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Original research

Effect of commonly used irrigants on the colour stabilities of two calcium-silicate based material

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Purpose

The aim of present study was to evaluate the color stability of calcium-silicate based cements (CSC) Mineral Trioxide Aggregate (MTA) and Biodentine™ when exposed to endodontic irrigating solutions 5% Sodium hypochlorite (NaOCl) or 2% Chlorhexidine (CHX).

Materials and Methods

A total of 60 (*n*=30) cylindrical samples (10 mm diameter, 2 mm height) were prepared by manipulating white MTA Angelus (Angelus, Londrina, PR, Brazil) and Biodentine™ (Septodent, Saint Maur, France) according to manufacturer's instructions. These samples were immersed in 5% sodium hypochlorite (Prime Dental Products Pvt. Ltd., Mumbai, India), 2% chlorhexidine gluconate (Dentochlor, Saronno VA, Italia), or distilled water for 24 hours. Color changes were measured using UV spectrophotometer (UV-1650, Shimadzu, Europe) and the values were tabulated.

Results

A significant difference was observed between group I and II with respect to both parameters A & B ($p<0.05$). Both the calcium-silicate-based materials exhibited significant discoloration when immersed in NaOCl and CHX. Distilled water did not cause clinically perceptible discoloration of any material.

Conclusion

A significant discoloration was observed with a specific combination of calcium-silicate-based cement and irrigant. Biodentine™ exhibited significant discoloration with CHX whereas, MTA showed more discoloration with NaOCl.

Keywords: *Calcium silicate; chlorhexidine, irrigants; mineral trioxide aggregate; sodium hypochlorite*

Introduction

Over 24 million endodontic procedures are performed worldwide on an annual basis, with up to 5.5% of those procedure involving endodontic apical surgery, perforation repair, and apexification (1). Many materials have been employed for these procedures like; calcium hydroxide, tricalcium phosphate, tetracalcium phosphate, mineral trioxide aggregate (MTA), resin-modified glass ionomer cement, and intermediate restorative material. Calcium-silicate-based materials have gained popularity in recent years due to their various clinical applications. Calcium-silicate-based materials have been proven to be beneficial for various procedures involving pulpal regeneration and hard tissue repair, such as pulp capping, pulpotomy, apexogenesis, apexification, perforation repair, and root-end filling owing to their sealing ability and biocompatibility (2).

MTA is composed of modified Portland cement with added bismuth oxide. MTA is a biomaterial that has been investigated for endodontic applications since the early 1990s (3). MTA is biocompatible and has

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antibacterial properties. It is a bioactive cement originally designed as an endodontic repair and root-end filling material with favorable physical properties and setting characteristics. The indications and clinical applications for MTA have expanded considerably (3,4). Owing to its high alkalinity, it has the ability to induce release of bioactive dentin matrix proteins (5). MTA exhibits good sealing ability, most likely due to a physical bond created by a layer of hydroxyapatite between MTA and dentin (6).

However, MTA has certain drawbacks such as long setting time, difficult handling property and discoloration (4). Biodentine™, a newly developed tricalcium-silicate cement, became commercially available in 2009 to overcome these drawbacks (7). As these calcium-silicate-based materials are similar to MTA in basic composition, they have gained popularity in recent year (8). Biodentine™ has drawn attention in the recent years and has been advocated to be used in various clinical applications that would typically utilize MTA (9). Apart from the various clinical applications, MTA has been reported to cause tooth discoloration when applied in the esthetic zone (10).

Tooth discoloration induced by endodontic materials is a commonly occurring issue (11). Tooth discoloration after endodontic therapy is mainly caused due to blood, necrotic pulp tissue, and endodontic materials penetrating the dentinal tubules (12). There is limited data thus far on color stability of calcium-silicate–based materials. Hence, the current study was devised that aimed to evaluate the color stability of two widely used calcium-silicate based materials (MTA and Biodentine™) when in contact with commonly used irrigating solutions (Sodium hypochlorite and Chlorhexidine). Distilled water served as a negative control for the study.

