

## Spectrophotometric analysis of shade duplication of various recent ceramic system used for porcelain fused to a metal crown: An invitro study

Das DK<sup>1</sup>, Dong CX<sup>2</sup>, Singh SK<sup>3</sup>, Roy J<sup>4</sup>

<sup>1</sup>Resident, Dalian Medical University, China, <sup>2</sup>Professor, Dalian Stomatological Hospital, China, <sup>3</sup>Associate Professor, <sup>4</sup>Dental Surgeon, UCMS, Bhairahwa, Nepal.

### Abstract

**Objective:** To evaluate and compare the colour difference of the total colour replication process and the direction of the individual color parameters for dental porcelain of three brands.

**Materials and methods:** The fabricated shades (A2) of 3 different porcelain companies were determined visually and instrumentally using Vita Lumin Shade Tab (A2) and Spectrophotometer. Corresponding porcelain disks were made of approximately 0.8 mm metal, 0.2mm opaque, 0.8 mm dentin, 0.5mm enamel and glaze were fabricated with each of the three porcelain brands (Vita VMK 95, Ceramco 3, Ceramax). The colour of the fabricated disks and master disks were measured with a spectroradiometer with a 45°/0° using {C.I.E 1931(xyz)} parameter. Analysis of variance (ANOVA) was applied to evaluate within group differences among the porcelain groups for total colour difference (D.E) and direction of colour parameters (D.L, D.RG, D.YB).

**Result:** The largest mean (D.E) was recorded for Ceramax and least for Vita VMK 95. A significant difference (P= 0.015) was found in yellow and blue axis (D.YB). Data collected further showed no significant difference between shade selection methods and the evaluated clinical criteria. The amount of change within each colour parameters was dependent on the porcelain system, as well as the amount of change among colour parameters.

**Conclusion:** Samples made with different brands of porcelains have noticeably different shade despite having the same Vita Lumin Shade Guide. Different brands of porcelain differ from each other more in redness and yellowness. Different brands of porcelain differ from each other more in lighter than darker shades.

**Key words:** Spectrophotometer, Vita shade guide, Porcelain systems

### Introduction

Colour matching between natural teeth, shade guides and metal ceramic restorations is a common clinical problem<sup>1</sup>. Use of shade guides is highly subjective<sup>2</sup>, most existing commercial shade guides do not represent the entire spectrum of tooth colour<sup>3</sup>. Due to inter human difference in the perception of colour, visual shade assessment of human teeth is lacking standardization that may be improved by use of spectrophotometer<sup>4</sup>. General variable such as external light conditions, experience, age, fatigue of human eye and physiological variables such as colour blindness lead to inconsistencies<sup>4</sup>. Computerized shade matching system offers better accuracy, improved efficiency and esthetic benefits to

the patient, dentist and technician. It analyzes the color of natural tooth and calculate the exact rates of hue, chroma and value for multitude of points on the tooth surface and display this information on the computer screen<sup>2</sup>.

### Materials and methods

The materials used in this study were - **Porcelain systems:** 1: Ceramco 3 (Dentsply International, USA, code C) 2: Ceramax (Alphadent Co. Ltd, Korea, code CM) 3: Vita VMK 95 (Vita Zahnfabrik H. Rauter GmbH & Co.KG, Germany, code V) -**Base Metal Alloy:** Ni-Cr alloy: (Brand-Ugirex, France, code N)

### Correspondence

Dr. Dilip Kumar Das, Dalian Medical University, China  
E-mail: dilipdollops@yahoo.com

In this study 15 substructure patterns were fabricated using inlay wax, then cut into 1 x 1 cm square pieces, measured with digital Vernier caliper, followed by casting with Ni-Cr alloy. Thickness of each specimen was measured at nine locations having average mean thickness of 0.8 mm approximately. The surface of alloy in which porcelain was to be fired was air abraded with 50µm aluminum oxide at 75psi pressure. All the specimens were cleaned with pressurized steam for any surface contaminants. The specimens were held under vacuum for 2 minutes at 960° C with temperature increase of 70° C per minute according to the manufacturer instructions.

Each type of porcelain was applied on 5 samples each (5 each of Ni-Cr). Wash opaque was applied as thin layer with brush and fired. Each company shade had its own opaque paste which was applied in thin layer and then fired. Opaque thickness was determined with a micrometer by measuring the sample at 3 points on each disk. Dentine porcelain was mixed to a creamy consistency using distilled water, vibrated mechanically for proper condensation and fired. Final thickness of 1.8 mm approximately was ground to matte finish and steam cleaned for removal of any surface contaminants. Enamel powder was mixed on the glass slab with a special liquid provided by the manufacturer into a creamy consistency, spread evenly and over build to compensate for the firing shrinkage and then fired. The specimens were ground to approximate thickness of 0.5 mm of enamel porcelain. A thin layer of glaze was applied and fired. All the five layers were fired by strictly following the manufacturer's instructions.

