COLOR ASSESSMENT OF A ZIRCONIA ALL-CERAMIC SYSTEM UNDER DIFFERENT ILLUMINANTS

Karim A. Bakr, Amina A.Zaki, and Rasha N. Mohamed

ABSTRACT

Statement of problem. Color matching problems may be encountered in a definitive restoration despite careful shade selection. Spectrophotometric color measurements of shade differ depending on standard illuminant employed.

Purpose. This study examined the effect of two different construction techniques of prettau zirconia system, and three different illuminants (D55, D65 and F2), on the color parameters of the prettau zirconia all-ceramic system.

Materials and methods. Disc specimens of a 10 mm diameter were obtained by manually milling prettau zirconia blocks. According to the two construction techniques, the discs were divided into 2 groups (10 discs for each group): Group I milled zirconia discs of 2mm thickness representing the thickness of a full contour zirconia restoration. Following milling of the discs, application of coloring paint was carried out to obtain the shade A3. Group II milled zirconia discs of 1mm thickness veneered with 1 mm thickness of the veneer ceramic of shade A3. Spectrophotometric color assessment of the samples was carried out under the illuminants (D55, D65 and F2). Data were collected, tabulated and statistically analyzed.

Results. With F2 illuminant, Group I (full Prettau) showed statistically significant higher mean (ΔE) value (11.6±0.3) than Group II (Prettau/veneering ceramic) (5.2±0.4). With D55 illuminant, Group I (full Prettau) showed statistically significant higher mean (ΔE) value (10.6±0.3) than Group II (Prettau/veneering ceramic) (4.7±0.4). With D65 illuminant, Group I (full Prettau) showed statistically significantly higher mean (ΔE) value (10.6±0.3) than Group II (Prettau/veneering ceramic) (4.7±0.4). Regarding the translucency With F2 illuminant, Group II (Prettau/veneering ceramic) showed statistically significant higher mean translucency value (4.23±0.2) than Group I (full Prettau) (3.35±0.2). For D55 illuminant, Group II (Prettau/veneering ceramic) showed statistically significant higher mean translucency value (4.00±0.2) than Group I (full Prettau) (3.27±0.2).With D65 illuminant, Group II (Prettau/veneering ceramic) showed statistically significant higher mean translucency value (3.89±0.2) than Group I (full Prettau) (3.14±0.2).

Conclusion. ΔE was dramatically decreased when the thickness of zirconia was decreased from 2mm to 1mm and veneering porcelain was used and shade match under sunlight will not differ from using color corrected lamp but will differ from taking shade under fluorescent lamp.

*As

INTRODUCTION

The CIELAB color space is a uniform 3-dimensional color order system. Equal changes in any of the 3 coordinates can be perceived as visually similar. Total color differences were calculated with use of the following equation:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

The L* coordinate indicates the lightness-darkness of the specimen. The greater the L* is the lighter the specimen. The a* coordinate refers to the chroma along the red-green axis. A positive a* relates to the amount of redness and a negative a* relates to greenness of a specimen. The b* coordinate refers to the chroma along the yellow-blue axis. A positive b* relates to the amount of yellowness, while a negative b* relates to the amount of blueness of the specimen. ΔL^*, Δa^* and Δb^* are the differences in the CIE color-space parameters between 2 colors.(1)

Instrumental color analysis offers a potential advantage over visual color determination, as instrumental readings are objective, quantifiable and more rapidly obtainable. (2)

An **illuminant** is a set of numbers (relative energy versus wavelength) that represent the spectral quality of a type of white light source and is used in calculation of color measurements in colorimetric software. The choice of illuminant is independent of the instrument lamp. (3)

Despite the success of metal-ceramic restorations in terms of strength and fracture resistance, the increased interest for improved esthetics has prompted researchers to investigate various new materials and techniques. (4) In the last 10 years, core-veneered all-ceramic restorations have gained popularity among patients and clinicians. (5) These new ceramic systems do not require the use of metal substructure, they are capable of achieving the same fitting precision and the high strength of conventional porcelain fused to metal systems. (6)

Five methods are present for fabricating all ceramic crowns: condensation and sintering, cast and ceraming, pressing, slip casting and machinable ceramics or presintered blocks. (7, 8)