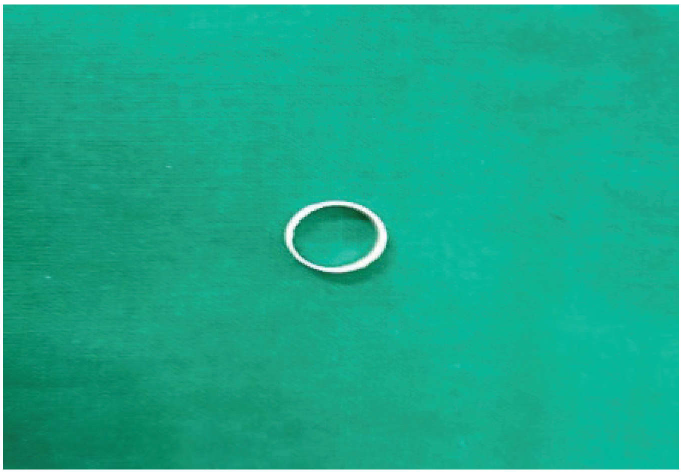

Figure 1. *Mold for sample preparation.*

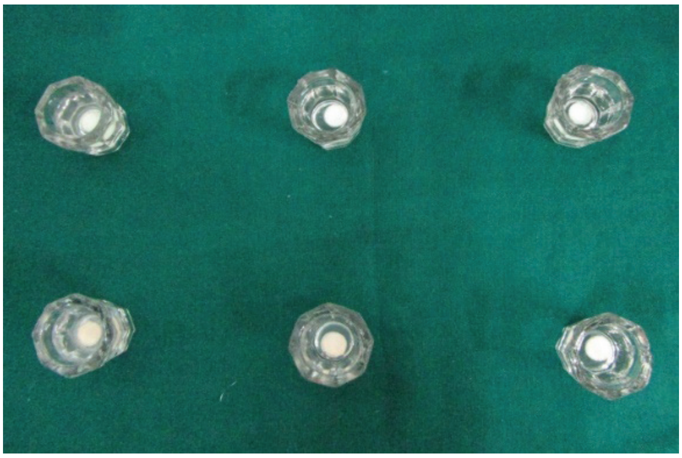

Figure 2. *Specimens immersed in irrigants.*

Materials and Methods

Sample preparation

Two groups of materials were tested in the current study, with 3 subgroups for each material (for irrigant treatment). The materials tested were: wMTA Angelus (Angelus, Londrina, PR, Brazil) and Biodentine™ (Septodent, Saint Maur, France). The irrigant treatment for the above mentioned 2 materials were: 5% sodium hypochlorite (Prime Dental Products Pvt. Ltd., Mumbai, India), 2% chlorhexidine gluconate (Dentochlor, Saronno VA, Italia), and distilled water.

The test materials (wMTA and Biodentine™) were mixed homogeneously following each manufacturer's instructions, and cylindrical specimens were obtained by using moulds of 10mm diameter and 2mm height (Figure 1). The specimens were then stored at 37°C and 100% humidity for the materials to reach their optimal mechanical properties. Following the complete setting of the materials (wMTA: 10 min, and Biodentine™: 10–12 min), the set specimens were immersed for 24 hours; in one of the tree different irrigating solutions (Figure 2). The groups for the current study were as follows: Group I wMTA, and group II Biodentine™ with sub-groups A, B, and C in which the specimens were immersed in 5% NaOCl, 2% CHX, and distilled water, respectively.

Spectrophotometric analysis

The specimens were allowed to dry completely before testing them in the UV spectrophotometer (Figure 3). Spectrophotometer (UV-1650, Shimadzu, Europe) was used to measure color under constant laboratory light by the same operator. Spectrophotometric analysis was applied because of the technique's repeatability, objectivity, and sensitivity to small changes in color (13). Images of the samples were taken before and after immersion using a digital camera.

