



Comparison of Tooth Discoloration Induced by Calcium-Enriched Mixture and Mineral Trioxide Aggregate

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ARTICLE INFO	ABSTRACT
<p>Article Type: Original Article</p> <p>Received: 1 Jan 2016 Revised: 23 Mar 2016 Accepted: 05 Apr 2016 Doi: 10.7508/iej.2016.03.005</p> <p>*Corresponding author: Majid Akbari, Dental Research Center, Faculty of Dentistry, Mashhad, Iran. Tel: +98-915 1104273 E-mail: akbarim@mums.ac.ir</p>	<p>Introduction: The aim of this <i>in vitro</i> study was to evaluate the tooth discoloration induced by calcium-enriched mixture (CEM) cement and mineral trioxide aggregate (MTA). Methods and Materials: Forty five endodontically treated human maxillary central incisors were selected and divided into three groups ($n=15$) after removing the coronal 3 mm of the obturating materials. In the MTA group, white MTA plug was placed in pulp chamber and coronal zone of the root canal. In CEM cement group, CEM plug was placed in the tooth in the same manner. In both groups, a wet cotton pellet was placed in the access cavity and the teeth were temporarily sealed. After 24 h the teeth were restored with resin composite. In the negative control group the teeth were also restored with resin composite. The color change in the cervical third of teeth was measured with a colorimeter and was repeated 3 times for each specimen. The teeth were kept in artificial saliva for 6 months. After this period, the color change was measured again. Data were collected by Commission International de l'Eclairage's L^*a^*b color values, and corresponding ΔE values were calculated. The results were analyzed using the one-way ANOVA and post-hoc Tukey's test with the significance level defined as 0.05. Results: There was no significant differences between CEM group and control group in mean discoloration. The mean tooth discoloration in MTA group was significantly greater than CEM and control groups ($P<0.05$). Conclusion: According to the result of the present study CEM cement did not induce tooth discoloration after six months. Therefore it can be used in vital pulp therapy of esthetically sensitive teeth.</p> <p>Keywords: Calcium-Enriched Mixture; Dental Cements; Mineral Trioxide Aggregate; Tooth Discoloration; Vital Pulp Therapy</p>

Introduction

Biomaterials are used in many endodontic treatments, including repair of tooth perforation, as root end filling material, treatment of teeth with open apices and as pulp capping agents. One of these biomaterials which is being widely used is mineral trioxide aggregate (MTA). MTA is a biocompatible material with profound sealing properties that make it suitable for sealing root perforations [1-5]; and root end fillings [1, 6]. MTA is also used as a pulp capping agent and treatment of teeth with open apices [7]. However, one of the major drawbacks of MTA is tooth discoloration potential; which can be produced by both white and grey formulations [7-9].

Many studies have confirmed tooth discoloration potential of MTA. Kohli *et al.* [10] evaluated coronal tooth discoloration by various bioceramic cements and stated that both white and gray formulations of MTA caused significant discoloration in time. Kang *et al.* [11] also evaluated color change of teeth after using different MTA based materials and showed ProRoot MTA and Angelus MTA caused distinct color changes.

Calcium-enriched mixture (CEM), is another biomaterial [12], with high biocompatibility and low cytotoxicity, antibacterial properties and good sealing ability [13-15]. Its clinical applications are similar to those of MTA, including root-end filling, pulp capping, pulpotomy of primary and permanent teeth, repair of tooth perforations and vital pulp therapies [15-19].

One of the major concerns in using dental materials especially in aesthetically strategic areas is potential of tooth discoloration. The aim of this *in vitro* study was to evaluate the tooth discoloration potential of CEM cement in comparison with MTA.

Materials and Methods

Forty five freshly extracted single-rooted human maxillary central incisors were used in this study. All specimens were clinically and radiographically examined for the absence of caries, cracks, restoration, discoloration and calcification. External surfaces of the teeth were cleaned with curette and prophylactic brushes and stored in a physiologic saline solution until usage.

After preparation of the access cavity and removing the pulp tissue by barbed broaches (Dentsply, Tulsa Dental, Tulsa, OK, USA), working length was determined visually after reducing 1 mm from length of a #10 K-file (Dentsply, Tulsa Dental, Tulsa, OK, USA) inserted into the canal after emergence of its tip from the apical foramen.

Cleaning and shaping of each canal was done by using K-files (Dentsply, Tulsa Dental, Tulsa, OK, USA) and Gates-Glidden drills (Dentsply, Tulsa Dental, Tulsa, OK, USA) in a step-back manner and the apical area was prepared up to #40. A 2.5% concentration of sodium hypochlorite was used for irrigation of root canals. The root canals were dried with paper points and a #40 master gutta-percha (Aryadent, Tehran, Iran) was placed in the canal and confirmed radiographically. Obturation of each tooth was carried out using lateral compaction of gutta-percha and AH-Plus sealer (Dentsply, De Trey, Konstanz, Germany). The cutting of gutta-percha was done 3 mm below the orifice and the obturating material was compacted vertically. The remnants of sealer and gutta-percha were completely removed from the pulp chamber.

