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# EFFECT OF CERAMIC THICKNESS, TRANSLUCENCY AND CEMENT SHADE ON COLOR MASKING ABILITY OF PRESSABLE ZIRCONIA BASED LITHIUM SILICATE LAMINATE VENEER

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## *ABSTRACT*

**Objective:** This in-vitro study aimed to evaluate the effects of ceramic thicknesses and translucencies as well as resin cement shades on the masking ability of zirconia based lithium silicate discs (ZLC).

**Materials and Methods:** Eighty-four ceramic discs were manufactured from high translucent (HT) and translucent (T) ZLC ceramic. Discs were divided into three equal subgroups according to their thickness (0.5, 1, 1.5 mm). Background composite resin discs (shade C4D) were used to simulate the color of dark abutments. Ceramic discs were cemented to composite ones with either translucent or opaque resin cements. Color parameters were measured using a spectrophotometer and recorded by CIELab system, color difference between ceramic discs and cemented ceramic discs to composite were calculated as $\Delta E$. All data were statistically analyzed using unpaired-t test, ANOVA test and Tukey HSD test. Statistical significance was set at $p<0.05$.

**Results:** A statistically significant color difference ($\Delta E$) was found between (HT) and (T) discs ($P<0.05$). $\Delta E$ values of both translucencies were affected by ceramic thickness ($P=0.000$). Resin cement shade had no significant effect on $\Delta E$ values when the thicknesses of ceramic veneer were 1.0 mm or 1.5 mm (P values=0.495 and 0.265 respectively). While the cement shades had a highly significant effect on $\Delta E$ values when ceramic disc thickness was 0.5 mm (P value<0.0001).

**Conclusion:** As the veneer thickness increased, color change decreased significantly. Ceramic translucency and cement shade significantly influence the final color of pressable ZLC veneers only if the thickness is less than 1 mm.


**KEYWORDS**: Color, Laminate veneers, Zirconia based lithium silicate, Resin cement, Ceramic thickness.

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## INTRODUCTION

Recent improvements in esthetic dentistry led to the development of innovative ceramic materials with better mechanical, physical and optical properties.[1] Since the 2000s, lithium silicate and disilicate glass ceramics as well as yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) were used in fixed prosthodontics. [2] Recently, zirconia-reinforced lithium silicate glass ceramics (ZLS) was introduced to the dental market [3]. In ZLS restorations, 10% zirconium dioxide ($ZrO_2$) particles are homogeneously incorporated inside lithium-metasilicate ($Li_2SiO_2$) glass ceramic matrix improving its biocompatibility, surface finish, mechanical and esthetic properties. [3-5]

In 2017, Saavedra et al [6] reported satisfactory success rates of anterior crowns fabricated from ZLS after a 2-years clinical study. In 2020, Rinke et al [7] concluded a 99% survival rate after success of sixty-six partial coverage ZLS crowns out of sixty-nine, after 3 years of observation period. ZLS may be presented as machinable CAD blocks either in a partially crystallized form as Vita Suprinity (Vita Zahnfabrik, Bad Säckingen, Germany) or in a fully crystallized state as Celtra Duo (Dentsply Sirona co., USA). [8] In 2019, ZLC was presented as pressable pellets (Vita Ambria, Vita Zahnfabrik, Bad Säckingen, Germany), Vita Ambria is used for fabrication of inlays, onlays, partial veneer crowns, full veneer crowns, three- units bridges up to the second premolars and laminate veneers. [9]

In general, ceramic laminate veneers are preferable to resin laminates, as the latter's durability is questionable due to wear, discoloration and marginal fracture. [10] Ceramic laminate veneers are bonded to the prepared and unprepared teeth with composite resin cement where the laminate's thickness varies from 0.5 to 1.5mm. [11] Moreover, 0.3 mm. thick prep-less anterior laminates are also possible. [12] Shade matching of laminate veneer with the neighboring teeth and masking the original color of the abutment is a complex challenging clinical step. Final shade of a laminate veneer is influenced by many ceramics-related factors such as (ceramic brand and batches [13], ceramic translucency and opalescence[14,15],ceramic thickness and shade, condensation technique and number of firing cycles.[16,17] In addition, cement shade and the color of underlying abutment are important factors.[15,18,19] Translucent and highly translucent Vita Ambria ZLC are used in the construction of esthetically anterior laminate veneers, however their translucencies may affect the masking ability which means that discoloration may be noticeable through the ceramic .[20,21] When laminate veneer is thin, numerous shades [22,23] and brightness levels[24,25] of resin cements may influence the color. Thus, optical properties of the composite resin cement decide the final color of veneers.[22, 26].

