A Comparison of Coronal Tooth Discoloration Elicited by Various Endodontic Reparative Materials MTA Plus, Bio MTA+, and Biodentine: An Ex Vivo Study

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ABSTRACT

Aim and objectives: To compare coronal tooth discoloration obtained by different endodontic materials—MTA Plus, Bio MTA+, Biodentine. Materials and methods: Pulps in 30 caries-free mandibular and maxillary intact human premolars and molars scheduled for extraction for periodontally compromised reasons were mechanically exposed and allocated to each of the three groups, MTA Plus, Biodentine and Bio MTA+. After the pulpotomy procedure, the base of resin-modified GIC was given and the teeth were filled with composite resin. After extraction, the teeth were stored in artificial saliva and spectrophotometer analysis done eventually at 1, 7, 30, and 60 days later. Images of all teeth were recorded at each interval using a digital camera and the ΔE values for all specimen at interval were recorded and compared. Results: Majority of the specimens showed discoloration after placement of MTA Plus, Biodentine, and Bio MTA+. The statistical analysis showed significant differences between the MTA Plus, Bio MTA+, and Biodentine experimental groups during the observation period. Conclusion: Under the states of this study, compared to Bio MTA+ and MTA Plus, Biodentine created significantly less discoloration. Clinical significance: Mineral trioxide aggregate materials lead to higher amount of discoloration on the tooth surface than Biodentine. Hence, Biodentine should be the material of choice for use in esthetic area to avoid chances of tooth discoloration. Keywords: Bio MTA+, Biodentine, Blood contamination, Pulpotomy, Spectrophotometer, Tooth discoloration.

INTRODUCTION

In dentistry, esthetics play a significant role and any tooth discoloration can have a major effect on individual life quality. The discoloration may be due to materials used in endodontics and hence impair the esthetic outcome of the treated tooth.¹

As a result of caries, trauma, or cavity preparation, dental pulp exposure can occur. As per the European society of Endodontontology, pulpotomy is the procedure of removal of an exposed vital pulp by means of preserving the vitality and function of the remaining part. In endodontics treatments, biomaterials like calcium silicate-based cements produce a durable seal against the migrating microorganisms stimulating tissue healing without any inflammation, according to manufacturer-recommended biomaterials possessing high esthetic properties to salvage the clinically exposed pulp.² However, clinical studies showed even the preferred materials with lightest hue, which discolor after application when the coherence occurs with blood, sodium hypochlorite, or residual irrigating solutions. Ca(OH)₂ is widely recognized as a valuable pulpotomy material though having disadvantages like a poor seal, subject to dissolution over time, and suspecting to incubate multiple canal defects in the dentinal bridge.³ MTA, as following invention was preferred introduces as a grey-colored material showing some discoloration was then upgraded to off-white color.³ This still have some shortcomings like long setting time, extensive technique sensitive, and potential of discoloration. Biodentine contains zirconium oxide as radiopaqueifier is emerged as a commercially available material possessing bioactive and biocompatible properties.⁵ Bio MTA+ smallest size of grain consisting of hydroxyapatite showed to have three times higher durability than traditional MTA. Instrumental measurements done by dental colorimeters and spectrophotometers usually utilize the Commission International de l’Eclairage’s (CIE) L*α*β* system. Among which the spectrophotometer is the most accurate, useful, and flexible to evaluate the tooth discoloration.⁵

So, this study was conducted using a spectrophotometer to check which of the materials among MTA Plus, Biodentine, and Bio MTA+ would give us minimum discoloration at different time intervals while use in the vital pulp therapy procedure.

MATERIALS AND METHODS

The study was performed at the Department of Conservative Dentistry, Endodontics, and Esthetics at Manubhai Patel Dental College and ORI, Vadodara, Gujarat, India. The study was performed at the Department of Conservative Dentistry and Endodontics, Manubhai Patel Dental College and ORI, Vadodara, Gujarat, India, Phone: +91 9909152456, e-mail: dishabastawala7455@yahoo.com

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mandibular premolars and molars. Thirty teeth of both male and female, which were caries-free, intact, endodontically sound, and periodontally involved maxillary and mandibular posterior teeth, were selected. Teeth with caries, fracture, restoration, cracks, and grade III mobile teeth were excluded from the study.

The volunteers fulfilling all above criteria were included in the study. The procedure and its possible risks were explained to the patients. An informed consent was taken in English and local Gujarati language.

Pulpotomy and Restoration
Before the start of the study, all the teeth were subjected to preoperative clinical and radiographic analysis. Vitality tests were done using an electric pulp tester (Parkell). After proper case selection, buccal infiltration was given for maxillary premolars and molars and inferior alveolar nerve block was given for mandibular premolars and molars by 2% lignocaine-containing adrenaline 1:80,000 (Lignox 2% A). For each tooth, rubber dam isolation was done. The teeth were endodontically accessed with sterile round diamond bur (BR 41; MANI, Japan) and ENDO Z bur (FG—25 mm, Dentsply) from central fossa to the tooth pulpal exposure was performed and with straight fissure diamond bur.(SF 41; MANI, Japan) convenience was achieved.

