Faculty of Science - University of Benghazi
Libyan Journal of Science & Technology
(Formerly known as Journal of Science & It's Applications)
journal home page: www.sc.uob.edu.ly/pages/page/77

Comparison between two ceramic veneer materials in their color and translucency before and after applying luting agent layer

Najat H. Bubteina [a], Rafa A. Mohamed [b], and Saied H. Mohamed [c,*]

[a] *Department of Operative Dentistry, Faculty of Dentistry, University of Benghazi-Libya*
[b] *Department of Physics, Faculty of Science, University of Benghazi, Libya*
[c] *Department of Removable Prosthodontics, Faculty of Dentistry, University of Benghazi*

ARTICLE INFO

Article history:
Received 03 July 2017
Revised 24 July 2017
Accepted 30 July 2017
Available online 13 August 2017

Keywords:
Veneer Materials, Optical Properties, Spectrophotometer.

* Corresponding author:
E-mail address: sd_abidi@yahoo.com
S.H. Mohamed

ABSTRACT

Statement of problem: In making veneer restoration to restore the human teeth, it is essential to produce the color and the shape of the artificial restoration similar to the natural teeth and this is not easy produced. Therefore, the effect of cementation layer on optical characteristic of aesthetic restoration is one of the critical factors in controlling the aesthetic outcome of veneer restorations.
The aim: The aim of this work is to evaluate the effect of luting cement on color and translucency of commercially available aesthetically ceramic veneer materials.
Materials and methods: The materials used were Zirkon Zahn and IPS e.Max Empress. All the experimental samples of laminate veneers (LVs) were prepared using readymade veneer mould (3M ESPE) to standardize the thickness and the dimension of the tested samples. Single layer of the luting cement was applied on the fitting surface of the veneer samples. The samples prepared following the manufacturers' instructions. Spectrophotometer was used to evaluate the color and translucency of tested samples.
Results: The IPS e.max samples showed higher TP and C*ab* values compared with zirconia samples. However, color difference (ΔE) values were higher for zirconia (3.28) compared with IPS e.max samples (2.92). Cement layer showed great effect on translucency and color parameter. Statistically, there was a high significant difference between tested samples (P-0>0.000).
Conclusion: The IPS e.max ceramic showed better color measurement than zirconia samples, however both materials found to be in the acceptable range of observation values. The luting cement had limiting the translucency and affects the aesthetic outcome.

1. Introduction

A veneer is a layer of material placed over the labial surface of a tooth, either to improve the aesthetics of discolored tooth or to protect the tooth's surface from damage (Dhir, 2015). Surface spectral reflectance has effect on the color of an object. Three-color systems (hue, chroma, and values) have been conventionally recognized; even though the translucency is one of the important factor in clinical selection of esthetic materials (Devigus *et. al.*, 2004; Baldissara *et. al.*, 2010; and Shiraishi *et. al.*, 2011). Spectrophotometers reported to be the most accurate instruments for measuring color in dentistry (Douglas *et al.*, 2007, Chu *et al.*, 2010 and Öngül *et al.*, 2012). These instruments measure spectral reflectance and can express it in terms of three coordinate values (L^*, a^*, b^*), which locate the object's color within the CIE (Commission internationale de l'éclairage) $-L^*a^*b^*$ color space. The CIE recommended calculating color difference (ΔE) based on CIELAB color parameters. The L^* coordinate represents the brightness of an object, the a^* value represents the red (positive value) or green (negative value) chromacity, and the b^* value represents the yellow (positive value) or blue (negative value) chromacity (CIE, 2004). The color difference (ΔE) of two materials can be evaluated by comparing the differences between respective coordinate values of each material. A lower ΔE value means a closer color match between a specimen and a target color (Chu *et al.*, 2010). There are two types of ceramic material used to fabricate a veneer: zirconia and IPS pressed ceramic. These materials were fabricated outside patient's mouth then bonded to the tooth surface using resin cement (Dhir, 2015, Chang *et al.*, 2009). Due to advanced technology and development in field of restorative dentistry, the concern about aesthetic restorations has been increased extremely. Dental professionals were challenged to construct restorations that duplicate form, function, and aesthetics of the natural teeth (Wee *et al.*, 2002; Tung *et al.*, 2002; and Lee *et al.*, 2007). The human eyes easily distinguish between natural and artificial teeth even when there are a little differences in color and translucency (Heffernan *et al.*, 2002 & Llie and Hickel 2008). Translucency were described as a state between complete opacity and transparency (Powers 2006; and Pe´rez *et al.*, 2010). Thickness, scattering, absorption coefficients, grain size and pigments were found to effect on the translucency of dental ceramic restorations. The translucency of a material is usually characterized employing the translucency parameter (TP), which defined as the color difference of a material of a given thickness over white and black backgrounds, and corresponds directly to common visual assessments (Johnston *et. al.*, 1995). A zero value of TP is representing completely opaque material and the greater the TP value the higher the actual translucency of the material. Good color match, associated with proper translucency, usually give superior aesthetics of the restoration (Raptis *et. al.*, 2006; Powers 2006; and Pe´rez *et al.*, 2010). Translucency is highly related to the thickness of the ceramic layer to be crossed by the light beam which influenced by light scattering. Scattering of the light is effected by many factors, such as different refractive indexes with ceramic phases, voids and porosities, high crystalline content, and crystal number and size, especially when the crystal particles are slightly larger than the wavelength of the incident light (Brodbelt *et al.*, 1980; Antonson and Anusavice 2001). The aim of current study deals with evaluation of the color parameters and translucency of veneer materials commercially available (Zirconia, and IPS e.max empress) bonded by Variolink Esthetic dental cement using spectrophotometer apparatus.

