Comparison of the Potential Discoloration Effect of Bioaggregate, Biodentine, and White Mineral Trioxide Aggregate on Bovine Teeth: *In Vitro* Research

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Abstract

Introduction: Tricalcium silicate cements can be used for pulp capping, pulpotomies, apical barrier formation in teeth with open apices, repair of root perforations, regenerative endodontics, and root canal filling. The aim of this study was to evaluate and compare the discoloration potential of 3 different tricalcium cements using a bovine tooth model. **Methods:** Forty bovine anterior teeth have been used for the study. Crowns separated from the roots were randomly divided into 4 groups: the BioAggregate (IBC, Vancouver, Canada) group, the Biodentine (Septodont, Saint Maur des Fosses, France) group, the mineral trioxide aggregate Angelus (Angelus, Londrina, PR, Brazil) group, and the only blood group. Materials have been placed to the standardized cavities on the lingual surfaces of the crowns, and their contact with blood has been provided. The color values of the samples were measured with a digital tooth shade determinator (VITA Easyshade; VITA Zahnfabrik, Bad Sackingen, Germany) before the placement of the materials, after the placement of the materials, in the 24th hour, in the first week, in the first month, in the third month, and in the first year. The mean value of all groups was compared using the Tukey multiple comparison test ($\alpha = 0.05$). **Results:** All groups displayed increasing discoloration during a period of the first year. The "only blood group" showed the highest color change values, and it was followed as BioAggregate, mineral trioxide aggregate Angelus, and Biodentine, respectively. Statistically significant differences were found for Biodentine when compared with the only blood and BioAggregate groups ($P < .05$). **Conclusions:** Considering the results of the study, Biodentine is found to have the least discoloration potential among the tested materials. *(J Endod 2016;■:1–4)*

Key Words

BioAggregate, Biodentine, discoloration, mineral trioxide aggregate

Significance

This study highlights the potential of discoloration in bioceramics. The existing studies involving BioAggregate and Biodentine are not sufficient enough to determine the potential of discoloration in literature.

Tricalcium silicate cements have been developed to constitute more suitable root-end filling materials and have became an alternative for materials such as intermediate restorative material and amalgam. Today, they can be used for some other indications such as pulp capping, pulpotomies, apical barrier formation in teeth with open apices, repair of root perforations, regenerative endodontics, and root canal filling (1). These significant inherent advantages make them versatile materials that can be used in several treatment options.

The most well-known and used tricalcium silicate cement is mineral trioxide aggregate (MTA). MTA has a very good sealing ability and has better biocompatibility and less cytotoxicity than other similar materials. The first developed MTA was gray, which has the potential to cause tooth discoloration. White MTA (wMTA) was developed in order to overcome this disadvantage. The major difference between wMTA and gray MTA is that wMTA contains fewer metal oxides such as Al_2O_3, MgO, and FeO, which were assumed to be the main causes of discoloration, but even wMTA has been shown to cause tooth discoloration (2).

BioAggregate (IBC, Vancouver, Canada) is a bioceramic root-end filling material that is composed of tricalcium silicate, dicalcium silicate, calcium phosphate monobasic, amorphous silicon dioxide, and tantalum peroxide. The differences between BioAggregate and MTA are that BioAggregate does not contain aluminum but rather contains calcium phosphate monobasic and tantalum peroxide as radiopacifiers instead of bismuth oxide. It has been shown that MTA and BioAggregate have comparable antibacterial effects (3), biocompatibility (4), and sealing ability (5). It has also been stated that BioAggregate induced mineralized tissue formation (6) and differentiation of human periodontal ligament fibroblasts (7–9).

Another calcium silicate–based material is Biodentine (Septodont, Saint Maur des Fosses, France), which contains tricalcium silicate, $CaCO_3$, zirconium oxide, a water-reducing agent, and a water-based liquid containing calcium chloride as the setting accelerator (8, 10). Biodentine has been developed and produced with the aim of

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bringing together the high biocompatibility and bioactivity of calcium silicates, with enhanced properties such as a quick setting time (a function of the calcium chloride added to the Biodentine liquid) and high strength (result of the low water-to-cement ratio made possible by the addition of a water-soluble polymer), which are properties not usually associated with said cements. The manufacturer claims to be able to maintain a balance between the 2 through its water-reducing agent in Biodentine, thus offering a homogeneous, dense product with maximized strength. Biodentine includes zirconium oxide as a radiopacifying material (1, 9).

Felman and Parashos (11) showed that MTA could cause discoloration, and the contact of MTA with blood increases the discoloration potential. It has been stated that many studies have used whole blood in order to stain teeth. Although the mechanism has been explained with the invasion of erythrocytes in dentinal tubules, the exact process of how the co-occurrence between MTA and blood exacerbates this discoloration is currently unknown.

Alternative tricalcium cements have been developed to overcome the disadvantages of MTA. The aim of this research was to evaluate and compare the discoloration potential of 3 different tricalcium cements using a bovine tooth model: MTA Angelus (MTA-A) (Angelus, Londrina, PR, Brazil), BioAggregate, and Biodentine.

