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Metameric effect between dental porcelain and porcelain repairing resin composite

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ABSTRACT

Objectives. The objectives were to evaluate the metameric color and hue angle (°) changes between dental porcelain and porcelain repairing resin composites.

Methods. Color of three shades (A2, A3, A3.5) of one brand of dental porcelain and three original shades (A2, A3, A3.5) and three combinations (A2–A3, A3–3.5, A2–A3.5) of three brands of porcelain repairing resin composites (ABT, FSP, TCR) were measured relative to the three standard illuminants (D65, A and F2). Specimen was 2 mm in thickness, and 1 mm of each shade was layered to make combined shades. Color differences (ΔE^*_{ab}) between each shade of dental porcelain and repairing resin composites relative to the three illuminants were calculated, and the ratios of color difference (modified metamerism index) by the change of illuminant were calculated. The ratios of hue angle changes were also compared.

Results. Differences in modified metamerism index and the ratio of hue angle changes were influenced by the porcelain shade, brand of resin composites and shade of resin composites. In all three brands of resin composites, A3.5 shade showed the smallest values in modified metamerism index regardless of the shade of porcelain. The average ratio of hue angle changes between each porcelain shade and all the shades of each resin composites showed similar trend when illuminant was changed from D65 to F2.

Significance. Metameric effect between dental porcelain and repairing resin composites varied depending on the shade of porcelain, brand of resin composite and the illuminant. Therefore, shade matching between porcelain and repairing resin composite should be performed carefully. This study confirmed that shades should be matched under the light corresponding to that of use.

1. Introduction

The appearance of an object is dependent on the nature of the light under which the object is viewed because the spectral distribution of the light reflected from or transmitted through an object is dependent on the spectral distribution of the incident light. Daylight (D65), incandescent lamp (A), and fluorescent lamp (F2) are common sources of light in dental operatory or laboratory, and each of these has a specific spectral distribution. Therefore, color match between restorative materials and teeth or between different restorative materials may also vary depending on the light source. This phenomenon that objects appear to be color matched under one illumination but different under another illumination is metamerism [1–3].

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Spectral reflectance curve shows the fraction of light reflected by an object at each wavelength [4], and the situation in which the spectral reflectance curve of an object can be duplicated in other object is rare. Changes in light source, observer and other conditions destroy the color match for two objects with different spectral reflectance curves [5].

A measure of color difference between two metameric pairs caused by substituting a test illuminant of different spectral power distribution for a reference illuminant is a 'spectral metamerism index (change in illuminant)'. It is recommended that for two specimens whose corresponding tristimulus values are identical with respect to a standard illuminant (D65 is recommended), the metameric index (M_t) is set equal to the index of color difference (ΔE^*_{ab}) between two specimens computed for the test illuminant t [6]. If two specimens whose metamerism index is to be evaluated fail to be a match with respect to a reference illuminant, a suitable account should be taken of the failure [6].

In esthetic dentistry, adequate shade selection is one of the most challenging procedures. Color coordinates vary significantly by the brand of resin composites even though the shade designations are the same [7–9]. Spectrophotometric study with dental porcelain shows that corresponding shades of different brands of porcelain can produce perceivably different colors [10]. Color matching problems can be reduced by realizing the role of metamerism and minimizing it [5]. When resin composites are used for repairing fractured porcelain restorations, not only quality of bonding system but also natural color matching to the surrounding intact porcelain should be considered [11–13]. Although it has been generally recognized that metamerism can influence the color match of esthetic restorations, there have been few studies on this subject.

The null hypothesis in this study was that there was no significant difference in metameric color changes depending on the shade of dental porcelain, the brand of repairing resin composites and the illuminant. The objective of this study was to evaluate the difference in the changes of metameric color and hue angle (°) between a dental porcelain and porcelain repairing resin composites under three standard illuminants (D65, A and F2).

2. Materials and methods

2.1. *Porcelain specimen preparation*

Three body or dentin shades (A2, A3, A3.5) of one brand of dental porcelain (P; IPS d.SIGN, Ivoclar Vivadent AG, Schaan, Liechtenstein) were used. Powder is composed of 50–65 wt.% SiO_2, and small amount of Al_2O_3, K_2O, Na_2O, CaO, P_2O_5, F, Li_2O, ZrO_2 and pigments. Liquid (IPS d.SIGN Build-Up Liquid *Medium*; Ivoclar Vivadent AG) is composed of water, butylenes glycol and additives.

Barrel of a plastic syringe (15-mm in diameter, Medi-Hut International, Korea) cut perpendicular to the long axis, as well as a plunger, was used as a mold. The barrel was made of polypropylene and the tip of the plunger (gasket) was made of rubber. The powder slurries were mixed at room temperature on a glass slab and loaded into the plastic syringe. The syringe was vibrated with a serrated spatula, and excess water brought to the surface of the specimen during condensation was blotted away using an absorbent tissue. The plunger of the syringe was then pushed to a predetermined line on the syringe barrel, marked at a distance of 3 mm away from the top of the barrel. The specimen surface was leveled using a razor blade to provide a uniform thickness before removal from the syringe. The condensed specimen was placed on a honeycomb firing tray, dried, and fired in a vacuum furnace (Austromat 3001, Dekema Dental-Keramiköfen GmbH, Freilassing, Germany) [14]. Firing parameters were as follows: low temperature of 403 °C, heat rate of climb of 60 °C, and top temperature of 870 °C were used. Hold time at top temperature was 1 min, and vacuum was started at 450 °C and ended at 869 °C. Five specimens were made for each shade of porcelain.

2.2. *Resin composite specimen preparation*

Three porcelain repairing resin composites were selected (Table 1). Resin composite was packed into a polytetrafluoroethylene mold of 12.5 mm in diameter and 2 mm in thickness on an acetate matrix strip. After packing the composite, resin filled mold was covered by an acetate matrix strip and pressed between two glass plates. Specimens were light cured at five different sites of both sides each for 20 s with a light curing unit (Spectrum 800, Dentsply/Caulk, Milford, DE, USA) with an intensity setting of 500 mW/cm^2. Output of the curing light was checked with a curing radiometer. Five specimens were made for each brand/shade combination. For ABT and TCR, shades were A2, A3, A3.5, A2–A3, A3–A3.5, and A2–A3.5. For FSP, shades were A2B, A3B, A3.5B, A2E–A2B, A3E–A3B, and A3E–A3.5B. A2–A3 means specimen layered with A2 (enamel portion) of 1-mm thick and A3 (dentin portion) of 1-mm thick, and other combinations indicate the layering with the same method.

2.3. *Polishing procedure*

One side of porcelain and resin composite specimens was polished with wet 600-, 1000-, and 1500-grit silicon carbide papers fixed to a rotating wheel. For layered resin specimens, enamel side was polished. Thickness of polished specimens was within the range of 1.8 ± 0.05 mm both in porcelain and resin composites.

2.4. *Color measurement*

Spectral reflectance and color coordinates were measured according to the CIELAB color scale relative to the standard illuminants D65, A and F2 on a reflection spectrophotometer (CM-3500d, Minolta, Osaka, Japan). Polished surface of specimens was measured under the condition that external light was blocked in a zero calibration cylinder (CIE L^* = 0.09, a^* = 0.01 and b^* = 0.01, average reflectance = 0.01%, Zero Calibration Box, CM-A124, Minolta). This configuration eliminated the influence of variations at the background [15]. UV component of illumination was included, and the specular component of reflection was excluded (SCE mode). The aperture size was 8 mm in diameter, and illuminating and viewing configuration was CIE diffuse/10° geometry.