Coronal Tooth Discoloration and White Mineral Trioxide Aggregate

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Abstract

Introduction: This study assessed and characterized discoloration when white MTA (wMTA) was placed in the coronal aspect of the root canal *ex vivo* and the influence of red blood cells on this discoloration. **Methods:** Canals were prepared from the apical aspect and restored with either wMTA + saline (n = 18), wMTA + blood (n = 18), or controls (n = 4 + 4) (blood or saline alone). Color was assessed according to the CIE L*a*b* color space using standardized digital photographs at 3 time points: baseline, day 1, and day 35. Statistical analysis was performed by using 1-way analysis of variance and a 2-sample t test with $P < .05$. **Results:** All teeth discolored when restored with wMTA, which was most prominent in the cervical third of the crown. The presence of blood within the canal adjacent to the setting wMTA exacerbated the discoloration (P = .03). **Conclusions:** wMTA induces the gray discoloration of the tooth crown, and the effect is compounded in the presence of blood. *(J Endod 2013;39:484–487)*

Key Words

Discoloration, mineral trioxide aggregate, vital pulp therapy, white mineral trioxide aggregate

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The initial formulation of mineral trioxide aggregate (MTA) was a gray powder and was associated with coronal tooth discoloration (1, 2). Other studies have also reported discoloration after the placement of MTA but have not specified the type (3, 4). Because of the coronal discoloration caused by gray MTA, white MTA (wMTA) was developed and has been commercially available since 2002 (5). This formulation was thought to be more suitable for use as a pulp capping material in the esthetic region (6, 7) although slight discoloration may still result, necessitating a veneer or crown (7).

Discoloration associated with wMTA was initially reported in *in vitro* and *ex vivo* studies, with the discoloration affecting the material both on its surface and internally (8, 9). Subsequent case reports have also described coronal tooth discoloration associated with wMTA (10, 11) although the discoloration is reversible with a simple walking bleach technique (11).

To date, there are no studies that account for or quantify the discoloration of wMTA. Although the material itself may cause discoloration, another possible mechanism is an interaction between the red blood cells within the adjacent vital pulp and the setting wMTA. Red blood cells are a known tooth staining agent (12, 13). The aim of this study was to assess and quantify coronal tooth discoloration by wMTA.

Materials and Methods

Tooth Preparation

Forty-four single-rooted, unrestored premolar and incisor teeth extracted predominantly for orthodontic reasons were selected. The teeth were stored in chloramine T neutral (1%) followed by storage in buffered calcium phosphate solution until they were used in accordance with ethics approval guidelines (Ethics ID: 1035181, Human Research Ethics Committee, The University of Melbourne, Melbourne, Victoria, Australia).

Extrinsic stain and calculus were removed with an ultrasonic scaler followed by polishing with pumice and water. The root tips were resected (2–3 mm) to expose the root canals and canal preparation standardized as follows. Canals were measured and enlarged from the apical aspect to the most coronal aspect of the pulp chamber to allow standardization of the thickness and volume of MTA and provide a closed system without the potential complication of coronal microleakage. Canal enlargement was initially performed with stainless steel K-files (VDW, Munich, Germany) followed by Gates-Glidden drills (#2–5). Finally, ParaPost drills (Coltène/Whaledent, Altstätten, Switzerland) were used in sequence to produce a canal size equivalent to a ParaPost size 7 drill (Green, 1.75-mm diameter). Root canals were irrigated with sodium hypochlorite (6 mL, 4%; DentaLife, Croydon, Australia) to remove any pulp tissue remaining in pulp horns and not removed with the largest ParaPost drill followed by EDTA (4 mL, 15%, DentaLife) for 2 minutes to remove the smear layer and to expose the dentinal tubules. Canals were irrigated with a final rinse of sodium hypochlorite (1 mL, 4%).

Blood Collection

Whole blood (12 mL) was collected from a volunteer by venipuncture by a specialist medical hematologist. The blood collection tubes (3 × 4 mL) were sterile and spray coated with the anticoagulant K_2EDTA to prevent clotting in order to facilitate the experiment. Hematologic testing (CELL-DYN Ruby; Abbott Laboratories, Abbott Park, IL) included a baseline hematocrit (percentage volume of erythrocytes).

TABLE 1. Teeth and Materials in Experimental and Control Groups

Experimental groups	Control groups
wMTA + saline (wMTA and saline moistened sterile cotton pellets; n = 18)	Negative control (Saline moistened cotton pellets; n = 4)
wMTA + blood (wMTA and blood moistened sterile cotton pellets; n = 18)	Positive control (Blood moistened cotton pellets; n = 4)

To maximize the erythrocyte-mediated tooth discoloration in the experiment, the hematocrit was increased from ~45% to ~70% by volume. This involved fractionation via centrifugation (3000 rpm for 2 minutes), blood plasma removal, reconstitution, and reassessment. This cycle was repeated until a hematocrit level of 70% was achieved. The vials were then sealed and refrigerated (4°C) until they were used.

Experimental Setup

Teeth were randomized into experimental or control groups (Table 1) using a random number generator (14). wMTA (ProRoot MTA; Dentsply Tulsa Dental, TN) was mixed according to the manufacturer's directions and packed via the apical aspect to the most coronal aspect of the standardized preparation to a thickness of 3 mm with an endodontic plugger (size 9/11; Hu-Friedy, Chicago, IL). Indirect ultrasonic compaction (10 seconds) minimized voids within the material and ensured uniformity between the samples.