There are two main options when using ceramics for prosthetic restorations: a single layer ceramic attached to the tooth structure or a two-layered structure with a high-strength ceramic core material which supports the more brittle veneering ceramic. (9)

Yttria-stabilized tetragonal zirconia (Y-TZP) is gaining use in dentistry due to its good mechanical properties. It is currently used as a core material in all-ceramic dental restorations (10, 11) and implant superstructures. (12) Compared to other dental ceramics, its superior mechanical properties, such as higher strength and fracture toughness (10, 13, 14) are due to the transformation toughening mechanism, similar to that observed in quenched steel. Zirconia oxide (ZrO_2) is a polymorphic material that has 3 allotropes: the monoclinic phase is stable up to 1170°C, at which point it transforms into the tetragonal phase, which is stable up to 2370°C, and the cubic phase exists up to the melting point at 2680°C.(15)

MATERIALS AND METHODS

In the present study, twenty all-ceramic discs of a 10 mm diameter were obtained by manually milling prettau zirconia blocks (ZirkonZahn GmbH, Italy) (Fig.1) then according to different construction techniques, they were divided into two groups (10 discs each) as follows: group I: milled zirconia discs of 2mm thickness representing the thickness of a full contour zirconia restoration. Following milling of the discs, application of coloring paint was carried out to obtain the shade A3.Group II: milled zirconia discs of 1mm thickness then veneered with 1 mm thickness of the A3 shade veneer ceramic.

Fig. (1) Milling of Zirconia discs.

Samples› fabrication

1) **Mold construction**

i) Fabrication of mold A:

A specially designed circular split Teflon® mold was machine crafted. The mold consisted of two equal parts in the form of half circles assembled by an external copper ring. The mold had a circular central hole of 10 mm diameter and 2 mm thickness. Mold A served for the construction of group I resin pattern and the ceramic dentin application of group II.

ii) Fabrication of mold B:

A Teflon® cylinder in shape was especially machine crafted. The cylinder was 15 mm in height and 20 mm in diameter. A hole of 10 mm in diameter was drilled in the center of the cylinder along its height. A Teflon® bar of 10mm in diameter and 14mm in height was machine crafted to fit inside the center of the cylinder, leaving a mold space of 1mm in thickness. Mold B served for the construction of group II resin pattern.

2) Construction of the resin pattern discs:

i) For the fabrication of group I:

The mold A was placed on a clean and dry flat glass slab and a thin layer of a separating medium (Isocera, Bego Bremer, Goldschlagerei Wilh. Herbbst, Gmbh and Co.) was applied using a brush into the inner wall of the central hole of the mold. The composite resin (ZirkonZahn GmbH, Italy) was applied into the central hole of the mold to fill it. Another clean and dry flat glass slab was placed over the mold. The whole assembly was placed under a special light cure unit(ZirkonZahn GmbH, Italy). After curing, the upper glass slab and the outer assembly ring were removed and the split mold was disassembled to obtain the resin disc.

ii) For the fabrication of group II:

A thin layer of the separating medium was applied using a brush into the inner wall of the central hole of mold B. The composite resin was applied into the central hole of the mold to fill it then covered with a clean and dry flat glass slab. The mold with the glass lab were placed under the light cure unit. After curing the resin disc was pushed out with the central bar to obtain the resin disc.

All the resin pattern discs were finished with a superfine diamond bur and checked for any discrepancies using a magnifying loop, and for the required thickness and diameter using a caliber (Dentaurum, Germany).

3) construction of the zirconia discs:

Twenty zirconia discs were fabricated with the Zirkonzahn manual milling unit: Zirkograph 025 ECO (ZirkonZahn GmbH, Italy) (Fig.2).

Fig. (2) Coloring Prettau zirconia discs.

Coloring:

After milling the discs, prettau color liquid A3 (ZirkonZahn GmbH, Italy) was used to color the discs. Then drying was done under infrared lamp: Zirkonlampe 250 (ZirkonZahn GmbH, Italy) for one hour. Then one Disc was placed at a time on the firing tray for sintering in the furnace: Zirkonofen (ZirkonZahn GmbH, Italy).