With the help of a sharp spoon excavator, the coronal pulpal tissue was removed below the level of cementoenamel junction (CEJ). The pulp chamber was irrigated with sterile normal saline solution and bleeding from the pulp chamber was arrested with sterile adrenaline solution.

The 3-mm buccal enamel-dentine thickness will be standardized. As per manufacturer’s recommendations, all materials with 3-mm thickness were allowed to set above the orifice level. Material groupings were as follows:

- Group I: MTA Plus (Prevest Denpro, Jammu, India)
- Group II: Bio MTA+ (Cerkamed Company, Poland)
- Group III: Biodentine (Septodont, France)

For groups I, II, and III, one scoop of powder and one small drop of liquid were dispensed on a nonabsorbent pad and desired putty-like consistency was achieved. The material was then delivered to the pulp chamber immediately by the means of the MTA cement carrier. It was condensed with help of an endodontic hand plugger with light pressure and was allowed to set.

Resin-modified glass ionomer (Gold Label Lc Universal Restorative; GC Corporation) with 3-mm thickness was placed over every material and allowed to set. The conventional resin composite restoration (Filtek Z350 XT—3M ESPE) was performed in the entire cavity and cured by a light-curing unit. After assessing the procedure, postoperative radiographs were taken (Fig. 1).

Once the pulpotomy procedure was over, teeth were subjected to extraction by an oral surgeon on same day. Teeth were stored in artificial saliva after extraction (Fig. 2). Later at 1, 7, 30, and 60 subsequent days, the spectrophotometer analysis was done (Fig. 3).

Every tooth images were recorded at each interval by using a digital camera. For all specimen at each interval, the $\Delta E$ value would be calculated (Fig. 4).

Statistical Analysis
With the use of the one-way ANOVA test and the post hoc test, the data were analyzed. Due to abnormalities in both the distribution and variance of the mean data, the present study got mean difference $\Delta E$ by 1.08 with std. deviation of 0.5 at 5% risk, 80% power.

Results
For groups I–III the mean values of the CIE $L^*$, $a^*$, and $b^*$ parameters for all time intervals are shown in Table 1. A significant decrease in the $L^*$ parameter was measured in both MTA Plus and Bio MTA+ experimental groups. Significance difference in the mean $L$ value between all three groups was found for day 1 where $p$ value was 0.022 and for 1 week where $p$ value was 0.031. Under visual perception, the $L^*$ values show a darkening effect in tooth crowns and $a^*$ and $b^*$ values show a reduction in redness and yellowness and increasing tendency toward green and blue, respectively.

A significant decrease in the $A^*$ parameter was measured in both MTA Plus and Bio MTA+ experimental groups compared to the Biodentine group. Significance difference in mean $A$ value between all three groups was found after 1 day, 7 days, 30 days, and 60 days where $p$ value was <0.001.

A significant decrease in the $B^*$ parameter and alterations observed in the MTA Plus group and Bio MTA+ group were significantly greater compared with the Biodentine group. Significance difference in mean $B$ value between all three groups was found after 7, 30, and 60 days where $p$ value was <0.005.

A significance difference in mean $\Delta E$ value between all three groups was found after 7, 30, and 60 days, which is shown in Table 2 and Figure 5. At 30 and 60 days, MTA Plus showed more discoloration compared to Bio MTA+ with insignificant differences.
Both MTA Plus and Bio MTA+ showed significantly higher $\Delta E$ values compared to Biodentine.

**Discussion**

Color is the most important property of observation during dental procedures. Tooth discoloration impairs the esthetic outcome of the tooth. A major etiology of tooth discoloration is the complex reaction between the filling materials and coronal dentine of the pulp chamber, which alters the appearance of the crown. If visionary and color properties of the dentinal structure change, it tends to alter the outward appearance of the crown; factors may be the reflection and transmission of light. We used a spectrophotometer (VITA) to measure color changes because of its enhance data stability and accuracy.7

Pulpotomy involves the complete amputation of the coronal pulp below the level of CEJ, whereas direct pulp capping involves sealing of a small pulpal wound with a biomaterial. In pulpotomy, the area of contact at the cement-dentin interface is more compared to direct pulp capping. Posterior teeth possess relatively larger pulp spaces than anterior teeth; hence, it was decided to perform pulpotomy on posterior teeth to fully evaluate discoloration of the selected biomaterials.

In our study, we selected caries free periodontally compromised posterior teeth to decrease high chance of fracture during extraction in comparison to the orthodontic teeth or impacted third molars.