2. Materials and methods

2.1. Sample preparation

Materials used in this study were Zirconia (Zirkon Zahn–Italy) and IPS e.max Empress (Ivoclar. Viadent, Swisser-land) bonded by luting agent (Variolink Esthetic DC - Ivoclar Vivadent). Twelve samples of laminate veneers (LVs) were prepared using readymade veneer mould (3M ESPE, Seefeld, Germany) to standardize the thickness and the dimension of the tested samples.

2.1.1 Zirconia samples preparation

First, the veneer was prepared using light cure composite. The composite was filled in the veneer mould and cured by light cure for 20 seconds, then finished and polished. The final thickness was measured to be about 0.3 mm. Next, the composite veneer was fixed to a plate index in one side and zirconia block fixed in another side, then the block ground sequentially by milling machine to duplicate it to zirconia veneer. Later, the milled veneer was immersed in colouring liquid (A1 shade) for 5 second, then drying it under drying lamp for 10 minutes. The final sintering of zirconia veneer was done in sintering furnace for 9 hours. The glaze layer was done at a temperature of 910^{0}C.

2.1.2 IPS e.max samples preparation

IPS e.max empress samples were prepared using ingot medium opacity A1. The veneer was prepared first from wax pattern filed into readymade mold to standardize their thickness, then invested with refractory material. Afterward, the wax pattern was burnout as in conventional procedure. The ingot of porcelain was milt and injected using Ivoclar furnace (E.P. 300 Swiss). Then after, facial surface was cutback (Remove thin layer from facial surface). The coloured layer was applied onto one side of the specimens and fired at 765°C. All the specimens were examined under magnified lens to exclude any specimen that showed any surface defects. Meanwhile, the thickness was measured at three central points located at each quadrant in the cervical, middle, and incisal thirds of the labial surface of the laminate veneers to be 0.3 mm for all samples.

2.2. Applying of luting cement layer

The pre-treatment of the fitting surfaces of the laminate veneers was performed according to manufacturer's instruction. Each fitting surface was first cleaned through rinsing it with water spray and drying with oil-free air. This was followed by conditioning with Monobond Etch & Prime using microbrush, which was agitated into the surface for 20 seconds. A thorough rinsing off Monobond Etch & Prime with water spray was performed until the green colour had disappeared followed by drying the restoration with a strong stream of oil- and moisture-free compressed air for approximately 10 seconds. Subsequently, Monobond plus bonding agent was applied with a microbrush to the pre-treated surface, and was lifted for 60 s to react and then it was dispersed with a strong stream of air for 10 seconds. Single layer of the luting cement was applied on the fitting surface of the veneer using a microbrush and a new brush was used with each specimen. Separating medium (Vaseline) was applied on the lower part of the mould. The readymade mould (3M. ESPE) was used to standardize the thickness of cement layer and measured with veneer calibre to be about 0.1 mm in three different parts. Then the veneer was pressed firmly over the labial surface of the model and cured. The labial surface of the laminate veneers was subjected to a polymerization light using LED curing unit (SDI radii Plus Australia) with light intensity ≥ 500 mW/cm^2 for 20 seconds at a distance of 10-15 mm by moving the polymerization light in a circle in clockwise direction.