Veneering of group II samples:

The group II zirconia discs were subjected to the veneering procedure.Then all the discs were glazed.

Procedures of measurement:

A spectrophotometer is used in the measurement

White standard plates were introduced at the exit port of the integrating sphere both on the sample and reference side. They were fixed to the integrating sphere with the use of the accessory kurled head thumb screws, in this condition a baseline correction over the required wavelength range was performed. After this, the sample side standard white plate was exchanged by the desired samples. The samples were then seated to the holder and placed inside the integrating sphere so that the zirconia disc was directed toward the light source. The color parameters of the A3 Vitapan classic shade tab (Vita Zahnfabrik, Germany) was measured for color difference comparison with the two groups. All the samples tested were measured under the illuminants selected: D55, D65 and F2.

RESULTS

Color Change (ΔE)

With F2 illuminant, Group I (full Prettau) showed statistically significant higher mean (ΔE) value (11.6±0.3) than Group II (Prettau/veneering ceramic) (5.2±0.4). With D55 illuminant, Group I (full Prettau) showed statistically significant higher mean (ΔE) value (10.6±0.3) than Group II (Prettau/veneering ceramic) (4.7±0.4). With D65 illuminant, Group I (full Prettau) showed statistically significantly higher mean (ΔE) value (10.6±0.3) than Group II (Prettau/veneering ceramic) (4.7±0.4). This was represented numerically in Table (1) and graphically in (Fig.3).

TABLE (1) The mean (ΔE), standard deviation (SD) values and results of comparison between the two materials with each illuminant

Material / Illuminant	(Group I)		(Group II)		*P*-value
	Mean	**SD**	**Mean**	**SD**	
F2	11.6	0.3	5.2	0.4	<0.001*
D55	10.6	0.3	4.7	0.4	<0.001*
D65	10.6	0.3	4.7	0.4	<0.001*

**: Significant at $P \leq 0.05$*

Where:

Group I(GpI): full Prettau

Group II (GpII):Prettau/veneering ceramic

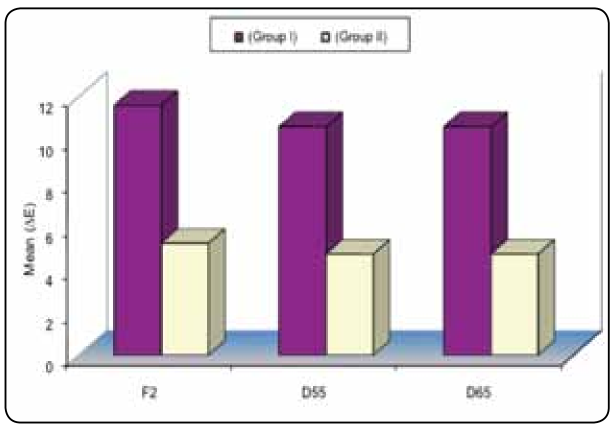

Fig. (3) Bar chart representing mean (ΔE) of the two materials with each illuminant.

Translucency

With F2 illuminant, Group II (Prettau/veneering ceramic) showed statistically significant higher mean translucency value (4.23±0.2) than Group I (full Prettau) (3.35±0.2).For D55 illuminant, Group II (Prettau/veneering ceramic) showed statistically significant higher mean translucency value (4.00±0.2) than Group I (full Prettau) (3.27±0.2). With D65 illuminant, Group II (Prettau/veneering ceramic) showed statistically significant higher mean translucency value (3.89±0.2) than Group I (full Prettau) (3.14±0.2). This was represented numerically in Table (2) and graphically in (Fig.4).

TABLE (2) The mean translucency, standard deviation (SD) values and results of comparison between the two materials with each illuminant

Material / Illuminant	Group I (GpI)		Group II (GpII)		*P*-value
	Mean	**SD**	**Mean**	**SD**	
F2	3.35	0.2	4.23	0.2	<0.001*
D55	3.27	0.2	4.00	0.2	<0.001*
D65	3.14	0.2	3.89	0.2	<0.001*

**: Significant at $P \leq 0.05$*

Where:

