitation cycles were employed for 20 seconds. The first one in a mesial-distal direction and the other in a cervical-incisal direction.[24]

After endodontic sealers adaptation, the cavities were restored using 37% phosphoric acid gel (Maquira, Maringá, PR, Brazil), Magic Bond adhesive (Coltene, Rio de Janeiro, RJ, Brazil), and a composite resin (Lis Esmalte Gnatus, Barretos, SP, Brazil). The composite resin was polymerized using LED light (Optilight LD Max; Gnatus, Barretos, SP, Brazil) for 60 seconds. Finally, the samples were numbered and individually stored at room temperature, indirectly exposed to the light, and stored in centrifuge tubes containing 2 mL of saline, where they remained during all experimental time.

Color change analysis

The color analysis was performed according to Lenherr et al.[16] in a dark room by employing a digital spectrophotometer (VITA Easyshade compact; VITA Zahnfabrik AG, Bad Sachington, Germany), mounted in a customized device. This enabled standardized measurements of each sample over time. The digital spectrophotometer was calibrated before color assessment as well as in between samples. The measurements were immediately obtained after the insertion of the endodontic sealers (T0), 7 (T1), and 180 (T2) days after the insertion. The color change parameters were determined following the International Commission on Illumination (CIE, 1978), considering "L", "a" and "b". "L" represents the values of color luminosity, whereas "a" and "b" corresponds to color measurement along the red-green and yellow-blue spectrum axes. Color alterations (ΔE) to time intervals were calculated according to the equation:

$$\Delta E = [(L1-L0)^2 + (a1-a0)^2 + (b1-b0)^2]^{1/2}$$

Table 1. Endodontic sealers and their respective compositions.

Sealers	Composition
AH Plus (Dentsply-Sirona, Ballaigues, Switzerland)	» Paste A: Bisphenol-F Epoxy Resin; Calcium Tungstate; Zirconium Oxide, Silica and Iron Oxide. » Paste B: AH Plus pasta B: Adamant amine: N,N'-Dibenzyl 5-oxanonane-diamine-1,9; TCD-Diamin; calcium tungstate; Zirconium Oxide, Silica and Silicone Oil.
MTA Fillapex MTA Fillapex (Angelus Dental Products S/A, Londrina, PR, Brazil)	» Base Paste: Salicylate resin, Natural resin, calcium tungstate, nano particulate silica, pigments. » Catalist Paste: Diluent resin, mineral trioxide aggregate, nanoparticulate silica, pigments.
Pulp Canal Sealer EWT (Sybronendo, Orange, CA, USA)	» Powder: silver powder, zinc oxide, thymol iodide, dimeric acid resin. » Liquid: clove oil, balsam of Canada and eugenol.
Sealer Plus (MK Life Medical and Dental Products, Porto Alegre, Brazil)	» Base Paste: bisphenol A, bisphenol F epoxy resin, zirconium oxide, silicone and siloxanes, iron oxide, calcium hydroxide. » Catalyst Paste: hexamethylethylenetetramine, zirconium oxide, silicone and siloxanes, calcium hydroxide, calcium tungstate.

Data statistical analysis

Giving the non-parametric distribution of these data, the Kruskal-Wallis, Dunn, and Mann-Whitney test with a significance level of 5% was used to perform statistical analyses.

Results

The data regarding color alterations (ΔE) observed overtime are described in Table 2. The analysis of color alteration on day 7 demonstrated that the four endodontic sealers tested caused a clinically visible dental discoloration, ΔE reaching above 3.7. The lowest and highest values were achieved by using AH and MTAF sealers, leading to ΔE values of 9.81 and 13.49, respectively, both without ultrasonic agitation. The clinically perceived dental discoloration observed on day 7 was still present in all groups on day 180, being PCS/ultrasonic agitation (10.27) and AH (16.73) groups the ones that reached the lowest and highest ΔE values, respectively. No significant difference overtime was found between groups regardless of the use of ultrasonic agitation or the type of endodontic sealer ($P > .05$). When time points were considered and compared within each group, significant differences were found for groups SP and AH, both without ultrasonic agitation, being a higher dental discoloration observed on day 180 ($P < .05$).

Discussion

The most common cause of dental discoloration is the presence of endodontic sealers into the dental pulp chamber through dentin tubules, leading to dental discoloration.[29] Given this context, this study evaluated the dental discoloration caused by four types of endodontic sealers, two of which are traditionally employed in the dental practice: Pulp Canal Sealer EWT and AH Plus. These brands were compared to Sealer Plus and MTA Fillapex.

Bovine teeth were used in this study as described by Lenherr et al. (2012)[16] and other available studies.[22,26] Choosing bovine teeth allows for better standardization of experimental protocols, obtention of the necessary number of slabs for an optimum number of experimental replicates, as well as due to morphological similarities when compared to human teeth such as the number of dentin tubules per mm^2 and tubule diameter.[23] Regarding the method for determining color changes, this study employed the color system CIE LAB, approved by the American Dental Association (ADA), a protocol that is largely used both in vitro[21] and in vivo.[9] Given the exposed, the spectrophotometer Vita Easy Shade was chosen due to its high precision under standardized conditions of light.[4] In this evaluation system, ΔE values over 3.7 are considered a clinically perceivable dental color alteration.[15]

Table 2. Median of the corresponding groups with and without ultrasonic agitation and minimum and maximum values of discoloration in the groups of sealers analyzed.