3. Measurement of color and translucency

Color (ΔE) was measured according to CIEL *a*b* system using spectrophotometer (Visible and UV/Visible Spectrophotometer- Shimadzu mini 1240- Japan) operating in the light range 0f 400-700 nm equipped with integrating sphere. The samples were directly tested by the spectrophotometer without a model. Color differences between black and white background readings were used for the analysis of translucency parameter (TP) and Chroma,

$$C^*_{ab} = \sqrt{(a^{*2} + b^{*2})} \quad (1)$$

Color measurement of each sample was done over white and black backgrounds in three coordinate dimensions of L^*: from 0 for "black" to 100 for "white" using the following equation,

$$\Delta E = \sqrt{(L^*_1 - L^*_0)^2 + (a^*_1 - a^*_0)^2 + (b^*_1 - b^*_0)^2} \quad (2)$$

Where: a^*- denotes green-red colors ($-a^*$=green, $+a^*$= red), b^*- denotes blue-yellow colors ($-b^*$=blue, $+b^*$= yellow), 0- represents the reflectance mode before the placement of cement (control), 1- represents the reflectance mode after the placement of cement. The translucency parameter (TP) of each sample was calculated using the following equation,

$$TP = \sqrt{(L^*_B - L^*_W)^2 + (a^*_B - a^*_W)^2 + (b^*_B - b^*_W)^2} \quad (3)$$

Where: the subscription B and W denotes the measurement modes on black and white backgrounds respectively. The measurements of all the above-mentioned parameters were taken on nine different areas of each sample and the mean was displayed for each parameter.

4. Statistical analysis

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. One way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance between groups. Paired sample t-test was used to compare between pairs of groups. Statistical analysis was performed using SPSS IBM V.22. P values ≤0.05 are considered to be statistically significant difference between groups.

5. Results

Table 1, Fig. 1 and Fig. 2 show the mean values of translucency parameter (TP), color differences (ΔE) and total CIE coordinate (L^*, a^*, b^*) before and after applying cement layers. It can be seen that IPS e.max samples displayed higher TP compared to zirconia samples (19. 17 and 13.11 respectively). In addition, C_{ab} values were higher for IPS e.max compared to zirconia samples. However, ΔE values were higher for zirconia (3.28) compared to IPS e.max samples (2.92) indicating that zirconia is more opaque than that of IPS e.max materials. Statistically, there was a high significant difference between two tested groups. From the results the luting cement has an impact in the color and translucency of ceramic materials and was reduced the color parameter values for both materials.

Table 1
Comparison of color parameters and translucency of Zirconia and e.max. IPS samples.

Samples	TP	C^*_{ab}	ΔE
Zr.	13.20±0.61	12.54±0.28	3.28±0.05
Zr. With cement	11.50±0.20	14.39±0.25	
e. max	19.64±0.52	21.46±0.31	2.92±0.34
e.max. with cement	17.96±0.86	23.75±0.34	
P-Value	0.000**	0.000*	0.000**

5. Discussion

The materials used in current study are widely accepted as aesthetics materials as well are available on the local marked and used in daily clinical practise. The use of color measurement devices such as colorimeters and spectrophotometers has become popular because of their accuracy, standardization, and numerical expression of colors (Dozic *et al.*, 2007; Lehmann *et al.*, 2011 & Llena *et al.*, 2011). The translucency of a material is laid between complete opacity and transparency (Powers 2006 & Pe´rez *et al.*, 2010).

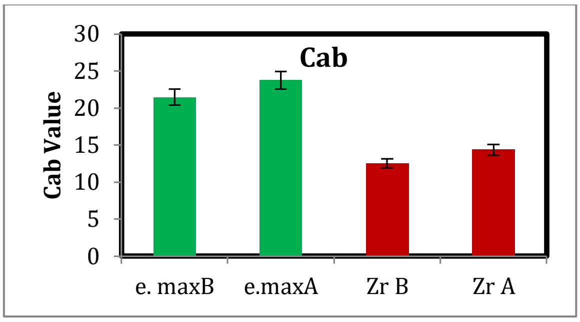

Fig. 1. Bar chart of Cab values for e. max and zirconia samples before and after applying cement layer

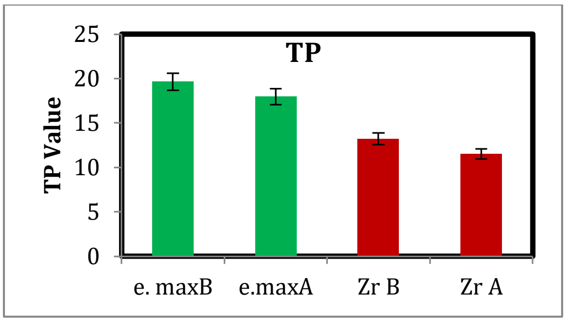

Fig. 2. Bar chart of TP values for e. max and zirconia samples before and after applying cement layer