Group I(GpI): full Prettau

Group II (GpII):Prettau/veneering ceramic

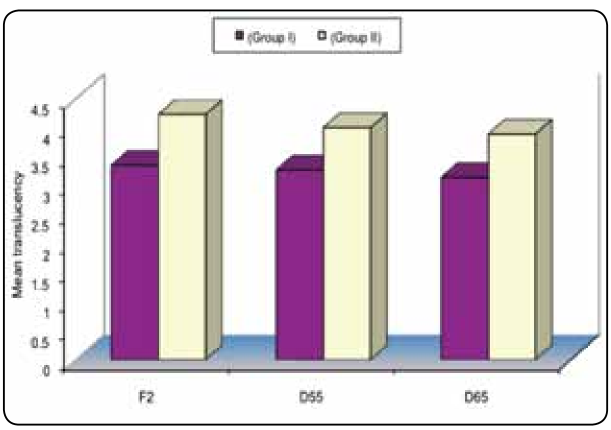

Fig. (4) Bar chart representing mean translucency of the two materials with each illuminant.

DISCUSSION

Zirconia is more opaque than feldspathic porcelain, so this difference in the ΔE between the two groups may be due to the fact that group I was made of 2mm zirconia while group II was made of 1mm zirconia + 1mm porcelain so as the thickness of the veneering material increased in relation to the core thickness, the effect of the core color and opacity decreases as the majority of diffuse reflection occurred in the veneering ceramic, this finding were in agreement of previous studies **(Uludag et al).** [16]

The fact that even group II (Prettau/veneering porcelain) exceeded the clinically acceptable level (ΔE > 3.7) may be due to increasing the thickness of the zirconia from average of 0.4-0.6 (coping) mm as recommended by **Potiket et al**. [17] and **Sven et al.** [18] to 1mm and decreasing the veneering thickness.

Regarding the illuminants, Illuminant F2 showed the statistically significant highest mean (ΔE) value for both groups (for group (I) 11.6 and for group (II) 5.2) and there was no statistically significant difference between illuminant D55 and D65; both showed the statistically significant lowest mean (ΔE) values (group (I) 10.6 for D55 compared to 10.6 for D65 while group (II) 4.7 for D55 compared to 4.7 for D65). This was in agreement with **Park et al**. [19] who found that mean (L*) and chroma value of the 16 VITA shade tabs relative to illuminant D65 was the lowest followed by that relative to illuminant F2.

The fact that there was no statistical difference between D55 and D65 may be attributed to the close temperature between them (5500° Kelvin for D55 and 6504° Kelvin) also due to their close relative spectral distribution (relative energy versus wavelength). [3]

With respect to the translucency of the two groups, Group II (Prettau/veneering ceramic) showed statistically significant higher mean translucency than Group I (full Prettau) (4.04 for group II and 3.25 for group I). Since The amount of light that is absorbed, reflected and transmitted depends on the amount of crystals within the core matrix, their chemical nature, the size and distribution of the particles compared to the incident light wavelength[20] and the zirconia is characterized by the opaque nature of its particles as well as the large size of the particles contributed in the final zirconia structure and its higher refractive index[21,22]. So increasing the thickness of the zirconia (2mm for group I and 1mm for group II) led to increasing the amount of light that is scattered and reflected therefore decreasing the translucency.

Regarding the illuminants, with group I (full Prettau) there was no statistically significant difference between illuminant F2 and D55; both showed the statistically significant highest mean translucency, Illuminant D65 showed the statistically significant lowest mean translucency. With group II (Prettau/veneering porcelain) illuminant F2 showed the statistically significant highest mean translucency. There was no statistically significant difference between illuminant D55 and D65; both showed the statistically significant lowest mean translucency. This was in agreement with **Ahn et al** [23] that stated that the translucency value relative to the illuminant D65 was lower than that relative to the illuminant F2.

CONCLUSION

Within the limitations of the present in vitro study the following conclusions were drawn:

1- The color parameters of the new zirconia (Prettau) when used as a full contour zirconia restoration was significantly different from the standard and could be considered as a mismatch in the oral environment.

2- ΔE was dramatically decreased when the thickness of zirconia was decreased from 2mm to 1mm and veneering porcelain was used.

3- Shade match under sunlight will not differ from using color corrected lamp but will differ from taking shade under fluorescent lamp.

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