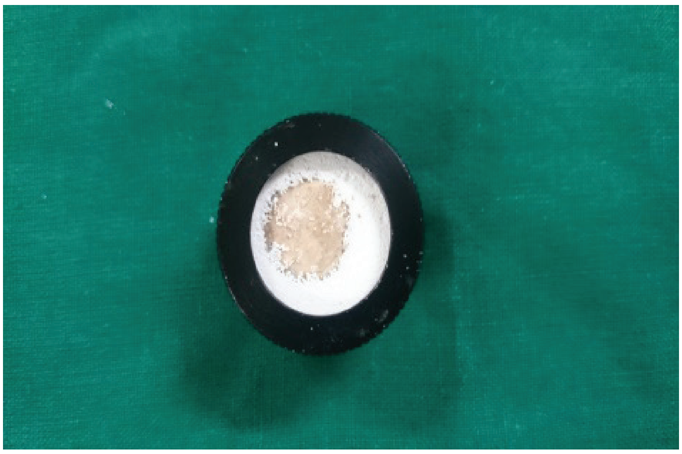

Figure 3. *Specimen preparation before placing in the spectrophotometer.*

Statistical analysis

The data collected was graphically represented as shown. (Figure 4) The data was evaluated with Kruskall Wallis ANOVA by using Statistical package for social sciences (SPSS v 22.0, IBM). The significant effects and interactions were further investigated using Mann Whitney U test for pair wise comparison.

For all the statistical tests, $p<0.05$ was considered to be statistically significant. A significant difference was observed between group I and II with respect to both parameters A & B ($p<0.05$)

Results

The groups tested in the current study exhibited significant color changes. The mean values for each group were calculated and are plotted in Figure 4. Group IA was associated with (0.191667 ± 0.0140119), group IB (0.033667 ± 0.0080208), group IC (0.013000 ± 0.0055678), group IIA (0.100067 ± 0.0090738), group IIB (0.291333 ± 0.0173877), group IIC (0.019 ± 0.0145258). MTA exhibited more discoloration when immersed in Sodium hypochlorite; as compared to Chlorhexidine (p value <0.05). Whereas Biodentine™ exhibited more discoloration when immersed in Chlorhexidine solution (p value <0.05), as compared to Sodium hypochlorite. Distilled water (control group) did not cause clinically perceptible discoloration of any material.

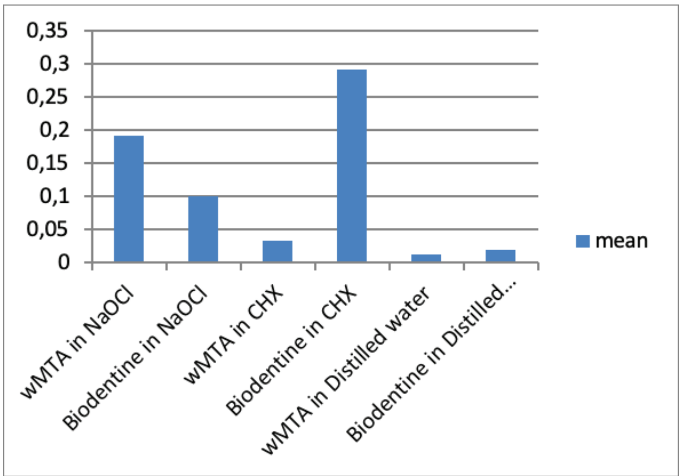

Figure 4. *NaOCL: Sodium hypochlorite, CHX: Chlorhexidine.*

Discussion

This study was performed to provide detailed information regarding the color stability of calcium-silicate-based cements when in contact with common irrigating solutions. Color is one of the most important properties to be observed during dental procedures involving teeth in aesthetic areas. Color changes in dental materials can be measured with specific instruments (14). Visual spectrophotometry is a gold standard method used in dentistry because of the technique's sensitivity to small changes in color, repeatability and objectivity (14).

Calcium-silicate-based cements (CSC), including mineral trioxide aggregate (MTA), are self-setting hydraulic cements (15). The powder of CSC is composed mainly of dicalcium and tricalcium-silicate. After mixing the powder with water, Ca(OH)2 and calcium-silicate hydrate are produced primarily, and the mix forms a sticky colloidal gel (calcium-silicate hydrate gel) that eventually solidifies to a hard structure (16). Calcium-silicate-based cements are used commonly in endodontic procedures involving pulpal regeneration and hard tissue repair, such as pulp capping, pulpotomy, apexogenesis, apexification, perforation repair, and root-end filling (17). The sealing ability and biocompatibility of CSC, in addition to physicochemical interaction with the local environment, are believed to be primary factors contributing to their suitability in the aforementioned clinical situations (18,19).

