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Color Masking Ability of Three Dental Ceramics with Different Translucencies

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ABSTRACT

Purpose: the aim of this study was to evaluate the color masking ability of three dental ceramics with different translucencies. **Materials and methods:** Fifty-four discs of ceramics were made from three dental ceramic materials (High translucency zirconia, low translucency IPS E.max CAD and translucent Vita Suprinity). Shade of three dental ceramics was A2. They were divided into three equal groups (n=18). Each group was subdivided into three subgroups (n=6) according to composite substrate shade (A4, B4, C4) on which each ceramic disc was cemented with translucent resin cement. Color difference(ΔE) and translucency parameter (TP) were evaluated by spectrophotometer. **Results:** Before cementation, IPS E.max showed the highest median TP values. As regards color change, no statistically significant difference between the three dental ceramic types was found. Also, non-statistical significance difference between three shades of composite substrate (A4, B4, C4). **Conclusions:** IPS E.max (low translucency) shows better translucency than translucent vita suprinity and High translucency zirconia. In all types of ceramics, there was statistically significant decrease in translucency parameter (TP) after cementation with translucent resin cement. The color changes (ΔE) exceeded the perceptible limit for the three types of dental ceramic, so it was concluded that the tested ceramics didn't exhibit sufficient color masking ability to hide the dark substrate of the composite shades used (A4, B4, C4).

KEYWORDS

Color masking, Translucency, Dental ceramics

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INTRODUCTION

In comparison to traditional metal-ceramic restorations, ceramics are widely employed in dentistry because of their superior esthetics, chemical and color stability, great wear resistance, and biocompatibility[1].

Glass ceramic restorations are better than metal-ceramic restorations because they allow more light transmission and have the ability to mimic the natural appearance of the tooth structure. The stronger the light transmission, and the more lifelike the appearance, the more translucent the ceramic is [2].

Replicating the appearance of the natural tooth with ceramic restoration is a multi-factorial procedure that continues to be a source of concern. Color stability and shade of the ceramics like: level of translucency, fluorescence, opalescence, surface texture, thickness of ceramics, and technique of fabrication, all influence the final color of the ceramic restoration. Because of this combination, the ceramic shade chosen may not match the exact color of the dental complex, jeopardizing the final ceramic`s appearance. As a result, the definitive restoration color should not be assessed separately [3].

The success of dental treatment, on the other hand, is multi-factorial and depends on a good match of colors between the ceramic restoration and the remaining tooth structure, as well as the thickness, type, and shade of ceramic and adhesive resin luting agents. Furthermore, the degree of light reflection and dispersion determines the translucency of the restorative substance. Resin-based cements, together with all-ceramic materials, are regarded as the most significant component of dental treatment success [4].

The final color of ceramic is determined by the opacity and the color of the darkened substrate, nature of ceramic, crystal particle`s size and number and the material's inherent optical properties of opalescence, fluorescence, and translucency [5]. Ceramic translucency can be affected by multiple elements including thickness, chemical nature, number of firing cycles and type of underlying cement [6].

Translucency is the relative amount of light transmission or diffuse reflectance from a surface. For translucent materials most of the incident light is transmitted and some of them is absorbed, whereas less translucent materials reflect and absorb light dropping on it [7].

Metal ceramic restorations have problems achieving a pleasing appearance, so all ceramic restorations have been commonly used. The usage of zirconia restorations has expanded in the dental area among several all-ceramic restorations. Zirconia crowns come in two varieties: complete zirconia crowns and zirconia-based crowns. Prefabricated zirconia cores are layered by porcelain veneers in zirconia-based crowns, whereas full zirconia crowns are monolithically manufactured from zirconia blocks by CAD-CAM without the requirement for layering [8].

Lithium disilicate is available in two forms: pressable and CAD-CAM. It appears to be the ideal material because rather than cutting back the core and applying ceramic powder and liquid ceramic on top, the preparation is milled to anatomical shape and stained, resulting in a highly strong restoration[9].