Sterile cotton pellets (size 4; Richmond Dental, Charlotte, NC) were loosely placed within the prepared canals from the apical access. A pipette was used to transfer the blood or saline to saturate the cotton pellets. The apical openings were sealed with sticky wax (Dentsply Tulsa Dental, Johnson City, TN). Control teeth were identically prepared but without the placement of wMTA (Table 1). All samples were stored at 100% humidity in an incubator at 37°C for 35 days (ie, from T1 to T35) with 0.5 mL phosphate-buffered saline seeded in each specimen tube to act as the humidifying agent.

Tooth Shade Assessment

The CIE L*a*b* color space was used for tooth shade assessment (15). The nonlinear relations for L*, a*, and b* are designed to approximate the perceptual response of the human eye. Of particular interest in this study was the L* component that closely matches the human perception of lightness (ie, value) ranging from L* = 0 (black) to L* = 100 (white). A decrease in the L* value denotes increased grayness and therefore tooth discoloration. In addition, a* values represent color gradients spanning green to red, and b* values represent blue to yellow.

Color measurements were recorded at 3 time points: (1) T0: baseline (after tooth preparation but before the placement of materials), (2) T1: 1 day after material placement, and (3) T35: 35 days upon retrieval. Color measurement points (51 × 51 pixels) were identified and recorded in the cervical, middle, and incisal thirds. Images T0, T1, and T35 were overlaid within Adobe Photoshop CS4 (Adobe, San Jose, CA) to ensure that all color measurement positions were coincident between the samples.

Digital photographic images were recorded under standardized lighting and desiccation conditions. Images were captured using a high-resolution digital camera (Canon EOS 450D, 12.2 MP; Canon Inc, Tokyo, Japan) in RAW file format with a 100-mm macrolens (Canon EF 100-mm F2.8 macro USM) under standardized conditions (exposure: 1/200 seconds, aperture: f/22; white balance flash: 5500 Ko) (16). Casmatch (Bear Medic Corp, Tokyo, Japan) shade reference cards were included in each image to provide a reference for shade control during analysis. Images were imported into Adobe Photoshop CS4 for shade analysis within the CIE L*a*b* color space.

For reproducible positioning of each tooth within the photographic setup, composite resin was bonded onto each root (away from the crown) such that the tooth crown was parallel to the glass platform on which it was being photographed. All tooth samples were numerically coded before randomization with no additional identifying data present, and the researcher was blinded to the specific treatment history of any given sample.

Statistical Analysis

Minitab statistical software (Minitab Inc, State College, PA) was used for the analysis with the level of significance set at $P < .05$. Two separate datasets were used to statistically analyze the relationships between the 4 study groups for the time points T0–T1, T0–T35, and T1–T35: (1) pooled (ie, cervical, middle, and incisal) and (2) cervical.

Calculated from these datasets were !L*, !a*, !b*, !E, !Chroma, and !Hue values (15) for each of the 3 time intervals. One-way analysis of variance using the Fisher method for individual comparisons and 2-sample *t* tests were applied to analyze the data. The Pearson correlation coefficient (*r*) was used to assess the correlation between baseline L* values and !L* for both datasets over each of the previously described time periods.

Results

The results relating to the gray discoloration (L*) data are summarized in Table 2. The percentage discoloration in the cervical region on days 1 and 35 is shown in Figure 1.

Control Groups

The most significant discoloration was observed in positive control teeth, most intensely in the cervical third of the crown. One day after blood placement within the canal, the cervical region showed a diffuse pink-red background stain with a* values (red) increasing some

TABLE 2. Grayness Expressed as Mean ± Standard Deviation Values for Baseline (T_0 L*) and Changes over the Time Periods T0–T1 and T1–T35 (ΔL*)

	Region	L* T0	ΔL* T0–T1	ΔL* T1–T35	ΔL* Total	% L* ΔTotal	
wMTA + saline	Cervical	80.83 ± 3.17	−1.83 ± 2.48	−1.78 ± 1.96	−3.61 ± 2.66	−4.47 ± 3.29	*
	Pooled	80.31 ± 3.51	−1.41 ± 2.11	−0.81 ± 2.09	−2.22 ± 2.62	−2.77 ± 3.26	A
wMTA + blood	Cervical	80.50 ± 3.97	−0.89 ± 1.81	−4.50 ± 2.38	−5.39 ± 2.33	−6.69 ± 2.89	¥
	Pooled	80.00 ± 4.06	−0.74 ± 1.92	−2.06 ± 2.78	−2.80 ± 2.82	−3.50 ± 3.53	A
Positive control	Cervical	77.75 ± 4.35	−12.50 ± 3.11	−11.50 ± 7.59	−24.00 ± 5.35	−30.87 ± 6.89	#
	Pooled	79.25 ± 4.41	−10.08 ± 3.58	−6.58 ± 7.06	−16.67 ± 6.77	−21.03 ± 8.55	B
Negative control	Cervical	80.50 ± 2.89	1.50 ± 1.29	1.25 ± 2.06	2.75 ± 1.71	3.42 ± 2.12	‡
	Pooled	79.83 ± 3.30	−0.33 ± 2.64	1.67 ± 2.39	1.33 ± 1.72	1.67 ± 2.16	C

The overall change in grayness values for each group and location is expressed as a percentage (% L* ΔTotal). Groups that do not share identical letters are significantly different ($P < .05$). Groups that do not share identical symbols are significantly different ($P < .05$).