Original Study

THE EFFECT OF COLOR DIFFERENCE OF ZIRCONIUM COPING ON THE FINAL COLOR OF ZIRCONIA RESTORATIONS

Ahmadzadeh A,[1] Mousavi N,[2] Mardasi N,[3] Ghotbzadeh O,[4] Rohani A [5]

1. Assistant Professor, Department of Prothodonticts, School of Dental Medicine, Ahvaz Jundishapur University of Medical sciences, Ahvaz, Iran.
2. Prosthodontics Resident, Department of Prothodonticts, School of Dental Medicine, Ahvaz Jundishapur University of Medical sciences, Ahvaz, Iran.
3. Prosthodontics Resident, Department of Prothodonticts, School of Dental Medicine, Ahvaz Jundishapur University of Medical sciences, Ahvaz, Iran.
4. Prosthodontics Resident, Department of Prothodonticts, School of Dental Medicine, Ahvaz Jundishapur University of Medical sciences, Ahvaz, Iran.
5. Dental Student, School of Dental Medicine, Ahvaz Jundishapur University of Medical sciences, Ahvaz, Iran.

ABSTRACT

Aim: Closely shade matching of restoration with natural teeth is one of the most challenging clinical procedures in dentistry. The aim of the present study was to compare the effect of color difference of zirconium coping on the final color of zirconia restorations.

Materials & Method: A total of 15 ceramic discs of 16 mm in diameter with minimum core/veneer thickness of three groups of ceramics, VITA In-Ceram YZ, IPS e.max ZirPress, and IPS e max ZirCAD were selected for the study. The discs were then veneered with veneering porcelain. Shade matching was performed using Vita Easyshade and Gretag Macbeth spectrophotometers. The colorimetric parameters L*a*b* were analyzed using One-Way Analysis of Variance (ANOVA) and Tukey's test. The ΔE of the specimens was compared with the ΔE of 2M2 shade (control group).

Results: The type of zirconia had a significant effect on the final color of zirconia restorations. The consistency of the Ivoclar Zirpress samples with the ΔE of 2M2 shade was within clinically acceptable limits (ΔE=2.8). The least ΔE for the shade-matching tabs was observed in VITA In-Ceram YZ (ΔE=5.8).

Conclusion: The type of zirconia has a significant effect on the final color of zirconia restorations and the minimum thickness of a core/veneer (1mm) in Vita and Ivoclar blocs cannot produce a clinically acceptable match.

Key words: Coping, Restoration, Shade, Zirconia.

Introduction

Color matching of restoration is still one of the furthermost challenging assignments in clinical dentistry. Natural looking restoration is an increasing petition from the patients, so to attain a natural looking restoration ceramic veneers have developed the cosmetic dentistry and have met the realistic expectations of the patients.[1]

In general, ceramic systems can be classified into two groups: Translucent and opaque. The translucent ceramics are used when color masking of its background are reasonable. The translucent ceramics included some type of IPS Empress esthetic press-ceramics and the feldspathic restorations applied to a refractory die and covered with platinum foil and sintered under a vacuum at a high temperature.[2] The opaque ceramics have the highest potential for strength and toughness and are used for core or coping and then veneered with translucent porcelain. Opaque ceramics contain high-strength core materials including alumina, zirconia, and lithium disilicate.[2] Although metal ceramic restorations have been well applied in dentistry, the color mismatch have been found in 37% of cases. As well as, ceramic cores with high formability and fracture strength have demonstrated better mechanical and esthetical results than base-metal restorations.[3] Various materials are used as coping in all-ceramic restorations including feldspathic porcelain, lithium disilicate, and zirconium oxide.[4]

The use of zirconium oxide in technical ceramics is well established due to its improved mechanical properties and high biocompatibility.[5] The mechanical properties of this material are better than any well-known dental ceramic, therefore, it is used for the framework of posterior bridges as well as low thickness coping.[5] Several factors including firing temperature, firing cycles, glaze firing cycle, opaque porcelain layer thickness, surface-finishing methods, veneering ceramic thickness, manufacturing system, and the degree of substrate affect the ceramic color.[3] Various studies have reported the effect of coping type on the final shade of restoration.[6] Lee *et al*., 2007 in a study showed that the CIE L* values of IPS coping (A2 veneer layered, 1mm thick) was lower than InCeram coping (A2 veneer layered, 1mm thick).[7] Ozturk *et al*., 2008 examined the effects of various dentin ceramic thicknesses and repeated firings on the color of lithium disilicate glass-ceramic (IPS e max Press) and zirconium-oxide (DC-Zirkon) all-ceramic systems and concluded that as the ceramic thickness increased, significant reductions in L* values were verified for IPS e max Press and DC-Zirkon specimens.[8]

Studies have shown that coping ceramics cause color discrepancies in final restorations with standard parameters. Since the color change is one of the most important attributes of aesthetic restorations, the aim of the present study was to compare the effect of color difference of zirconium coping on the final color of zirconia restorations.