Then the teeth were randomly divided into three groups ($n=15$) including one negative control group. In MTA group, a white MTA plug (Angelus, Londrina, PR, Brazil) was placed in pulp chamber and the root canal space below the orifice. In CEM cement group, CEM cement plug (Yektazist Dandan, Tehran, Iran) was placed in the tooth in the same manner as MTA group. In both MTA and CEM cement groups, the materials were mixed according to the manufacturers' instructions and a wet cotton pellet was placed in the access cavity and coronal seal was achieved using Coltosol (Coltene, Altstätten, Switzerland) for 24 h. After that, temporary filling and cotton pellet was removed and the materials were checked for setting. Then the teeth were restored with resin composite (Z100, 3M ESPE, MN, USA). In the negative control group the access cavity of the teeth were restored with resin composite.

A colorimeter (Minolta CR-300; Minolta Co, Osaka, Japan) was used relative to standard illuminant with a white background to measure the color of each specimen in a standardized condition according to the CIE LAB

(Commission International de l'Eclairage L^*a^*b) color space system. In this system, the L axis indicates the value that showed the degree of lightness [ranges from 0 (black) to 100 (white)], whereas a plane represents the degree of red or green [$+a$ (red) and $-a$ (green)] and b plane corresponds with the degree of yellow or blue [$+b$ (yellow) and $-b$ (blue)] within the sample. To position the tip of the colorimeter in the same location on each specimen, a silicon rubber mold was prepared. The colorimeter was calibrated on white calibration plate according to the manufacturer's instruction. The color of the cervical third of the teeth was assessed three times and the mean value was considered as the final measurement at the baseline examination. The teeth were then kept in an incubator 37°C in artificial saliva for 6 months, whereas artificial saliva was replenished each week. After this period, color assessment was made using the colorimeter in the manner described for baseline readings. The calculation of the discoloration (ΔE^*) between the two color measurements is as follows: $\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$. The human eye cannot perceive color difference between two specimens (ΔE) values less than 1. ΔE values between 1 and 3.3 represent a clinically acceptable range [20]. ΔE values of 3.3 and higher are reported to be unacceptable for human eyes in clinical conditions [21] thus 3.3 has been used as the upper limit in some studies based on the perceptibility of color differences.[22-25]

Preliminary analysis with Kolmogorov-Smirnov test was used to confirm the normal distribution of data. The results were analyzed using the one-way ANOVA and post-hoc Tukey's test with the significance level set at 0.05.

Results

The changes of color determinants from the baseline in the study groups are shown in Table 1. The mean \pm SD values of color change and descriptive statistics of the discoloration after 6 months in all groups are presented in Table 2.

There was no significant differences between CEM cement group and control group in mean discoloration value. The mean tooth discoloration in MTA group was significantly more than CEM cement and control groups ($P=0.000$)

Table 1. Changes of color determinants in the study groups

Groups	ΔL	Δa	Δb	ΔE
MTA	2.98	1.14	1.58	3.56
CEM cement	2.02	0.89	1.06	2.45
Control	1.86	0.75	0.91	2.20

Table 2. The mean \pm SD of ΔE in study groups

Groups (N)	Mean \pm SD
MTA (15)	3.5613 \pm 0.70590
CEM cement(15)	2.4507 \pm 0.51825
Control (15)	2.2007 \pm 0.38524
Total (45)	2.7376 \pm 0.46675

Discussion

Many studies have pointed to tooth discoloration as one of the major drawbacks of MTA [7-9]; which has been attributed to the presence of iron and manganese in the formulation of MTA [7]. The concentration of carborundum (Al_2O_3), periclase (MgO) and FeO has been lowered in white MTA compared to grey MTA but these metal oxides are still present in white preparations [26]. Marciano *et al.* [27] examined white Angelus MTA and observed that the reaction of dentin matrix collagen with bismuth oxide content in MTA caused a grayish discoloration of the tooth. Berger *et al.* [28] also reported combination of bismuth oxide with other chemical moieties as the primary cause of tooth discoloration.

Similarly EndoCem Zr (Maruchi, Wonju, Korea) and Retro MTA (BioMTA, Seoul, Korea) (both containing zirconium oxide) caused less discoloration than ProRoot MTA and Angelus MTA (which contain bismuth oxide) [11].