Research indicates in the pulpotomy procedure that the most pronounced staining from dental materials occurs in the cervical third of the crown;8 hence for our study also selected the cervical third portion for measurement of tooth discoloration.

All calcium silicate-based materials used for pulpotomy procedures show some amount of discoloration. The structure and composition of a material both are major factors determining its potential of discoloration. Metal constituents such as bismuth, iron, aluminium, and magnesium are responsible for the resultant discoloration.9 The porosities present in calcium silicate-based materials entrap blood components and cause discoloration of the material. This has a clinical significance because calcium silicate-based materials are usually in direct contact with the living vascular tissue.

Mineral trioxide aggregate, a biomaterial, is investigated for endodontic application and composed of hydrophilic particles like silicates and oxides. The bismuth oxide present in is MTA highly responsible for tooth discoloration as observed in pulp capping and pulpotomy procedures.10

Recently, researchers have shown other materials having the same biocompatibility as MTA and with more advantages over it. This material is Biodentine, a calcium silicate-based product that was introduced in 2009.11 Biodentine contains zirconium oxide as a replacement for bismuth oxide. Zirconium oxide is a bioinert material with favorable mechanical properties and resistant to corrosion. This was closely observed by Dettwiler et al. in 2016 in an experiment. Biodentine showed potential least discoloration and higher solubility and having the significant quicker setting time than MTA. Biodentine could start to block the blood components in 12 minutes, hence becomes more dense and packed after it sets completely so amount of erythrocytes penetration becomes less, which leads to less amount of tooth discoloration in the pulpotomy procedure.

The Biodentine material shows high impact upon numerous factors like absorption, strength, and density, as it contains more amount of powder with water-reducing agent and less porosity.13 Camilleri et al. in 2013 concluded Biodentine and IRM exhibited the lowest level or degree of porosity and less amount of tooth discoloration.14

Recently, Bio MTA+ is used as a filling material and for remineralization of root canals due to its smallest-size particles that contain hydroxyapatite. It becomes plastic after mixing and gives concrete consistency with advantage of three times higher durability in comparison of traditional MTA.

In the present study, sodium hypochlorite was not used during the procedure as NaOCl reacts with bismuth oxide and other heavy metal oxides and gives black precipitations and pigmentations, which cause tooth discoloration more after the pulpotomy procedure.

In the present study, the specimens were stored in artificial saliva throughout the period of analysis. Storage solutions are mostly used to prevent dehydration of teeth and cross-contamination between...
Table 1: Mean (SD) values of CIE L*, a*, and b* chromatic parameters

|            | Baseline | 1st week | 1st month | 2nd month |
|------------|----------|----------|-----------|-----------|
| **L* parameter** |          |          |           |           |
| Groups     | n        | L0       | L1        | L2        | L3        |
| MTA Plus   | 10       | 84.04    | 82.50     | 79.70     | 78.68     |
| Bio MTA+   | 10       | 78.87    | 77.76     | 75.34     | 74.32     |
| Biodentine | 10       | 75.52    | 74.87     | 74.14     | 73.95     |
| **a* parameter** |          |          |           |           |
| Groups     | n        | AO       | Al        | A2        | A3        |
| MTA Plus   | 10       | 2.42     | 1.81      | 1.31      | 0.84      |
| Bio MTA+   | 10       | 1.97     | 1.61      | 1.05      | 0.13      |
| Biodentine | 10       | 5.76     | 5.47      | 5.38      | 4.98      |
| **b* parameter** |          |          |           |           |
| Groups     | n        | BO       | Bl        | B2        | B3        |
| MTA Plus   | 10       | 23.44    | 22.10     | 21.33     | 20.29     |
| Bio MTA+   | 10       | 23.12    | 21.78     | 20.23     | 19.45     |
| Biodentine | 10       | 26.49    | 25.96     | 25.69     | 25.10     |

Table 2: Mean (SD) ΔΕ values of groups I–III in all experimental periods

|            | 1st week | 1st month | 2nd month |
|------------|----------|-----------|-----------|
| Mean ΔΕ value of groups |          |           |           |
| Groups     | n        | ΔΕ1       | ΔΕ2       | ΔΕ3       |
| MTA Plus   | 10       | 2.519     | 5.087     | 6.544     |
| Bio MTA+   | 10       | 2.127     | 4.815     | 6.264     |
| Biodentine | 10       | 1.219     | 1.887     | 2.435     |

Figs 4A to C: (A1) MTA Plus at baseline; (A2) MTA Plus at 60 days; (B1) Bio MTA at baseline; (B2) Bio MTA+ at 60 days; (C1) Biodentine at baseline; (C2) Biodentine at 60 days
extracted teeth. Dry storage of specimens caused changes in the material microstructure and cracks at the root dentine to the material interface.