Material	Agitation	7 days		180 days	
		Median	Min. - Max.	Median	Min. - Max.
Pulp Canal Sealer EWT	without	$10.78^{a.A}$	6.11 - 12.92	$14.52^{a.A}$	8.41 - 20.06
	with	$11.04^{a.A}$	8.08 - 17.91	$10.27^{a.A}$	6.13 - 27.01
MTA Fillapex	without	$13.49^{a.A}$	9.42 - 15.63	$13.07^{a.A}$	10.03 - 15.75
	with	$12.1^{a.A}$	6.6 - 13.46	$12.58^{a.A}$	7.96 - 20.06
Sealer Plus	without	$12.54^{a.A}$	11.01 - 15.56	$16.73^{a.B}$	11.48 - 22.93
	with	$12.08^{a.A}$	5.57 - 15.04	$13.82^{a.A}$	9.05 - 20.44
AH Plus	without	$9.81^{a.A}$	6.51 - 13.78	$16.54^{a.B}$	13.04 - 30.57
	with	$11.37^{a.A}$	8.61 - 15.12	$16.75^{a.A}$	10.34 - 20.09

^{a,b} Different lowercase letters represent significant differences for each period according to the Kruskal-Wallis and Dunn tests ($P < 0.05$).

^{A,B} Different capital letters represent significant differences for each group over the two periods according to the Mann Whitney test ($P < 0.05$).

Regarding the use of ultrasonic activation of the dental fillings, it is important to emphasize that the use of the adopted protocol in our study was based on published data that reported a higher penetration of the filling material into dentin tubules, creating a more satisfactory sealing interface onto the dentin substrate.[14] Based on such information, in this study, the ultrasonic activation was used to assess possible changes in dental color caused by the four types of endodontic sealer as a function of this very same ultrasonic agitation protocol.[3,14]

The results demonstrated that the dental discoloration caused by the types of endodontic sealers tested on day 7 achieved ΔE values higher than 3.7, which is a hallmark of clinically perceived dental discoloration.[15] Considering the material composition, this finding would be considered normal for PCS due to its greyish color and silver content.[31] Bismuth- or silver-containing formulations have been previously evaluated and reportedly caused dental discoloration within a 17-day period.[12] Bismuth has been also responsible for the dental discoloration caused by endodontic repair filling materials.[17,30] Other studies also reported the instability of this chemical element and its possible interaction with humidity and the dentin collagen,[7] not to mention cytotoxicity, hindering cell proliferation and growth, as well as cell death induction.[6]

Overall, all the groups showed changes in the intensity of dental discoloration over time, being the highest values reached on day 180. As for the two endodontic sealer SP and AH, such discoloration was not expected due to the absence of bismuth or silver in their composition as radio-opacifiers. Yet, the dental discoloration has been reported even in shorter periods of time.[12] These types of material have calcium tungstate and zirconium oxide, whereas MTA Fillapex has only calcium tungstate in its composition as a radio-opacifier. Calcium tungstate is a thin white powder produced by a stoichiometric mixture of calcium oxide, calcium carbonate, and tungstic acid.[19] There is no study showing dental discoloration caused by calcium tungstate. Contrarily, some studies attribute to calcium tungstate-containing materials color stabilization.[14,21] Zirconium oxide is also a white powder obtained from a rare material known as baddeleyite[19] whose use has not been associated with dental discoloration until now. Given these findings, dental discoloration might occur as a result of some reaction among the endodontic material substances with the radio-opacifiers or between the radio-opacifiers and the dental substrates, but further studies are necessary to identify the mechanisms that underlie dental discoloration under these conditions.

Regarding the use of ultrasonic agitation, the results pointed out no significant interference of it with the dental discoloration patterns caused by the types of endodontic sealers tested. Such findings do not corroborate with Aguiar et al.[1] who concluded that ultrasonic agitation reduced dental discoloration caused by endodontic repair filling materials that employ bismuth as a radio-opacifier and did not increase dental discoloration. Yet, other studies argue that ultrasonic agitation is advantageous.[3,14] This could be due to the chemical characteristics of the endodontic filling materials Aguiar et al.[1] evaluated, in which the ultrasonic agitation could have decreased their water content due to heating.

Given the exposed, clinicians should be aware that the endodontic therapy must not restrict itself to functional and biological aspects, but also it should value aesthetics outcomes to reduce the risks of dental discoloration - an undesirable and avoidable consequence. In this sense, even understanding the limitations of ex vivo studies concerning clinical translation, care must be taken when employing endodontic filling materials, especially in aesthetic areas, avoiding leaving behind any residue into the dental pulp chamber even if no possible dental discoloration is disclosed by the manufacturers of these materials.

Conclusion

The results of this study afford the conclusion that all the types of endodontic sealers tested, Pulp Canal Sealer EWT, AH Plus, Sealer Plus, MTA Fillapex, within 180 days caused dental discoloration at a clinically perceivable level. Furthermore, the ultrasonic agitation did not significantly affect ΔE, not influencing the dental discoloration caused by the tested types of endodontic sealers.

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