### Sample measurements and data manipulation

The samples were individually analyzed with Vita lumin shade guide (A2) in a spectrolino spectrophotometer. CIE standard illuminant D65 was used for all measurements. The colour of each sample in this study were described by 4 parameters of **C.I.E** (International Commission on Illumination) 1931(xyz). The resultant tristimulus values X, Y, Z are the standard response of the eye to the red, green, and blue stimuli from the object. The **X (D.L) parameter** defines the lightness or darkness of samples and its numerical value ranges from black (-) to white (+). Similarly the other two axis defines **(D.R.G) Red(+)** & **Green(-)** and **(D.Y.B) Yellow(+)** & **blue(-)**. Evaluation of color differences or **DE** in dental research is usually performed with the following formula.

$$D.E = \sqrt{DI^2 + D.RG^2 + D.YB^2}$$

The CIE system of color specification provides a common means of analyzing and presenting color measurements data.

For this study, the instrument geometry used was 45°/0° with specular component excluded, as this geometry closely relates to the normal human vision when observing a natural tooth.

### Results

Presented below is the comparative analysis of the respective mean values corresponding to each of the three brands viz. V (Vita VMK 95), C (Ceramco 3) & Cm (Ceramax); for each of the four parameters of C.I.E 1931(xyz) (International commission on Illumination) i.e. **D.E** (Total colour difference), **D.L** (Sample darker and lighter shades), **D. RG.** (Sample red and green) & **D.YB** (Sample yellow and blue).

Table 1 shows that the highest mean value (17.98) is recorded in case of brand Cm (Ceramax) & lowest (16.15) in case of brand V (Vita VMK 95).

Table 2 shows that the value of F is not significant at 5 percent level of significance. Three brands may be regarded as one and the same.

Table 3 shows that the highest mean value (14.25) is recorded in case of brand V (Vita VMK 95) & lowest (13.24) in case of brand Cm (Ceramax).

Table 4 shows that the value of F is not significant at 5 percent level of significance. Three brands may be regarded as one and the same.

Table 5 shows that the highest mean value (8.77) is recorded in case of brand Cm (Ceramax) & lowest (6.43) in case of brand V (Vita VMK 95).

Table 6 shows that the value of F is not significant at 5 percent level of significance. Three brands may be regarded as one and the same.

Table 7 shows that the highest mean value (6.72) is recorded in case of brand Cm (Ceramax) & lowest (2.98) in case of brand C (Ceramco 3).

Statistical Significance for difference in mean value has been tested by Analysis of Variance (ANOVA) through Table 8.

Table 8 shows that the value of F is significant at 5 percent level of significance. Three different brands cannot be regarded as one and same since these are resulting to mean values whose differences are significant at 5 percent level of significance.

As the difference between various brands has been found to be statistically significant; the individual comparisons between them are present in Table 9.

Table 9 shows that the difference between means of brands V (Vita VMK 95) and C (Ceramco 3) is not significant; while that of brand Cm (Ceramax) differs

significantly from V and also C, at 5 percent level of significance.

**D.E: Table 1: Mean Values**

Brand	Replication					Total	Mean	S. D	C.V (In %)
	I	II	III	IV	V				
V	15.64	14.81	15.70	18.07	16.54	80.76	16.15	1.24	7.68
C	18.48	19.20	19.12	15.56	10.44	82.80	16.56	3.73	22.52
Cm	18.72	17.79	18.31	14.38	20.72	89.92	17.98	2.30	12.79
Total	52.84	51.80	53.13	48.01	47.70	253.48	16.90	-	-

**Table 2: ANOVA (D.E)**

Source	Sum of squares	Df	Mean square	F	F tab	P value
					5%	
Between Groups	9.225	2	4.612	0.667	3.88	> 0.05
Within Groups	83.004	12	6.917	-	-	-
Total	92.229	14	-	-	-	-

**D.E: Table 3: Mean Values**

Brand	Replication					Total	Mean	S. D	C.V (In %)
	I	II	III	IV	V				
V	13.49	14.16	14.36	15.64	13.64	71.29	14.25	0.85	5.96
C	17.15	13.98	18.18	13.78	7.75	70.84	14.16	4.07	28.74
Cm	15.26	14.37	16.86	4.14	15.61	66.24	13.24	5.17	13.04
Total	45.90	42.51	49.40	33.56	37.00	208.37	13.89	-	-

**Table 4: ANOVA (D.L)**

Source	Sum of Squares	Df	Mean Square	F	F tab	P value
					5%	
Between Groups	3.114	2	1.557	.106	3.88	> 0.05
Within Groups	176.174	12	14.681	-	-	-
Total	179.288	14	-	-	-	-

**D.RG: Table 5: Mean Values**

Brand	Replication					Total	Mean	S. D	C.V (In %)
	I	II	III	IV	V				
V	7.38	4.06	6.00	5.66	9.07	32.17	6.43	1.90	29.55
C	6.14	12.05	5.74	6.90	6.39	37.22	7.44	2.61	35.08
Cm	7.90	9.62	4.76	11.57	10.00	43.85	8.77	1.41	16.08
Total	52.84	51.80	53.13	48.01	47.70	253.48	16.90	-	-