Changes in tooth color can be seen visually or with special devices. A spectrophotometer is proven to be most flexible and highly accurate instrument as observed in previous studies and was selected as choice of instrument throughout our study to measure degree of discoloration with different materials at different time intervals.15

Thus, the overall results showed alterations in the MTA Plus group and the Bio MTA + group, which were significantly greater compared with the Biodentine group. The application of MTA Plus in the pulp chamber in the esthetic zone should be avoided while Biodentine should be used with caution. So, further research in the direction may provide a more clear evidence in this regard.

CONCLUSION

In terms of chromatic parameters $L^*$, $a^*$, and $b^*$, a significant reduction was detected for MTA Plus and Bio MTA+ compared to Biodentine at all experimental periods. In terms of $\Delta E$ values, MTA Plus and Bio MTA+ exhibited more color change than Biodentine at all experimental periods. MTA Plus and Bio MTA+ induced visually perceptible crown discolouration after 1 month of the pulpotomy procedure, while Biodentine resulted in no visually perceptible color change. Under the conditions of this study, Biodentine showed significantly less discoloration as compared to MTA Plus and Bio MTA+.

CLINICAL SIGNIFICANCE

Mineral trioxide aggregate materials lead to higher amount of discoloration on the tooth surface than Biodentine. Hence, Biodentine should be the material of choice for best result in the esthetic zone to avoid chances of tooth discoloration.

REFERENCES

1. Louis J, Marconyk JR, Kirkpatrick TC, et al. A comparison of coronal tooth discoloration elicited by various endodontic reparative materials. J Endod 2016;42(3):470–473. DOI: 10.1016/j.joen.2015.10.013.
2. Claus L, European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. Int Endod J 2006;39(12):921–930. DOI: 10.1111/j.1365-2591.2006.01180.x.
3. Cox C, Subay R, Ostro E, et al. Tunnel defects in dentin bridges: their formation following direct pulp capping. Oper Dent 1996;19:541–544.
4. Ioannidis K, Mistakidis I, Beltes P, et al. Spectrophotometric analysis of coronal discoloration induced by grey and white MTA. Int Endod J 2013;46(2):137–144. DOI: 10.1111/j.1365-2591.2012.02098.x.
5. Vallès M, Roig M, Duran-Sindreu F, et al. Color stability of teeth restored with biodentine: a 6-month in vitro study. J Endod 2015;41(7):1157–1160. DOI: 10.1016/j.joen.2015.03.014.
6. Kalantari M, Ghoraishian S, Mohaghegh M. Evaluation of accuracy of shade selection using two spectrophotometer systems: vita easyshade and deugden shadepilot. Eur J Dent 2017;11(02):196–200. DOI: 10.4103/ejd.ejd_195_16.
7. Lehman KM, Igel C, Schmidtmann I, et al. Four color-measuring devices compared with a spectrophotometric reference system. J Dent 2010;38:65–70. DOI: 10.1016/j.jdent.2010.07.006.
8. Namazikhah MS, Nekoofar MH, Sheykhrzewa MS, et al. The effect of pH on surface hardness and microstructure of mineral trioxide aggregate. Int Endod J 2008;41:108–116.
9. Yuran L, Namki C, Jaehwan K, et al. Spectrophotometric analysis of crown discoloration induced by various MTA based materials. J Korean Acad Pediatr Dent 2017;44(1):28–37.
10. Marciano MA, Costa RM, Camilleri J, et al. Assessment of color stability of white mineral trioxide aggregate angelus and bismuth oxide in contact with tooth structure. J Endod 2014;40(8):1235–1240. DOI: 10.1016/j.joen.2014.01.044.
11. Rajasekharan S, Martens LC, Cauwels RG, et al. Biodentine™ material characteristics and clinical applications: a review of the literature. Eur Arch Paediatr Dent 2014;15(3):147–158. DOI: 10.1007/s40368-014-0114-3.
12. Dettwiler CA, Walter M, Zaugg LK, et al. In vitro assessment of the tooth staining potential of endodontic materials in a bovine tooth model. Dent Traumatol 2016;32(6):480–487. DOI: 10.1111/det.12285.
13. Keup M, Schafer E, Dammaschke T. An in vitro study of different material properties of bioceramic compared to ProRoot MTA. Head Face Med 2015;11(1):18. DOI: 10.1186/s13005-015-0074-9.
14. Camilleri J, Sorrentino F, Damidot D. Investigation of the hydration and bioactivity of radiopacified tricalcium silicate cement, bioceramic and MTA angelus. Dent Mater 2013;29(5):580–593. DOI: 10.1016/j.dental.2013.03.007.
15. ALGhazali N, Burnside G, Smith PW, et al. Performance assessment of vita easy shade spectrophotometer on colour measurement of aesthetic dental materials. Eur J Prosthodont Restor Dent 2011;19:168–174.