Mineral trioxide aggregate (MTA) is a biomaterial that has been investigated for endodontic applications since the early 1990s. MTA materials have been demonstrated to be biocompatible endodontic repair materials, with its biocompatible nature strongly suggested by its ability to form hydroxyapatite when exposed to physiologic solutions. MTA possesses biocompatibility, high alkalinity and anti-bacterial properties (20). The initially introduced MTA was grey. Although previous studies have reported frequent discoloration of dentinal tissue with grey MTA (21) Bismuth oxide the radiopacifier present in MTA composition, has been suggested as the chemical compound involved the discoloration verified for this material. To overcome these shortcomings, white MTA was introduced. However, in this study wMTA exhibited significant discoloration with sodium hypochlorite. These results were in accordance with results of previous studies (22,23).

Biodentine™, a new bioactive calcium-silicate-based cement has been introduced in the dental market as a 'dentin substitute' (24). This new biologically active material aids its penetration through opened dentinal tubules to crystallize interlocking with dentin and provide mechanical properties. Biodentine™ has been formulated using MTA-based cement technology and hence; claims improvements of some of the properties such as physical qualities and handling, including its other wide range of applications like endodontic repair and pulp capping in restorative dentistry (25) Biodentine™ contains zirconium oxide as radiopacifier instead of bismuth oxide in MTA. Very few studies have been conducted with respect to material discoloration of Biodentine™.

NaOCl is one of the most commonly used irrigating solutions. NaOCl has a tendency to crystallise and occlude the dentinal tubules; thus, may not be completely removed from the root canals [14]. Chlorhexidine digluconate possesses broad spectrum antimicrobial activity against most endodontic pathogens. As per the results of this current study, chlorhexidine exhibited significant discoloration of Biodentine™. This may be attributed to its property of substantivity, although more research is needed to verify the etiology of discoloration. The results obtained from present study exhibit that CHX and NaOCl cause considerable discoloration. These results are in congruence with previously reported studies (26,27).

Bhavya B et al. (27), attributed the contact of bismuth containing substances to NaOCl for the discoloration in their study. Camilleri J (28) recently reported that contact of wMTA and other bismuth-containing materials with NaOCl produces a change to a darker color because the oxide is converted to bismuth metal in contact with sodium hypochlorite and oxygen is lost. The mechanism of material discoloration with CHX is explored sparsely thus far. However, CHX has been reported to cause extrinsic discoloration of silicate filling materials and dental tissues at various concentrations by influencing dental pellicle or plaque (29). Also, the property of substantivity exhibited by CHX signifies prolonged interaction of CHX with dental materials. In our study specimens were immersed in irrigation solutions for 24 hours to duplicate prolonged contact of these calcium-silicate-based materials and the irrigating solutions.

However, it is important to note significant discoloration of specific combinations of calcium-silicate cement and irrigating solutions. In accordance with the results of our study, wMTA exhibited significant discoloration with NaOCl, whereas maximum discoloration was observed when Biodentine™ was immersed in CHX.

It was proposed by Camilleri et al. (30), that the discoloration induced by calcium-silicate-based materials can be prevented by the application of a double layer of the dentin bonding agent in the access cavity. Koubi et al. (9), reported that it may be prevented by treating with internal bleaching.

However, the calcium silicate cements in this study were immersed in irrigating solutions for 24 hours, which does not mimic the clinical scenario. Also this study emphasizes upon material discoloration over tooth discoloration. Thus owing to the limitations of this study; more studies are recommended that would mimic clinical conditions pertaining to tooth discoloration.

Conclusion

Calcium-silicate-based cements (wMTA & Biodentine™) showed significant material discoloration when in contact with commonly used irritating solutions (NaOCl & CHX). Thus, in aesthetically critical regions, it becomes imperative to wisely choose the combination of irrigant and calcium-silicate-based cement. In the present study, maximum discoloration was observed when Biodentine™ was immersed in CHX. However, wMTA exhibited significant discoloration with NaOCl. Thus, these combinations must be avoided. Further studies are needed to derive the clinical reflections of this finding to suggest optimal material that fulfils both functional an esthetic criteria.