Materials & Method

A total of 60 ceramic discs of 16 mm in diameter with minimum core/veneer thickness (1mm) of three groups of ceramics, VITA In-Ceram YZ (Vita Zahnfabrik, Germany) 2m2 shade, IPS e.max ZirPress (Ivoclar Vivadent, Germany) A2 shade, and IPS e.max ZirCAD (Ivoclar. vivadent) A2 shade, were selected for the study. To remove the possible effect of color substrate on the final color, a ceramic block with A2 shade was used as an infrastructure and to remove the cement color effect, glycerin (Nima Chemi, Tehran, Iran) was used to fill the space between the infrastructure and the dicks.

In the IPS e.max ZirPress group 20 disc specimens (16-mm diameter, core thickness= 0.8 mm, veneer thickness= 1mm) were fabricated according to the manufacturer's instructions. The lost wax technique was used and investment was performed and wax and acrylic patterns with the shape and size of the desired discs were used. The thickness of the discs was measured using a digital caliper (Vogel, Germany). In order to compensate porcelain shrinkage, the porcelain was applied over each disc twice and baked to obtain the preferred thickness. To avoid the effect of dentin porcelain and enamel thickness and to avoid an overcontoured restoration, the thickness of the dentin porcelain of 0.7 mm, and enamel porcelain of 0.3 mm was adjusted. In order to confirm the work-heat, or avoid the effect of time and temperature on the ceramic two phase of initially baking (low-bisque) and second corrective bake (patch bake) were adopted.

In the IPS e.max ZirCAD group, the zirconium oxide block was optically scanned and processed according to standard protocol using the Sirona in Lab CAD/CAM (Sirona, Bensheim, Germany) system. The CAD program was used to establish the coping thickness (0.5 mm) and other parameters as well as finalize the coping design. IPS e max ZirCAD block then was placed in the milling unit and milled, the margins were finished, and then the coping was sintered. The thickness of the dentin porcelain of 0.7 mm, and enamel porcelain of 0.3 mm was adjusted. In order to confirm the work-heat and to avoid the effect of time and temperature on the ceramic two phase of initially baking (low-bisque) and second corrective bake (patch bake) were adopted to achieve 1 mm veneer layer. The A2 shade was adopted for all of the veneered zirconia specimens.

In the VITA In-Ceram YZ (Vita Zahnfabrik, Germany) group, the zirconium oxide block was optically scanned and processed according to standard protocol using the Sirona in Lab CAD/CAM (Sirona, Bensheim, Germany) system. The CAD program was used to establish the coping thickness (0.5 mm) and other parameters as well as finalize the coping design. IPS e max ZirCAD block then was placed in the milling unit and milled, the margins were finished, and then the coping was sintered. The thickness of the dentin porcelain of 0.7 mm, and enamel porcelain of 0.3 mm was adjusted. In order to confirm the work-heat and to avoid the effect of time and temperature on the ceramic two phase of initially baking (low-bisque) and second corrective bake (patch bake) were adopted to achieve 1mm veneer layer. The 2M2 shade was adopted for all of the veneered zirconia specimens.

In order to remove the effect substrate color on the final color of zirconia, A2 substrates (2mm thickness) were used for all of the specimens. Shade matching was performed using Vita Easyshade (Vita, Germany) and GretagMacbeth spectrophotometers (Color-Eye 7000A, Germany). The ΔE of the specimens were compared with the ΔE of 2M2 shade (control group) and calculated by the following formula:

$$\Delta E = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$$

The colorimetric parameters L*a*b* were recorded by Easy Spectrophotometer (Vita Zahnfabrik, Bad Sackingen, Germany). The ΔE of the specimens was compared with the ΔE of 2M2 shade (control group). Data were analyzed using One-Way Analysis of Variance (ANOVA) and Tukey's test.

Results

In the present study the effect of color difference of three types of zirconium coping on the final color of zirconia restorations was examined. The ΔE of each group was compared with 2M2 shade(control group) and the clinical accepted level was determined. Data were analyzed using One-Way Analysis of Variance (ANOVA) and Tukey's test. The data from the Gretag spectrophotometer are presented in Table 1.