CEM cement, on the other hand contains CaO, SO_3 , P_2O_5 , and SiO_2 [29]. Despite the presence of metal oxides in CEM cement, in the present study, there was no tooth discoloration by this material after six months. However, all samples in MTA group showed significantly more discoloration than CEM group and control group after this period. Jacobovitz and de Lima [9] also observed grey discoloration with internal inflammatory root resorption in teeth treated with white MTA after 20 months. Akbari *et al.* [8] showed that both white and grey MTA placed below the root canal orifice, induced crown discoloration especially in the cervical area of teeth after six months. Jang *et al.* [30] also observed both ProRoot and Angelus MTA caused discoloration at the MTA-dentin interface and on the interior surface of dentin.

Felman and Parashos [31] restored teeth with white MTA and found tooth discoloration in the crowns of samples which was prominent in the cervical third of teeth. It is clear that, in cases of vital pulp therapies of anterior teeth, such as apexogenesis, MTA is the material of choice due to its excellent biocompatibilities; but in most cases, discoloration of the tooth makes it a challenging treatment.

CEM cement is a hydrophilic endodontic biomaterial. It has pH values similar to MTA [10]. Samiee *et al.* [32] showed both MTA and CEM cement had similar favorable biological response in furcation perforation repair and induced formation of cementum-like hard tissue and due to setting in wet environment, they are ideal as a perforation repair material. Two randomized controlled trials showed favorite outcomes following using CEM cement after vital pulp therapies of primary molar teeth [16, 32]. CEM cement also has good sealing ability as a root-end filling material [15]. Razmi *et al.* [33] showed both MTA and CEM cement has antibacterial effects against *E. faecalis*. Kangarlou *et al.* [34] also evaluated antifungal effects of CEM cement and found that it has

fungicidal effects against *Candida albicans* even in low concentration. Similar to the result of this study, Eghbal *et al.* [35] evaluated color stability of white MTA and CEM cement and found that after irradiation, color stability of MTA was inferior to CEM cement samples.

Color measurement has several techniques and in the present study the quantitative technique was used. The quantitative measurement of color difference (ΔE^*) with a colorimeter confers advantages such as repeatability, sensitivity and objectivity, despite some limitations [36, 37].

Conclusion

According to the results of this study, CEM did not have discoloration properties unlike other endodontic materials like MTA. CEM cement can be advocated as an endodontic biomaterial in esthetically sensitive teeth.

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Conflict of Interest: 'None declared'.

References

1. Torabinejad M PM. Mineral trioxide aggregate: a comprehensive literature review--part II: leakage and biocompatibility investigations. *J Endod.* 2010;36(2):190-202.
2. Ferris DM BJ. Perforation repair comparing two types of mineral trioxide aggregate. *J Endod.* 2004;30(6):422-4.
3. Weldon JK Jr PD, Loushine RJ, Weller RN, Kimbrough WF. Sealing ability of mineral trioxide aggregate and super-EBA when used as furcation repair materials: a longitudinal study. *J Endod.* 2002;28(6):467-70.
4. Daoudi MF SW. In vitro evaluation of furcal perforation repair using mineral trioxide aggregate or resin modified glass ionomer cement with and without the use of the operating microscope. *J Endod.* 2002;28(7):512-5.
5. Keiser K JC, Tipton DA. Cytotoxicity of mineral trioxide aggregate using human periodontal ligament fibroblasts. *J Endod.* 2000;26(5):288-91.
6. Pereira CL CM, Demarco FF. Sealing ability of MTA, Super EBA, Vitremer and amalgam as root-end filling materials. *Braz Oral Res.* 2004;18(4):317-21.
7. Pariookh M TM. Mineral trioxide aggregate: a comprehensive literature review--Part III: Clinical applications, drawbacks, and mechanism of action. *J Endod.* 2010;36(3):400-13.
8. Akbari M RA, Samiee S, Jafarzadeh H. Effect of dentin bonding agent on the prevention of tooth discoloration produced by mineral trioxide aggregate. *Int J Dent.* 2012;2012(2012):563203.
9. Jacobovitz M dPLR. The use of calcium hydroxide and mineral trioxide aggregate on apexification of a replanted tooth: a case report. *Dent Traumatol.* 2009;25(3):e32-6.