Türtçe Öz: *Sık kullanılan kanal yıkama çözeltilerinin iki kalsiyum silikat esaslı simanın renk stabilitesi üzerindeki etkileri. Amaç: Bu çalışmanın amacı kalsiyum silikat esaslı simanlar (KSS) olan Mineral Trioksit Agregat (MTA) ve Biodentin'in renk stabiliteleri üzerinde %5'lik sodium hipoklorit (NaOCl) ve %2'lik klorheksidin (CHX) kanal yıkama çözeltilerinin etkilerini incelemektir. Gereç ve Yöntem: Üretici firmaların önerilerine uygun olarak MTA Angelus (Angelus, Londrina, PR, Brezilya) Biodentine™ (Septodent, Saint Maur, Fransa) simanlarından toplam 60 (n=30) adet silindirik şekilli numune (10 mm çapında, 2 mm yüksekliğinde) hazırlanmıştır. Numuneler 24 saat boyunca %5'lik sodium hipoklorit (Prime Dental Products Pvt. Ltd., Mumbai, Hindistan), %2 klorheksidin glukonat (Dentochlor, Saronno VA, İtalya) ya da distile suda bekletilmiştir. Renk değişimleri UV Spektrofotometre cihazı (UV-1650, Shimadzu, Avrupa) ile ölçülmüş ve elde edilen bulgular karşılaştırılmıştır. Bulgular: 1. ve 2. gruplar arasında A ve B parametrelerinde istatistisel olarak anlamlı bir fark olduğu gözlenmiştir (p<0.05). Her iki kalsiyum silikat esaslı siman da NaOCl ve CHX çözeltilerinde bekletildiklerinde anlamlı renkleşme göstermişlerdir. Distile su numunelerde klinik olarak fark edilebilir bir renk değişimine sebep olmamıştır. Sonuç: Kalsiyum silikat esaslı simanların tipine göre anlamlı seviyede renk değişimi meydana geldiği izlenmiştir. Biodentine CHX çözeltisi ile belirgin bir renkleşme gösterirken, MTA ise NaOCl çözeltesinde daha fazla renkleşmiştir. Anahtar kelimeler: Kalsiyum silikat; klorheksidin, kanal yıkama çözeltisi; mineral trioksit agregat; sodium hipoklorit*

Ethics Committee Approval: Not required.

Informed Consent: Not required.

Peer-review: Externally peer-reviewed.

Author contributions: TS and KSB designed the study. KSB participated in generating the data for the study. TS participated in gathering the data for the study. KSB participated in the analysis of the data. TS wrote the majority of the original draft of the paper. TS and KSB participated in writing the paper. All authors approved the final version of this paper.

Conflict of Interest: The author had no conflict of interest to declare.

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References

1. Nask KD, Brown J, Hicks ML. Private practicing endodontists: production of endodontic services and implication for workplace policy. J Endod 2002;28:699-705. [CrossRef]
2. Ma J, Shen Y, Stojicic S, Haapasalo M. Biocompatibility of two novel root repair materials. J Endod 2011;37:793-8. [CrossRef]
3. Parirokh M, Torabinejad M. Mineral trioxide aggregate: a comprehensive literature review-part III: clinical applications, drawbacks, and mechanism of action. J Endod 2010;36:400-13. [CrossRef]
4. Sarkar NK, Caicedo R, Ritwik P, Moiseyeva R, Kawashima I. Physicochemical basis of the biologic properties of mineral trioxide aggregate. J Endod 2005;31:97-100. [CrossRef]
5. Tomson PL, Grover LM, Lumley PJ, Sloan AJ, Smith AJ, Cooper PR. Dissolution of bio-active dentine matrix components by mineral trioxide aggregate. J Dent 2007;35:636-542. [CrossRef]
6. Sarkar NK, Caicedo R, Ritwik P, Moiseyeva R, Kawashima I. Physicochemical basis of the biologic properties of mineral trioxide aggregate. J Endod 2005;31:97-100. [CrossRef]
7. Kim JR, Nosrat A, Fouad AF. Interfacial characteristics of BiodentineTM and MTA with dentine in simulated body fluid. J Dent 2015;43(2):241-7. [CrossRef]
8. Abdullah D, Pitt Ford TR, Papaioannou S, Nicholson J, McDonald F. An evaluation of accelerated Portand cement as a restorative material. Biomaterial 2002;23:4001-10. [CrossRef]
9. G. Koubi, P. Colon, J.-C. Franquin et al. Clinical evaluation of the performance and safety of a new dentine substitute, BiodentineTM in the restoration of posterior teeth- a prospective study. Clinical Oral Investigations 2013;17(1):243-9. [CrossRef]
10. Howard W. Roberts, Jeffrey M. Toth, David W. Berzins, David G. Charlton. Mineral trioxide aggregate material used in endodontic treatment: A Review of the literature Dent Mat 2008;24:149-64. [CrossRef]
11. Khorkhar Z, Razzoog M, Yaman P. Color stability of restorative resins. Quintessence Int 1991;22:733-7.
12. 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. [CrossRef]
13. Guttierrez JH, Guzman M. Tooth discoloration in endodontic procedures. Oral Surg Oral Med Oral Pathol 1968;26:706-11. [CrossRef]
14. X. M.B. Kayahan, M.H. Nekoofar, A. McCann et al. Effect of acid etching procedures on the compressive strength of four calcium-silicate-based endodontic cements. Journal of Endodontics 2013;39(12):1646-8. [CrossRef]