The success of CAD-CAM technology and materials science has led to the development of new materials such as Zirconia reinforced-lithium Silicate (ZLS). Zirconia reinforced lithium silicate (ZLS) glass ceramic (Celtra duo or Suprinity) is one of the strongest, stiffest and hardest reinforced materials available in the market, with flawless presentation. A dual microstructure exists in zirconia reinforced lithium silicate, such as vita Suprinity or Celtra duo. The first component is lithium metasilicate particles with very tiny lithium disilicate crystals. The glassy matrix, which contains 10% zirconium oxide, is the second component. This microstructure provides for high flexural strength while also providing a high percentage of glassy matrix, resulting in optical, milling, and polishing qualities that are acceptable [10,11].

The purpose of this in vitro study was to assess the color masking ability of three dental ceramics with different translucencies (translucent Vita Suprinity, high translucency zirconia, low translucency IPS E. max) required for masking severe discoloration of different composite substrates (A4, B4, C4 shades). The null hypothesis was that all three types of dental ceramics would not be able to mask dark color of different substrates.

MATERIALS AND METHODS

1- Fabrication of ceramic samples:

Fifty-four Ceramic discs;18 low translucency IPS E.max CAD,18 translucent Vita Suprinity and 18 high translucent zirconia were cut at dimensions of 8mm in diameter and 1 mm in thickness with a low-speed diamond saw under water cooling (Isomet 4000). Shade of ceramic discs was A2. Then crystallization was done for both Vita Suprinity and IPS E.max CAD and sintering was done for high translucent zirconia. Finishing and polishing was done for samples by silicon carbide paper. Glazing was done by Cerabien ZR clear glaze material on high translucency zirconia discs, IPS E.max glaze material on low translucency IPS Emax CAD discs and Vita akzent® plus glaze material on translucent Vita Suprinity discs.

2- Experimental design:

Fifty-four discs of ceramics were divided into three equal groups (n=18).

- Group A: 18 discs of low translucent IPS E.max CAD.
- Group B: 18 discs of translucent Vita Suprinity.
- Group C: 18 discs of high translucent zirconia.

Each group was subdivided into three subgroups (n=6) according to substrate shade:

- Subgroup 1:6 discs of ceramics were cemented to composite resin substrate of shade A4.
- Subgroup 2:6 discs of ceramics were cemented to composite resin substrate of shade B4.
- Subgroup 3:6 discs of ceramics were cemented to composite resin substrate of shade C4.

3- Construction of composite resin substrate samples:

A total of fifty-four samples were made from light cured composite resin material with A4(n=18), B4 (n=18) and C4 (n=18) shades to stimulate different shades of the dark substrate with dimensions of 8mm in diameter and 5mm in thickness by using split copper mold.

4- Cementation of ceramic discs.

A layer of resin cement was put between ceramic discs and substrate (Fig.1). Type of resin cement was translucent resin cement (Choice ™ 2, light cured veneer cement, Bisco). Cementation was done with application of 250 g load for 20 second using cementation device to make initial curing and get a uniform thickness of cement, then the load was removed for further curing for another 20 seconds.

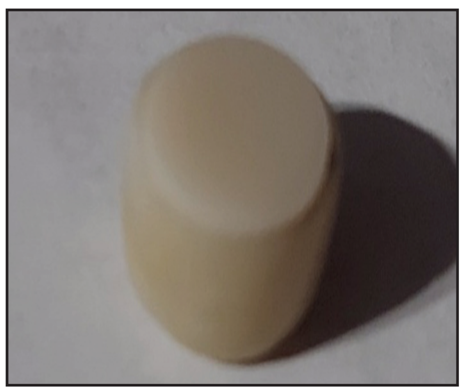

Figure (1): Ceramic disc cemented to composite substrate

5- Color measurement:

Color difference was measured before and after cementation by spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). The size of aperture was set to 4mm and the samples were aligned with the device. Measurements had been done according to CIE L*a*b* color space. Color difference (ΔE) between the values of L*, a* and b* obtained according to the following formula:

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

ΔL^* =lightness (0-100), Δa*= (color variation axis red/green) and Δb*= (change of the color of the yellow/blue) [12].