Gretag Macbeth Spectrophotometer color- Eye 7000A Observer: 10° Illuminant: D65 Measurement Type: Reflective			
	L	A	B
IPS e.max Zirpress +A2 veneer	91.69	94.1	15.81
IPS e.max ZirCAD +A2 veneer	72.73	61.1	16.91
Vita Yz blocs + 2M2 Veneer	8.74	1.71	28.14

Table 1: The color measurement values by Gretag spectrophotometer

CIElab values with spectrophotometer Illumination = 45° observer = 0°			
Tab	l	a	B
2M2	70.78	0.48	18.04

Table 2: The CIElab measurement values by spectrophotometer

In the present study the descriptive and statistical analysis were used to describe the basic features of the data in the study. One-way analysis of variance (ANOVA) was used for statistical analysis. There was a significant difference among the three groups concerning the L* parameter. The difference between Vita Yz blocs and IPS e.max ZirCAD was significant ($p<0.05$). The difference between IPS e max ZirCAD and both IPS e max Zirpress and Vita Yz blocs was statistically significant ($p<0.001$). Considering the a* parameter no difference was found between the Vita Yz blocs and IPS e.max ZirCAD ($p>0.05$), but a significant difference was found between IPS e.max ZirCAD and both IPS e.max Zirpress ($p<0.05$). As well as, the difference between IPS e.max ZirCAD and Vita Yz blocs was statistically significant ($p<0.001$). Regarding the b* parameter there was a significant difference among three groups ($p<0.001$). The mean of the data was compared with the parameters of 2M2 by t-test (for one sample t-test) and

significant difference was found among three groups (p<0.001).

In order to get the detailed descriptive statistics for each group the ΔE values of each group were compared with control group (2M2) by the following formula:

$$\Delta E = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$$

The calculation formula of the ΔE value specified that the ΔE of IPS e max Zirpress with control group was 2.8 = 2M2, ΔE of IPS ZirCAD with control group was 3.4=2M2, and the ΔE of Vita YZ blocs with control group was 5.6=2M2.

The color of three zirconia groups was also measured by Easyshade spectrophotometer (VITA Easy shade; VITA Zahnfabrik). The results showed that the ΔE of IPS e max Zirpress compared with 2M2 was equal to 1.5 and in IPS Zir CAD and Vita YZ blocs was 4.6 and 6.5, respectively.

The results of Gretag and Easyshade spectrophotometer evaluation both showed that the ΔE value of IPS e max ZirPress was clinically acceptable and presented satisfactory color match, however ΔE value of Vita YZ blocs was not clinically acceptable and did not display satisfactory color match. Additionally, IPS Zir CAD displayed low color match compared to control group.

Discussion

The present study examined the effect of color difference of three zirconium coping on the final color of zirconia restorations. The color of IPS e.max ZirPress in minimum thickness of restoration was clinically acceptable and presented satisfactory color match compared to other two studied ceramics. The color of Vita YZ blocs in minimum thickness of restoration was not clinically acceptable and did not show satisfactory color match.

Several factors influence the color of the ceramicrestoration, including the type of core, the type of veneer, the manufacturing system, the firing variables (temperature, duration, and frequency), thickness of the restoration, the substrate color, and the ceramic color.

Type of core

Kourtis *et al*., 2004 in a study stated that the final color of metal ceramic specimens was influenced both from the type of alloy substructure and from the type of overlying porcelain which consistent with the result of the present study. The results of Kourtis *et al*.'s study showed that Au and Co-Cr alloys were brighter (higher L* values) than the Ni-Cr and the Pd alloys. Ceramco porcelain was most red (higher a* values) for all tested alloys. Gold and Pd alloys caused a yellow shift to the metal-ceramic color compared to the Ni-Cr and the Co-Cr alloys with both porcelains.[10]

Lee *et al*., 2007 studied the interaction between all-ceramic and veneer ceramics. The results of the study showed that the CIE L (*), a (*), b (*), and C (*) (ab) values of A2- or A3-veneer layered specimens were influenced meaningfully by the combination of core and veneer ceramics and the CIE L (*) values of layered specimens were mostly influenced by the CIE L (*) values of the core ceramic. Likewise, in the present study the L* value of the final restoration was more attributed with L * value of zirconia core and b* value was in coordination with b* value of veneer. Therefore, two studies were in agreement with each other.

Uludag *et al*., 2007 in a study suggested that the final color of restorations was affected by core (0.6mm) and dentin ceramic thickness (0.5-, 1-, or 1.5-mm) which was consistent with the result of the present study.[11]

Tariq *et al*., 2012 in a study showed that Yttria-stabilized zirconia laminate veneers (layered with the appropriate veneer porcelain (1mm thickness, VITA VM9)) had the highest L* coordinate (L* = 74.00) compared to the L* value of IPS e max CAD (70.15) and feldspathic porcelain (70.00).12 Similarly, in the present study the zirconium restoration had the highest L* value.