15. Darvell BW, Wu RC. "MTA"-an hydraulic silicate cement: review update and setting reaction. Dent Mater 2011;27:407-22. [CrossRef]
16. Camilleri J. The chemical composition of mineral trioxide aggregate. J Conserv Dent 2008;11:141-3. [CrossRef]
17. Parirokh M, Torabinejad M. Mineral trioxide aggregate: a comprehensive literature review-part III: clinical applications, drawbacks, and mechanism of action. J Endod 2010;36:400-13. [CrossRef]
18. Wang X, Chang J, Hu S. A study on the sealing ability and antibacterial activity of Ca3SiO5/CaCl2 composite cement for dental applications. Dent Mater 2012;31:617-22. [CrossRef]
19. Sarkar NK, Caicedo R, Ritwik P, Moiseyeva R, Kawashima I. Physicochemical basis of the biologic properties of mineral trioxide aggregate. J Endod 2005;31:97-100. [CrossRef]
20. Laurent P, Camps J, De Meo M, et al. Induction of specific cell responsesto a Ca(3)SiO(5)- based posterior restorative material. Dent Mater 2008;24:1486-94. [CrossRef]
21. Bortoluzzi EA, Araújo GS, Guerreiro Tanomaru JM, TanomaruFilho M. Marginal gingiva discoloration by gray MTA: a case report. J Endod 2007;33:325-7. [CrossRef]
22. Felman D, Parashos P. Corona tooth discoloration and white mineral trioxide aggregate. J Endod 2013; 39:484. [CrossRef]
23. Ioannidis K, Mistakidis I, Karagiannis V. Spectrophotometric analysis of coronal discoloration induced by grey and white MTA. Int Endod J 2013;46:137-44. [CrossRef]
24. Heyden G. Relation between locally high concentration of chlorhexidine and staining as seen in the clinic.J. Periodontal Res Suppl 1973;8:76-80. [CrossRef]
25. Septodont Biodentine™ Active Biosilicate Technology™ Scientific file 2010.
26. Keskin C, Demiryurek EO, Ozyurek T. Color stabilities of calcium-silicate-based materials in contact with different irrigation solutions. J Endod Mar 2015;41(3):409-11. [CrossRef]
27. Bhavya B, Sadique M, Simon EP, Ravi SV, Lal S. Spectrophotometric analysis of coronal discoloration induced by white mineral trioxide aggregate and BiodentineTM: An in vitro study. J Conserv Dent 2017;20(4):237-40. [CrossRef]
28. Camilleri J. Color stability of white mineral trioxide aggregate in contact with hypochlorite solution. J Endod 2014;40:436-40. [CrossRef]
29. BiodentineTM Active Biosilicate Technology Scientific file, Septodont, Paris, France.
30. J. Camilleri. Investigations of BiodentineTM as a dentine replacement material. Journal of Dentistry 2013;41(7):600-10. [CrossRef]