The translucency of a material is usually evaluated by the translucency parameter (TP), which is the color difference of a material of a given thickness over a white and black backgrounds, then corresponds directly to common visual calculations (Johnston, 1995). Good color match, combined with proper translucency, usually produce superior aesthetics of the restoration (Raptis *et al.*, 2006, Powers 2006 & Pe´rez *et al.*, 2010). The threshold ΔE value, which is perceptible to half of the dentist observers, is about 2.6 ΔE units, and the acceptability tolerance for half of the dentist observers is 5.5 ΔE units (Douglas, *et al.*, 2007). The observation of the current study lay in this range. The materials that showed highly differences in their translucency values would be effect on the final restoration that are detectable by human eye (Shah *et al.*, 2008). The optical behaviour of a restoration needs to be similar to that of the replaced natural tooth (Shah *et al.*, 2008). IPS e.max samples demonstrated the slightly higher TP value than Zirkon Zahn, probably due to the intrinsic optical properties of the material. This may be due to small differences in internal structure and composition of the material and by the effect of milling process on the crystalline structure of the zirconia samples. There are various causes of diffusion within polycrystalline ceramic materials (Heffernan *et al.*, 2002; Chaiyabutr *et al.*, 2011 & Antonson and Anusavice 2011). The white opaque composite resin foundation increased the L^* and b^* values of the ceramic restorations and made the resultant restorations more yellow. The increase in b^* values for this group may due to the greater influence of the yellow luting agent against the white foundation material. The masking ability of the ceramic restorations depends on the optical properties of the material itself (Niu *et. al.*, 2013). The lower the percentage of light that is scattered and diffusely transmitted, the more opaque the material will appear. Degree of translucency found to be varies between different ceramic systems (Heffernan *et al.*, 2002, 2008; Spear *et al.*, 2008 and Kelly & Benetti, 2011). Subsequently, by increasing in crystalline content that give high core strength tend to be more opacity results in greater opaque material. Zirconia-based ceramic system has a higher opacity that can mask underlying color but cannot be manufactured without commercial laboratory facilities (Conrad *et al.*, 2007, and Kelly & Benetti, 2011).

6. Conclusions

Within the limit of this study, the following conclusion was drawn. The IPS e.max ceramic showed better color parameter than zirconia samples, however both materials found to be in the acceptable range of observation values. The luting cement had limiting the translucency and effects the aesthetic outcome. Spectrophotometer has been found to be reliable method for measuring the transparency of aesthetic materials.

Acknowledgments

The authors would like to thank Aljagbob Dental Laboratory-Benghazi Libya, for their kind help in preparation of testing samples.

References

Antonson, S.A., Anusavice, K.J. (2001) 'Contrast ratio of veneering and core ceramics as a function of thickness', *Int J. Prosthodont*, 4, pp. 316-20.

Azer, S.S., Rosenstiel, S.F., Seghi, R.R., Johnston, W.M. (2011) 'Effect of substrate shades on the color of ceramic laminate veneers', *J. Prosthet Dent*., 106, pp. 179-83.

Baldissara, P., Llukacej, A., Ciocca, L., Valandro, F.L., and Scotti, R. (2010) 'Translucency of zirconia copings made with different CAD/CAM systems', *J. Prosthet Dent*., 104, pp. 6-12.

Brodbelt, R.H., O'Brien, W.J., Fan, P.L. (1980) 'Translucency of dental porcelains', *J. Dent Res*, 59, pp. 70-5.

Devigus, A., Lombardi, G., Shading (2004) 'Vita In-ceram YZ substructures: influence on value and chroma, part II.' *International Journal of Computerized Dentistry*, 7, pp. 379–388.

Chaiyabutr, Y., Kois, J., Le Beau, D., Nunokawa, G. (2011) 'Effect of abutment color, cement color, and ceramic thickness on the resulting optical color of a CAD/CAM glass-ceramic lithium disilicate reinforced crown', *J. Prosthet Dent*., 105, pp. 83-90.

Chang, J., Da Silva, J.D., Sakai, M., Kristiansen, J., Ishikawa-Nagai, S. (2009) 'The optical effect of composite luting cement on all ceramic crowns', *J. Dent*., 37, pp. 937-43.

Chu, S.J., Trushkowsky, R.D., Paravina, RD (2010) 'Dental color matching instruments and systems. Review of clinical and search aspects', *J. Dent*., 38s, pp. 2-16.

CIE (Commission Internationale de I'Eclairage) (2004) 'Color-imetry-technical report'. *CIE pub. no.15*: 2004. 3rd ed. Vienna: Bureau Central de la CIE', pp. 18.