RESULTS

Translucency parameter (TP):

Before cementation, highest median value was recorded for IPS E.max, while lowest median value was recorded for high translucent zirconia (Table 1, Fig .2).

Table (1) *Descriptive statistics and results of Kruskal-Wallis test for comparison between TP values of different ceramic types.*

Shade& Cementation	IPS E.max		Suprinity		Katana		P-value	Effect size (Eta Squared)
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)		
A4 before cementation	23 (6)	22.2 (15.6-30.9)^A	20 (2.6)	19.6 (17.5-23.9)^B	14.9 (3.4)	16.6 (10.1-18) ^{C}	0.042*	0.36
B4 before cementation	20 (1.7)	19.8 (17.9-21.7)	16.7 (2.1)	16.7 (13.6-19.1)	20.1 (3.2)	19.1 (17-25.4)	0.074	0.267
C4 before cementation	18.5 (2.5)	18 (15.8-21.2)	16.1 (2.7)	16.1 (12.8-19.9)	15.8 (4.5)	17 (8.3-19.8)	0.395	0.012

**: Significant at $P \le 0.05$, Different superscripts in the same row indicate statistically significant difference between ceramic types.*

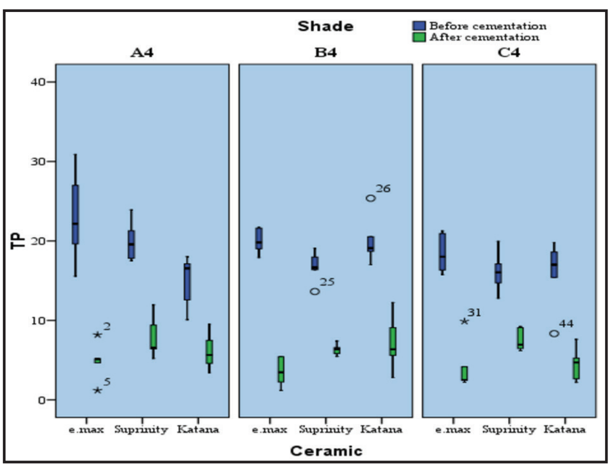

Figure (2): Box plot representing median and range values for TP of different ceramic types (Stars and circles represent outliers)

Color changes (ΔE):

Descriptive statistics showing mean, standard deviation and median of color changes test results measured in (ΔE) for three types of dental ceramics before and after cementation with translucent resin cement to different shades of composite. Results show that there was no statistically significant difference between ceramic types and all types would not be able to mask dark substrate (Table 2, Fig .3).

Table 2: *Descriptive statistics and results of Kruskal-Wallis test for comparison between ΔE values of different ceramic types.*

Shade	E.max		Suprinity		Katana		P-value	Effect size (Eta Squared)
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)		
A4	17.1 (4.1)	16.9 (11.1-22.2)	20.1 (3.9)	21 (15.3-25.4)	15.6 (6.7)	16.2 (4.7-22.7)	0.533	0.062
B4	15.7 (1)	15.4 (14.6-16.9)	16.7 (2.4)	17.4 (14.1-19.5)	17.2 (4.9)	15.5 (12.9-25.2)	0.827	0.135
C4	16.1 (3)	15.7 (12.2-19.9)	17.5 (3)	18.2 (13.3-21.1)	12 (2.9)	11.1 (9.4-16.4)	0.054	0.318