10. Kohli MR YM, Setzer FC, Karabucak B. Spectrophotometric Analysis of Coronal Tooth Discoloration Induced by Various Bioceramic Cements and Other Endodontic Materials. *J Endod.* 2015;41(11):1862-6.
11. Kang SH SY, Lee HS, Kim SO, Shin Y, Jung IY, Song JS. Color changes of teeth after treatment with various mineral trioxide aggregate-based materials: an ex vivo study. *J Endod.* 2015;41(5):737-41.
12. Asgary S SS, Jafarzadeh T, Amini S, Kheirieh S. The properties of a new endodontic material. *J Endod.* 2008;34(8):990-3.
13. Mozayeni MA MA, Marvasti LA, Asgary S. Cytotoxicity of calcium enriched mixture cement compared with mineral trioxide aggregate and intermediate restorative material. *Aust Endod J.* 2012;38(2):70-5.
14. Asgary S KF. Antibacterial effects of five different root canal sealing materials. *J Oral Sci.* 2008;50(4):469-74.
15. Asgary S EM, Parirokh M. Sealing ability of a novel endodontic cement as a root-endfilling material. *J Biomed Mater Res.* 2008;87(3):706-9.
16. Malekafzali B, Shekarchi F, Asgary S. Treatment outcomes of pulpotomy in primary molars using two endodontic biomaterials. A 2-year randomised clinical trial. *Eur J Paediatr Dent.* 2011;12(3):189-93.
17. Asgary S, Eghbal MJ, Ghoddsi J. Two-year results of vital pulp therapy in permanent molars with irreversible pulpitis: an ongoing multicenter randomized clinical trial. *Clin Oral Investig.* 2014;18(2):635-41.
18. Haghgoo R, Arfa S, Asgary S. Microleakage of CEM Cement and ProRoot MTA as Furcal Perforation Repair Materials in Primary Teeth. *Iran Endod J.* 2013;8(4):187-90.
19. Guler AU, Kurt S, Kulunk T. Effects of various finishing procedures on the staining of provisional restorative materials. *J Prosthet Dent.* 2005;93(5):453-8.
20. Seghi RR, Johnston WM, O'Brien WJ. Spectrophotometric analysis of color differences between porcelain systems. *J Prosthet Dent.* 1986;56(1):35-40.
21. Ruyter IE, Nilner K, Moller B. Color stability of dental composite resin materials for crown and bridge veneers. *Dent Mater.* 1987;3(5):246-51.
22. Inokoshi S, Burrow MF, Kataumi M, Yamada T, Takatsu T. Opacity and color changes of tooth-colored restorative materials. *Oper Dent.* 1996;21(2):73-80.
23. Kim HS, Um CM. Color differences between resin composites and shade guides. *Quintessence Int.* 1996;27(8):559-67.
24. Koishi Y, Tanoue N, Matsumura H, Atsuta M. Colour reproducibility of a photo-activated prosthetic composite with different thicknesses. *J Oral Rehabil.* 2001;28(9):799-804.
25. Stober T, Gilde H, Lenz P. Color stability of highly filled composite resin materials for facings. *Dent Mater.* 2001;17(1):87-94.
26. Asgary S, Parirokh M, Eghbal MJ, Brink F. Chemical differences between white and gray mineral trioxide aggregate. *J Endod.* 2005;31(2):101-3.
27. Marciano MA, Costa RM, Camilleri J, Mondelli RF, Guimaraes BM, Duarte MA. Assessment of color stability of white mineral trioxide aggregate angelus and bismuth oxide in contact with tooth structure. *J Endod.* 2014;40(8):1235-40.
28. Berger T, Baratz AZ, Gutmann JL. In vitro investigations into the etiology of mineral trioxide tooth staining. *J Conserv Dent.* 2014;17(6):526-30.
29. Asgary S, Ahmadyar M. Vital pulp therapy using calcium-enriched mixture: An evidence-based review. *J Conserv Dent.* 2013;16(2):92-8.
30. Jang JH, Kang M, Ahn S, Kim S, Kim W, Kim Y, Kim E. Tooth discoloration after the use of new pozzolan cement (Endocem) and mineral trioxide aggregate and the effects of internal bleaching. *J Endod.* 2013;39(12):1598-602.
31. Felman D PP. Coronal tooth discoloration and white mineral trioxide aggregate. *J Endod.* 2013;39(4):484-7.
32. Samiee M EM, Parirokh M, Abbas FM, Asgary S. Repair of furcal perforation using a new endodontic cement. *Clin Oral Investig.* 2010;14:653-8.
33. Razmi H AM, Bolhari B, Shamshirgar F, Shahsavan S, Shamshiri AR. Calcium Enriched Mixture and Mineral Trioxide Aggregate Activities against *Enterococcus Faecalis* in Presence of Dentin. *Iran Endod J.* 2013;8:191-6.
34. Kangarlou A SS, Yadegari Z, Asgary S. Antifungal effect of calcium enriched mixture cement against *Candida albicans*. *Iran Endod J.* 2009;4:101-5.
35. Eghbal MJ TH, Bagheban AA, Shamszadeh S, Marvasti LA, Asgary S. Color stability of mineral trioxide aggregate and calcium enriched mixture cement. *J Investig Clin Dent.* 2015;14.
36. Seghi RR GM, Kim J. Colorimetric changes in composites resulting from visible-light-initiated polymerization. *Dent Mater.* 1990;6:133-7.
37. Ahrari F AM, Mohammadpour S, Forghani M. The efficacy of laser-assisted in-office bleaching and home bleaching on sound and demineralized enamel. *Lazer Therapy.* 2015;24(5):257-64.

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