Conrad, H.J., Seong, W.J., Pesun, I.J. (2007) 'Current ceramic materials and systems with clinical recommendations: a systematic review', *J. Prosthet Dent*., 98, pp. 389-404.

Dhir, LCV. (2015) 'Porcelain laminate veneers for a conservative aesthetic enhancement of smile', *IJRID*, (5)4, pp. 96-101

Douglas, R.D., Przybylska, M. (1999) 'Predicting porcelain thickness required for dental shade matches', *J. Prosthet Dent*., 82, pp. 143-149.

Dozic, A., Kleverlaan, C.J., El-Zohairy, A., Feilzer, A.J., Khashayar, G. (2007) 'Performance of five commercially available tooth color-measuring devices', *J. Prosthodont*, 16, pp. 93-100.

Heffernan, M.J., Aquilino, S.A., Diaz-Arnold, A.M., Haselton, D.R., Stanford, C.M., Vargas M.A. (2002) 'Relative translucency of six all-ceramic systems. Part I: core materials', *J. Prosthet Dent*., 88, pp. 4-9.

Heffernan, M.J., Aquilino, S.A., Diaz-Arnold, A.M., Haselton, D.R., Stanford, C.M., Vargas, M.A. (2002) 'Relative translucency of six allceramic systems. Part II. Core and veneer materials'. *Journal of Prosthetic Dentistry*, 88, pp. 10–5.

Johnston, W.M., Ma, T., Kienle, B.H. (1995) 'Translucency parameter of colorants for maxillofacial prostheses'. *International Journal of Prosthodontics*, 8, pp. 79–86.

Lee, Y.K., Cha, H.S., Ahn, J.S. (2007) 'Layered color of all-ceramic core and veneer ceramics', *J. Prosthet Dent*., 97, pp. 279-86.

Lehmann, K.M., Devigus, A., Igiel, C., Wentaschek, S., Azar, M.S., Scheller, H. (2011) 'Repeatability of color-measuring devices'. *Eur J Esthet Dent*., 6, pp. 428-35.

Llena, C., Lozano, E., Amengual, J., Forner, L. (2011) 'Reliability of two color selection devices in matching and measuring tooth color', *J. Contemp Dent Pract*., 12, pp. 19-23.

Llie, N., Hickel, R. (2008) 'Correlation between ceramics translucency and polymerization efficiency through ceramics'. *Dent Mater*., 24, pp. 908-14.

Kelly, J.R., Benetti, P. (2011) 'Ceramic materials in dentistry: historical evolution and current practice', *Aust Dent J*; 56 (suppl 1), pp. 84-96.

Öngül, D., Sermet, B., Balkaya, M.C. (2012) 'Visual and instrumental evaluation of color match ability of 2 shade guides on a ceramic system', *J. Prosthet Dent*., 108, pp. 9-14.

Powers, J.M. (2006) 'Restorative dental materials'. 12th ed. St. Louis: Mosby; pp. 35–42.

Pe´rez, M.M., Ghinea, R., Ugarte-Alva´n, L.I., Pulgar, R., Paravina, R.D. (2010) 'Color and translucency in silorane-based resin composite compared to universal and nanofilled composites', *J. Dent*; 38 (S), pp. 110–116.

Shah, K., Holloway, J.A., Denry, I.L. (2008) 'Effect of coloring with various metal oxides on the microstructure, color, and flexural strength of 3Y-TZP', *J. Biomed Mater Res B Appl Biomater*; 87, pp. 329-37.

Shiraishi, T., Wood, D.J., Shinozaki, N., van Noort R. (2011) 'Optical properties of base dentin ceramics for all-ceramic restorations', *Dental Materials*, 27, pp. 165–72.

Spear, F., Holloway, J. (2008) 'Which all-ceramic system is optimal for anterior esthetics', *J. Am Dent Assoc*, 139 (suppl), pp. 19-24.

Tung, F.F., Goldstein, G.R., Jang, S., Hittelman, E. (2002) 'The repeatability of an intraoral dental colorimeter', *J. Prosthet Dent*., 88, pp. 585-90.

Raptis, N.V., Michalakis, K.X., Hirayama, H. (2006) 'Optical behavior of current ceramic systems'. *International Journal of Periodontics & Restorative Dentistry*, 26, pp. 31–41.

Wee, A.G., Monaghan, P., Johnston, W.M. (2002) 'Variation in color between intended matched shade and fabricated shade of dental porcelain', *J. Prosthet Dent*., 87, pp. 657-66.