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

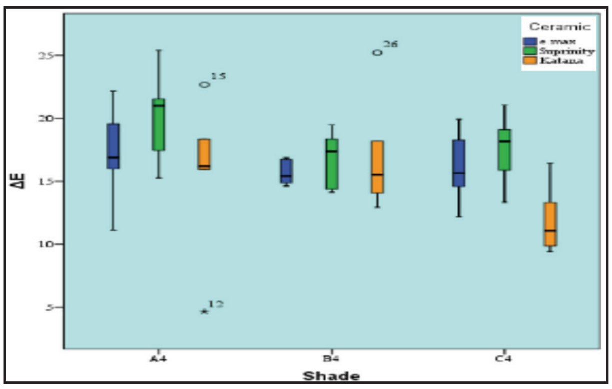

Figure (3): Box plot representing median and range values for ΔE of different ceramic types (Star and circles represent outliers)

DISCUSSION

Dental ceramics were one of the most important materials used as a final anterior esthetic restoration, due to their optical properties as they resembled the natural teeth, good wear resistance, and color stability. Recently, the companies claim that the newly -introduced all-ceramic systems in dentistry had translucent properties comparable to feldspathic porcelains with enhanced mechanical resistance. As a result, longevity and aesthetics must be taken into account while making a decision (13).

Lithium disilicate ceramic material is regarded as one of the most important ceramic materials nowadays. The translucency and light diffusion property of lithium disilicate ceramics could imitate natural tooth structure for an esthetic invisible restoration (14).

New category of glass ceramics is being added in an updated classification in 2015 as the zirconia-reinforced lithium silicate. In vitro testing of the ZLS recorded a positive combination between the material characteristics of zirconia and glass ceramics, however these materials are recent in the market (15).

Because of the high translucency of materials that have been mentioned before, zirconia-based restoration was evaluated to assess their translucency & color masking ability. Therefore, the study reported here was to assess the color masking ability of three dental ceramics with different translucencies.

The Null hypothesis of our study stating that the three types of dental ceramics would not be able to mask dark substrate was accepted, because the color difference (ΔE) of ceramic restorations was affected by the type, translucency of dental ceramics and the shade of the substrates. This finding was in accordance with previous studies (15-17). Their reasons were related to thickness of the dental ceramics. Thickness of dental ceramics is inversely proportion to translucency and color difference (ΔE). Articles using ceramic thickness of 1mm or less, concluded that the ceramic material couldn't mask dark substrate color. Other explanations were related to microstructure of dental ceramics and usage of translucent resin cement as translucent types of ceramics or cement produced samples with dark color.

One of the studies in agreement with us stated that the color differences (ΔE) were constantly over the clinically perceptible level when using ceramic thickness 1mm and color differences would not be adequately hidden by changing the shade of the cement. If the thickness of the ceramic was 2 mm or more, the color of the darkened substrate and the shade of cements were found to have no effect on the final color [16].

Another study in accordance with us evaluated the effect of background color and thickness of lithium disilicate (low translucency) and zirconia - reinforced lithium silicate(translucent). Shade of composite background was (A2 and C4). It was concluded that the increased ΔE values in all studies between ceramic color before and after cementation to the dark substrate due to the translucency of the ceramic itself which allow passage of light through it to reach the dark background, then the light was reflected through the ceramic influencing the final color [17].

Our finding was matching with another study that evaluated the effect of substrate and resin cement shades on dental ceramic color masking ability. Ceramic discs were fabricated from IPS E.max (low translucency) and Translucent Vita Suprinity. Backgrounds were fabricated from shade A3 and C4 composite. Translucent and opaque resin cements were used. The results revealed that translucent resin cement recorded higher (ΔE) color change mean values than opaque resin cement on dark substrate. Another study reported that translucent resin cement decreased L* values and produced samples darker in color [18].

Results of the current study were against some previous studies that reported different reasons like the usage of neutral background and the usage of ceramic material with high contrast ratio [19,20].

The author of one of the contradicting research looked at how the color of the composite substrate and cement affected the color of lithium disilicate. White opaque cement caused clinically unacceptable color changes, whereas translucent resin cement had no effect on the final color of ceramics. It's possible that this is because they utilized a tooth-colored substrate rather than a dark one [19].