Materials and Methods

The study was approved by the Gazi University Faculty of Medicine Ethics Committee. Forty bovine anterior teeth that were stored in tap water after extraction were used. The surfaces of the teeth were cleaned by scalers. After removal of the roots, crowns in $1 \times 1 \times 0.5$ cm sizes were selected in order to achieve standardization. Using a cylindrical-shaped bur with a 3-mm diameter, a cavity with 3-mm height and 3-mm diameter was prepared for each sample from the lingual surface of the crowns. The sizes of enamel dentin crowns were measured with an electronic caliper. After the preparation, the height of the remaining tooth structure between the labial surface of the crowns and the bottom of the cavity was measured as 2 mm for each sample. The samples were left in 1% sodium hypochlorite for 30 minutes, dried with air, and placed in 20% EDTA solution for an extra 2 minutes. This procedure provided the removal of the smear layer. The samples were then stored in tap water.

The samples were randomly divided into 4 groups: the BioAggregate group (IBC, Vancouver, Canada), the Biodentine group (Septodont, Saint Maur des Fosses, France), the MTA-A group (Angelus, Londrina PR, Brazil), and the only blood group. The color values of the samples were measured with a digital tooth shade determination device (VITA Easyshade Compact; VITA Zahnfabrik, Bad Sackingen, Germany) in the same room. After the initial color measurement (T0), 1.5 μL bovine blood was placed on the cavity floor with a pipette (0.5–10 μL). The materials were prepared as indicated by the manufacturer's guidelines/recommendations. BioAggregate for group 1, Biodentine for group 2, and MTA-A for group 3 were set according to the manufacturers' instructions and placed into the bloody cavities by using finger pluggers. Group 4 is the only blood group, and no materials were applied. The cavities were than restored with resin-modified glass ionomer cement. Every sample was placed into a single tube with tap water (Standard Micro Test Tube 3810; Eppendorf AG, Hamburg, Germany). The tubes were stored at room temperature and kept in the dark.

The second color measurement was applied after the placement of the materials (24th hour [T1]). The other measurements were repeated in the first week (T2), the first month (T3), the third month (T4), and the first year (T5). The samples were stored in a dark environment between the measurements. The CIE L*a*b* values were noted for each specimen specifically. L* values describe lightness, which range from black (0) to white (100), whereas a* values represent red (+80a*) to green (−80a*), and b* values represent yellow (+80b*) to blue (−80b*) color variations. The total color differences (ΔE) were calculated according to the following equation: $\Delta E = ([L1 - L0]2 + [a1-a0]2 + [b1-b0]2)½$.

Color change values between T1 and T0, T2 and T1, T3 and T2, T4 and T3, T4 and T0, T5 and T4, and T5 and T0 were calculated. A 2-way analysis of variance was used to assess significant differences between the tested tricalcium silicate–based materials. The mean value of all groups was compared using the Tukey multiple-comparison test ($\alpha = 0.05$).

Results

All groups displayed increasing discoloration during a period of the first year. The color change values between T1 and T0, T2 and T1, T3 and T2, T4 and T3, T4 and T0, T5 and T4, and T5 and T0 are shown in Table 1. At the 24th measurement, BioAggregate was showed the highest color change, and it was followed by MTA-A, Biodentine, and only blood, respectively. However, no significant difference existed between groups ($P > .05$). At the first month measurement, MTA-A was found to have the highest statistically significant color change ($P < .05$). At the third month measurement, the only blood group was shown to have the highest color change, and it was followed by BioAggregate, MTA-A, and Biodentine, respectively. Biodentine and MTA-A were found to have statistical differences between the only blood and BioAggregate groups ($P < .05$). At the first year measurements, the only blood group showed the highest color change values, and it was followed by BioAggregate, MTA-A, and Biodentine, respectively (Fig. 1*A–D*). Biodentine was found to have statistical differences between the only blood and BioAggregate groups ($P < .05$).

Discussion

The aim of this study was to evaluate the discoloration potential of 3 tricalcium silicate–based materials using a bovine tooth model in line with the research by Lenherr et al (12).

For color determination, the Vita Easyshade color measurement device was used in this research. The Vita Easyshade color measurement device is one of the most accurate and reliable spectrophotometers and has excellent repeatability. In light of similar studies to simulate the oral environment and to avoid the effect of sunlight in terms of

TABLE 1. Mean and Standard Deviations of Discoloration Potential in the Material according to Measured Time Interval

Material	T1–T0	T2–T1	T3–T2	T4–T3	T4–T0	T5–T4	T5–T0
BioAggregate	20.52 ± 7.55	7.12 ± 4.65	6.23 ± 3.31[a]	4.92 ± 2.40[a,b]	12.03 ± 3.24[a,b]	6.62 ± 3.55	12.4 ± 3.91[b,c]
Biodentine	16.01 ± 7.76	7.11 ± 4.80	4.95 ± 2.78[a]	3.43 ± 1.75[a]	9.17 ± 4.57[a]	3.44 ± 2.71	7.65 ± 3.06[a]
wMTA	18.17 ± 2.83	8.01 ± 5.21	11.86 ± 5.93[b]	6.08 ± 3.81[a,b]	10.72 ± 3.15[a]	3.14 ± 2.16	10.74 ± 3.8[a,b]
Only blood	15.75 ± 5.84	8.70 ± 4.62	4.67 ± 3.59[a]	8.39 ± 5.19[b]	16.61 ± 3.64[b]	6.4 ± 5.25	16.71 ± 4.61[c]

wMTA, white mineral trioxide aggregate.

The mean difference is significant at the 0.05 level.