**Table 6: ANOVA (D.RG)**

Source	Sum of squares	Df	Mean square	F	F tab	P value
					5%	
Between Groups	13.721	2	6.861	1.203	3.88	> 0.05
Within Groups	68.422	12	5.702	-	-	-
Total	82.143	14	-	-	-	-

**D.YB: Table 7: Mean Values**

Brand	Replication					Total	Mean	S. D.	C.V (In %)
	I	II	III	IV	V				
V	2.88	1.50	2.05	7.07	2.28	15.78	3.15	2.24	71.11
C	3.08	5.29	1.58	2.18	2.81	14.94	2.98	1.41	47.32
Cm	7.42	4.13	5.32	7.48	9.25	33.60	6.72	2.00	29.76
<b>Total</b>	13.38	10.92	8.95	16.73	14.34	64.32	4.29	-	-

**Table 8: ANOVA (D.YB)**

Source	Sum of squares	Df	Mean square	F	F tab	P value
					5%	
Between Groups	44.380	2	22.190	6.018*	3.88	< 0.05
Within Groups	44.248	12	3.687	-	-	-
<b>Total</b>	88.628	14	-	-	-	-

\*: Significant at 5 percent level of significance

**Table 9: Summary Table**

Brand	V	C	Cm	C. D (critical difference)
<b>Mean</b>	3.15	2.98	6.72	1.21

## Discussion

The most important goal in modern dentistry is to restore colour and appearance of natural dentition<sup>5</sup>. Due to superior optical properties, ceramics have become a standard application as a dental restorative material to mimic natural tooth esthetics<sup>6</sup>. A large number of studies have shown the variation in shade due to the type of metal alloy<sup>7,8</sup>, shade selected<sup>9,10</sup>, brand and batch of porcelain<sup>11</sup>, firing temperature and number of firings<sup>12</sup>, as well as thickness of the porcelain layer<sup>13,14</sup>. Minimizing one or more of these errors will overall help in duplication of more acceptable shades for the patient. In such scenario, instrumental color analysis offers potential advantages over visual color determination. Vita lumin shade guide is the most widely used standard for shade selection in dentistry worldwide in spite of its many drawbacks<sup>2, 15</sup>.

The specimens were made manually and there is bound to be difference within an experimental group, which contained five samples, each fired on the same metal with different brand of porcelain. This error is mostly due to difference in condensation of the porcelain as any air bubbles incorporated usually influences the shade<sup>16</sup>. The Vita VMK 95 experimental group samples presented the minimum deviation in D.E, D.L among all the groups i.e. it was least technique sensitive. The Ceramco 3 experimental group samples presented minimum deviation in D.YB and Ceramax experimental samples group presented minimum deviations in D.RG group.

The particle size of the porcelain is known to affect the perceived colour by affecting the scattering property, as small particles scatter less light than big particles. These 2 properties, the smooth surface topography and the small particle size, are thought to be responsible for the better colour quality and reproducibility.

One of the objectives of this study was to evaluate the shade difference when A2 shades of 3 different brands of porcelain were fired on the same metal. This difference is due to the different concentration of shade pigments used by the manufacturers. The 3 porcelain brands differed significantly from each other mostly in their amount of yellow saturation. In our study observation of Chroma of all three samples (Ceramco 3, Ceramax and VitaVMK 95) was statistically insignificant in terms D.RG (Red and Green). Batch to batch variation of porcelain may necessitate the fabrication of customized shade tabs with fresh batch of porcelain<sup>11,17</sup>. In our study, observation of Chroma of all three samples (Ceramco 3, Ceramax and Vita VMK 95) varied and significant in terms of D.YB (yellow and blue) where as in other studies, the yellowness increased with thickness and shade of opaque. Their observation showed difference (0.05) due to difference in thickness in porcelain and also due to different types of condensation techniques<sup>16,18</sup>. Also difference in D.L lightness (value) has been seen between 3 samples of experimental group of porcelain and was statistically insignificant. In our study D.E

(difference) in all three samples (Vita VMK 95, Ceramax, Ceramco3) were subjectly observed and statistically insignificant. The experimental group which came closest to the shade tab was VitaVMK 95 samples, as the saturation of the colouring oxides are under the control of the same manufacturer both in shade guide and porcelain powder<sup>3</sup>.The largest error was seen with Ceramax. The operator using porcelain should posse sufficient knowledge so that the best judgment can be exercised in the selection of physical and chemical property of different types of material.

### Conclusions

1. Samples made with different brands of porcelains have noticeably different shades despite having same Vita Lumin shade guide.
2. Different brands of porcelain differ from each other more in redness and yellowness.
3. Different brands of porcelain differ from each other more in lighter than darker shades.

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