Our findings contradicted those of a previous study that looked at the impact of different background colors on zirconia crowns. A3 was the zirconia shade. They used a metal cast post and a prefabricated post. There were no significant changes in the L*, a*, and b*values of zirconia crowns cemented on the two posts, according to the researchers. It's possible that this is due to the use of material with a high contrast ratio. The contrast ratio (CR) of the ceramic material should be between 0.93-0.94 to give results less than 3.7. In that investigation, the contrast ratio of zirconia restoration was high, making it opaque [20].

Regarding to the translucency parameter (TP), we have found that lithium disilicate showed statistically significant higher median translucency compared to zirconia- reinforced lithium silicate and zirconia ceramics. This finding is in accordance with some previous studies. Their explanations were that the glassy matrix of IPS E. max is responsible for the translucency of material. TP valves of human enamel and dentin are near to those of lithium disilicate and away from zirconia, Refractive index of lithium disilicate was close to the refractive index of glass ceramics which gave the material higher translucency [21-24].

Another finding in accordance with us, reported that the high translucency of lithium disilicate may be due to glassy phase responsible for light transmission. Proper translucency needs material with low light absorption and low scattering of incident light by close matching of refractive index between crystals and glassy matrix [21].

Another study in agreement with our findings, assessed TP of (LDS) lithium disilicate in both translucencies (High and low) and zirconia -reinforced lithium silicate (ZLS-HT). TP values of LDS was close to those values of human enamel and dentin. As a result, LDS had the highest translucency, followed by ZLS [22].

Another study aimed to evaluate TP between lithium disilicate and different monolithic zirconia ceramics. Translucency results coincided with the present study. TP values in IPS E.max CAD were found to be greater than in zirconia ceramics. This could be because zirconia's TP was lower than that of human enamel and dentin. The ability of glass ceramics to produce a superior visual likeness to natural teeth was confirmed by these findings [23,24].

Results of the current study were against some previous studies. Some of them reported that zirconia-reinforced lithium silicate (ZLS)has better translucency than IPS E.max, due to ZRO_2 which act as nucleating center and produces fine grain size that gave ZLS higher translucency than IPS E.max, and others reported that both materials have the same translucency as they have similar composition [25-27].

This was not in accordance with the results of some studies, which assess translucency of (ZLS) zirconia reinforced lithium silicate in both translucencies (high and low) and (LDS) lithium disilicate glass ceramics in also both translucencies (high and low). it was concluded that ZLS demonstrated better translucency than LDS. This might be due to the presence of ZRO_2 particles that acted as centers of nucleation, leading to more homogenous structure with fine grain size (0.5μm) for vita suprinity, so producing more translucent appearance for vita suprinity and less translucency for LDS [25].

Another contradiction was found with other studies, which evaluated the translucency of Zirconia -reinforced lithium silicate (high and low translucencies) and lithium disilicate (high and low translucencies). Ceramic samples were prepared in different thicknesses (1,1.2,1.5,2 mm). They concluded that ZLS had much higher TP values than LDS. The reason for this could be due to presence of 10% zirconia dissolved into silicate glass matrix, which resulted in 4 times smaller crystal size, implying a high glass content and higher translucency than conventional lithium disilicate, so ceramic translucency increases as particles size decreases [26].

However, the translucency results of the present study were not consistent with some studies which claimed that zirconia reinforced lithium disilicate (ZLD-HT-A1) and lithium disilicate (LDS-HT-A1) had similar translucency. This observation could be explained by the fact that LDS and ZLS ceramics have comparable compositions [27].

CONCLUSIONS

Within the limitations of this study, it was concluded that:

- The underlying tooth abutment color and ceramic type had impact on the color matching of the dental ceramic materials used.
- The translucency of lithium disilicate ceramic was superior than zirconia and zirconia reinforced lithium silicate.
- Color difference (ΔE) was clinically unacceptable for the three types of dental ceramics used; the three types couldn't mask the dark substrates used.
- There is no statistically significance difference in color difference (ΔE) between the three types of dental ceramics and the three substrate shades.

RECOMMENDATIONS

Opaque ceramics and opaque cements could be used to mask darkened substrates.

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NO CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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