Indian Journal of Dental Sciences.
June 2011 Issue:2, Vol.:3

www.ijds.in

Original Article

Indian Journal
of Dental Sciences

E ISSN NO. 2231-2293
P ISSN NO. 0976-4003

Difference Between Shade Guides And Fired Porcelain- A Comparative Study

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Date of Submission : 23/01/2011

Date of Acceptance : 18/02/2011

Abstract
There has always been a felt difference in the ready made shade guides available and the porcelain fired for metal ceramic crowns after selecting the shade from the guide. Most brands of porcelain are labeled to match shades of the Vita shade guide, but produce slightly different colors from this guide upon firing. The objective of this study was to quantify in CIE AE* units the color differences between the Vita shade guide colors and two commercial porcelains for metal ceramic crowns. Two operators prepared shade-guide teeth from four shades of two brands of porcelain. Opaque, body, and incisal layers were applied and fired in the form of shade-guide teeth on Vita ceramic carriers used for making custom shade-guide teeth. The colors of these teeth were measured with a Beckman spectrophotometer with an integrating sphere. The average AE* values for the differences between the colors of the Vita shade guide and the fired porcelains for each of the brands were 2.9, and 2.0 respectively, for the first operator and 2.6 and 2.8 respectively, for the second operator. The color difference between the custom shade-guide teeth and the Vita master shade guide were significantly affected by both brands and shades. The overall average error resulting from the differences in colors between the Vita shade guide and fired porcelains was 2.4 for the first operator and 2.7 for the second operator. The mean AE*between the teeth prepared by the two operators was 3.6. The color difference between the teeth made by the two operators was not ignificantly affected by brands or shades.

Key Words
Porcelain, Shade Guide, Chroma

Introduction

Visual shade matching is the most used method of selecting shade for crowns from the shade guides available in the market. Many of the studies in the past have shown errors associated with the use of commercial shade guides [1,2]. Problems identified that porcelains do not match the shade guides to which they are compared and shade variations exist between different lots of porcelain from the same manufacturer. Hence it was suggested that a custom shade guide could minimize these problems. The following ifficulties were reported with the fabrication of custom shade guide (1) the problem of matching a thin piece of porcelain to a shade guide several millimeters thick, (2) the variations of porcelain powder batches that do not match the shade guide consistently, and (3) the difficulty of predicting the final color of the typical layered veneer of opaque, dentin, and enamel.[2]

Studies have shown the use of different techniques [2-10] to obtain customized guides of various shapes and sizes the importance of the geometric design of a tab for color matching, that is. a flat shade tab and a rounded tab made of the same formula will not match [11]. Hence, a study was designed to compare the color of a custom shade guide to a Vita master shade guide. To quantify color difference, the CIE LAB color system(1976), is frequently used. This color system has three parameters, L*, a*, and b*, to define color. The L* coordinate - measure of the lightness-darkness of the sample. The greater the L, the lighter the sample. The a* coordinate - measure of the chroma along the red-green axis. A positive a* relates to the amount of redness and a negative a* relates to the amount of greenness of the sample. The b* coordinate - measure of the chroma along the yellow blue axis, that is, a positive b* relates to the amount of yellowness and a negative b* relates to the amount of blueness of the sample.

The magnitude of the total color difference is frequently represented by a single number, E*. Because the CIE LAB system is based on rectangular coordinates, the equation for calculating total color difference, E*. is $E^* = \sqrt{(L^*)^2 + (a^*)^2 + (b^*)^2}$ (1) where L*. a*, and b* are the differences in the CIE color-space parameters of the two colors.

Because a single number only tells the size of the total difference rather than the direction or nature of the difference from the standard, valuable information can be obtained by dividing a calculated color difference, E*,-into its components and examining them separately. It is convenient to separate E* into components correlating with hue, value, and chroma. The difference for each of these components can be calculated using equations (2) through (4).

The CIE value difference, L* is calculated using the following equation; = $L^*_2 - L^*_1$ (2)
The CIE chroma difference, C*, is calculated using $C^* = \sqrt{a_2^{*2} + b_2^{*2}} - \sqrt{a_1^{*2} + b_1^{*2}}$ (3)
And the CIE hue difference, H*, is calculated using $H^* = \sqrt{(E^*)^2 - (L^*)^2 - (C^*)^2}$. (4)

The purpose of this study was to determine the color difference between a Vita master shade guide and the custom shade-guide teeth prepared by two operators using commercial porcelains for metal ceramic crowns. A technique for preparation of an individualized shade guide (Vita VMK-lndividual-skala Kit, Vident. Baldwin Park. Calif] was used to duplicate the shape of the Vita master shade-guide teeth.

Materials and Methods

The colors of a Vita master shade guide, supplied by Vident, were measured using a dual-beam spectrophotometer {Model ACTA CIII, Beckman Instruments, Fullerton, Calif) and reported by O'Brien.12 Two operators each prepared a set of 8 custom shade-guide teeth. using the same lots of porcelain. Two commercial brands of porcelain, Ceramco III {Dentsply, Germany), and Vita Zahnfabrik VMK 95 in four Vita shades (A1,A2, A3, B2) were chosen for evaluation. A Vita ceramic carrier was used as the foundation for each custom shade-guide tooth. This carrier is designed to simulate a metal casting and therefore has the same color as oxidized metal. For each tooth, the opaque and body porcelains of the designated shade were used along with the incisal porcelain recommended for that shade. The opaque porcelain was applied onto a ceramic carrier and
fired according to the respective manufacturer's instructions for the porcelains used in this study.