In another studty Lee *et al*. evaluated four different zirconium blocks (Vita Inceram Alumina blocks, Digiden Digizone (Germany), (Vita) Vita 2000 Yz, and ADens zircon, Korea), with the core thickness of 0.4 and 1-1.1mm veneer (2M2). The result of the study showed that in the zirconium cores with the mean L* value of 83 (L*=83, a*=0.7, and b*=1.5) the veneer value was (L*=62, a*=1, and b*=1.5). Lee *et al*. suggested that L* value was associated with L* value of core and with both a* and b* values of the final core-veneered restoration which in agreement with the result of the present study.[13]

The high L* value of core and zirconium restoration are associated with the white and high opacity of zirconium core. Zirconia naturally has white appearance. In metallic ceramic restorations, the metallic appearance appears particularly in the margin. In the crystalline content attaining to greater strength often results in greater opacity and with the rise of the thicknesses the opacity and bonding strength decrease. In the present study, to provide sufficient strength the minimum thickness was assigned, however, the minimum thickness of the zirconium core also had high opacity. Heffernan *et al*., 2002 suggested the opacity value of 1 for 0.5mm thickness of In-Ceram zirconia core.[14] Similarly, Chen *et al*., 2008 reported the opacity value of 1 for 0.5mm thickness Cercon base zirconia and the highest rate of translucency for the Lava ceramic core (0.3 to 0.5 mm thickness).[15] Therefore, the minimum thickness of the zirconium core coordinates the high opacity and L* values and as the core is very effective on the final color of the restoration, it provides brighter (L*) color of final restoration.

Ceramic manufacturing system

Antonson *et al*., 2001 in a study showed that the ceramic thickness was influenced by the manufacturers and developers of systems and materials. The mean contrast ratio values were significantly different at a thickness of

1.50 mm of the four core ceramic systems and among the four veneering ceramic brands.[16] Likewise, in the present study core material influenced the zirconia ceramic color (The Vita zirconia blocs had the lowermost coordinate and the highest ΔE, the Ivoclar zirconia blocs had the highest coordinate and the lowermost ΔE, and Zir press was stand at the end of this spectrum).

Li *et al*., 2009 compared three all-ceramic materials (IPS Empress II, In-Ceram ALUMINA, Vita Mark II). The results of the study showed that color differences and CIE L*a*b* value were significantly influenced by the ceramic system which consistent with the result of the present study.[17]

Ceramic thickness

In the present study to achieve appropriate final color appearance the minimum thickness of a porcelain restoration was used. Shokry *et al*., 2006 examined the effect of core and veneer thicknesses on the color parameters of two all-ceramic systems and showed that increasing the total disk thickness resulted in decrease of L*, a*, b* values and an increase of ΔE. Shokry *et al*. concluded that the color appearance of the layered ceramic disk specimens is strongly influenced by the core and veneer thickness. Ozturk *et al*., 2008 resulted that as the ceramic thickness increased, significant reductions in L* values were recorded for IPS e.max Press and DC-Zirkon specimens.[8]

Ho Jung *et al*., 2010 in a study suggested that the final appearance of ceramic restorations can be influenced by varying the dentin porcelain thickness.[20] By the same token, Dozić *et al*.'s study in 2003 stated that redness a* and yellowness b* increased with the thickness of opaque porcelain for all shades and concluded that slight variations in thickness and shade of opaque and translucent porcelain layers can influence the final shade of the layered porcelain specimen.[21]

Degree of firings

Gelik *et al*., 2008 compared the effect of repeated firings on the color of an all-ceramic system with two different veneering porcelain shades and concluded that the shade of the all-ceramic samples with different veneering porcelain shades is influenced by repeated firings. Similarly, Ozturk *et al*., 2008 suggested that the L*a*b* values of the ceramic systems were affected by the number of firings.[8] in the present study the firing variable was not evaluated.

Substrate color

In the present study the ceramic substrate was used for the determination of final color restoration.

Considering the factors involved in the final color restoration and since zirconia is rather opaque and monochromatic, the type of zirconium core seems to have a tremendous effect on the overall appearance of the final restoration, which is also attributed to the whiteness and opacity of the restoration.

Conclusion

The type of zirconia has a significant effect on the final color of zirconia restorations and the minimum thickness of a core/veneer (1mm) in Vita and Ivoclar blocs cannot produce a clinically acceptable match. The consistency of the Ivoclar Zirpress samples with the ΔE of 2M2 shade was within clinically acceptable limits.

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Corresponding Author

Dr.Nahal Mardasi
Prosthodontics Resident,
Department of Prothodonticts,
School of Dental Medicine,
Ahvaz Jundishapur University of Medical Sciences,
Ahvaz, Iran.
Email Id: - alirohani172@gmail.com