Body and incisal porcelains were mixed with distilled water to a creamy consistency. The ceramic carrier was then placed in the modeling mold supplied with the Individual-skala Kit, and the body porcelain was applied over the opaque layer to achieve a sample shape that duplicated the Vita shade-guide tooth.

After the carrier was removed from the mold, the body porcelain was beveled as described in the instructions for the preparation of a custom shade guide. The incisal porcelain was spread over the body porcelain to duplicate the construction of the Vita master shade-guide teeth. The unit was fired according to each manufacturer's instructions for the porcelains used in this study. Each tooth was adjusted and contoured to match the size, shape, and surface texture of the Vita master shade guide and then fired according to each manufacturer's instructions for natural glazing.

To provide a consistent background, the lingual surfaces of the shade guide teeth were coated with barium sulfate with a reflectance of approximately 90% prior to measurement. [12,13]The colors of the custom shade-guide teeth were measured using a dual-beam spectrophotometer (Beckman Instruments) equipped with an integrating sphere attachment (No. 198848, Model ASPHU, Beckman Instruments) and a beam-reducing accessory (No. 199056, Model ASPH-BR, Beckman Instruments). The precision of the method described here for measuring translucent shade guide teeth with the Beckman spectrophotometer was determined to be 0.50 E* units.[14] All samples measured had the same length and width, and the measurements were made vertically along a 1 mm wide area in the middle third of the tooth. This provided an average color for the tooth that minimized the influence of variations in thickness of each tooth along its length. Each sample was measured twice. Relative reflectance data were recorded in the range of 400 nm to 700 nm at intervals of 20 nm. Relative reflectance measurements were converted to absolute reflectance. The CIE LAB coordinates were determined for both measurements of each sample using a computer program (Macbeth 1500/Plus, IBM version 4.2,
Macbeth, Newburgh, NY}. Color differences(E*) between both measurements of the custom shade-guide teeth and the Vita master shade guide[12] were calculated using equation (1). A two-way analysis of variance (ANOVA) was performed to examine the effects of brand and shade on the E*. Associated with this ANOVA, a Tukey's Studentized Range (hsd) Test was performed to determine whether significant differences existed at the 95% confidence level. Similar tests were performed for L*, C*, and H*. Color differences were also calculated between the means of the tooth colors prepared by the two operators. These differences were grouped by brand or shade prior to statistical analysis.

Results

For the first operator, the average ÄE* values for the differences between the colors of the Vita master shade guide and the fired porcelains for each of the brands were 2.9 and 2.0, respectively. The overall average error due to the differences in colors between the Vita shade guide and fired porcelains was 2.4. For the second operator, the average E* value for each of the brands was 2.6 and 2.8 respectively. The overall error for the second operator was 2.7. The color difference between the Vita master shade guide and the custom shade-guide teeth was significantly affected ($P < .0001$) by both the brand and the shade for guides prepared by both

operators. The significance of the interaction indicates that some shades produced better matches with some brands than did other shades. Of the brands tested in this study, Ceramco III showed the lowest ÄE* for the custom shade-guide teeth prepared by both operators compared to the Vita master shade guide. The ÄL*, ÄC*, and ÄH* between the Vita master shade guide and the custom shade-guide teeth were significantly affected ($P< .0001$) by both the brand and the shade for guides prepared by both operators. Ceramco III consistently showed the smallest changes for value, chroma and hue. The overall mean ÄE* between the two operators was 3.6. The color difference between the teeth made by the two operators was not significantly affected {$P >.05$) by brands or shades. The value, chroma, and hue differences were not significantly affected {$P > .05$) by shade. Only ÄH* was significantly affected ($P < .0155$) by brand.

Discussion

This study compares the color difference of fired porcelains to a Vita master shade guide. Pigment formulation is one of the chief reasons for the color difference between the Vita shade-guide standards and the custom shade-guide teeth . Although the high fusing porcelain used for the shade guides is a different composition from the metal ceramic porcelains, both derive their color from highly colored pigment additions. Previous attempts to analyze these porcelains for pigment composition have not been successful because of the minute quantities present.

For this study, it was decided to use tooth shaped samples because flat samples do not reflect light in the same way that curved samples do.[11] The problem with using curved samples is of producing uniform specimens. However, this situation is similar to that encountered in the dental laboratory when porcelain restorations are prepared.

The proposed acceptance limit for dental shade guides is equal to a ÄE* of 2 units.[15] Therefore, the overall ÄE* of both of the custom shade guides when compared to the Vita master shade guide would exceed these limits. The color difference between the two

custom shade guides is greater than the color difference between either of them and the Vita master shade guide. Other factors include technique sensitivity, porcelain furnaces used, differences in surface texture, and porcelain thickness. Thinner samples would appear lighter as a result of the opaque porcelain showing through the translucent body and incisal porcelains. The chroma obtained by the first operator tended to be higher than that produced by the second operator. However, the chroma (C*) was not significantly affected by the thickness.

Conclusions

When the color of custom shade-guide teeth prepared by two operators from four shades of two brands of porcelain were compared to the color of a Vita master shade guide, three conclusions were made:

1. The mean color difference (2.4 and 2.7 for each of the two operators) exceeded the proposed acceptance limit for dental shade guides.
2. Of the brands tested in this study, Ceramco3 showed the lowest ÄE* (2.0 and 1.6 for each of the two operators).
3. The mean ÄE* between the teeth prepared by the two operators was 3.6 and illustrates the effect of operator variability when custom shade-guide samples are prepared.

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