Shade of the restoration can be determined either visually or instrumentally. Instrumental shade matching with a device as spectrophotometer can quantify color parameters (L, a, and b values) allowing precise and successful communication between prosthodontists and dental technicians [27]. The quantity of perceptible color changes in each specimen is evaluated using the Commission Internationale d'Eclairage (CIE) L,a,b measurements, The CIE Lab system was established based on the primary colors[28] to exclude inherent variations in color perception among different evaluators. [15]

The objective of this study was to determine the effect of different ceramic thicknesses (0.5 mm, 1 mm and 1.5 mm) fabricated from two Vita Ambria translucencies (Translucent, High translucent) and cemented on a chromatic background by two resin cement shades (translucent and opaque) on the masking ability and final color of laminate veneers. The null hypothesis was that different ceramic translucencies, ceramic thicknesses and resin cement shades would have no significant effect on the final color of laminate veneers.

## MATERIALS AND METHODS

Eighty-four ceramic discs (12 mm in diameter) were fabricated using ZLC pressable ceramic material (Vita Ambria, Vita Zahnfabrik, Bad Säckingen, Germany) from low translucency and translucent (T) ingots (A1 shade). The sample size was calculated using G*Power analysis program (v3.1.9; Heinrich-Heine-Universität Düsseldorf, Germany). According to previous studies [3,11,19],42 specimens per group representing 80% power, considering $\alpha$ equal to 5 %.

Samples were divided into two equal groups: group I: High Translucent (HT) discs (n=42) and group II: Translucent (T) discs (n= 42). Samples were subdivided into three equal subgroups (n=14) according to ceramic disc thickness: Subgroup A: 0.5 mm, Subgroup B: 1 mm, Subgroup C: 1.5 mm. Then samples were further equaly subdivided into two divisions (n=7) according to the shade of resin cement used; Division 1: samples were cemented with translucent resin cement. Division 2: samples were cemented with opaque resin cement. Sample grouping is shown in Table (1). Materials used in this study with their commercial name, specifications, compositions, and manufacturer are presented in Table (2).

TABLE (1) Sample Grouping

| HT Discs (42 samples) | | | | | | T Discs (42 samples) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 mm (14samples) | | 1 mm (14samples) | | 1.5 mm (14samples) | | 0.5 mm (14samples) | | 1 mm (14samples) | | 1.5 mm (14samples) | |
| Cement Translucent ( 7 samples) | Cement opaque ( 7 samples) | Cement Translucent ( 7 samples) | Cement opaque ( 7 samples) | Cement Translucent ( 7 samples) | Cement opaque ( 7 samples) | Cement Translucent ( 7 samples) | Cement opaque ( 7 samples) | Cement Translucent ( 7 samples) | Cement opaque ( 7 samples) | Cement Translucent ( 7 samples) | Cement opaque ( 7 samples) |
| Total number of samples = 84 | | | | | | | | | | | |

TABLE (2) Materials used in this study

| Material | **Type of material** | **Shade** | **composition** | **Manufacturer** |
|---|---|---|---|---|
| **Vita Ambria** | Pressable Zirconia reinforced lithium silicate ceramic | -Highly translucent<br>-Translucent | Components Wt.% : $SiO_2$ 58 – 66% ,$Li_2O_{12}$ – 16% , $ZrO_2$ 8 – 12% ,$Al_2O_3$ 1 – 4% , $P_2O_5$ 2 – 6% ,$K_2O$ 1 – 4% ,$B_2O_3$ 1 – 4% , $CeO_2$ 0 – 4% , $Tb_4O_7$ 1 – 4% , $V_2O_5$ < 1 %,$Er_2O_3$ < 1 % ,$Pr_6O_{11}$ < 1 % | Vita Zahnfabrik, Bad Säckingen, Germany |
| **Filtek Z350 XT** | visible light-activated composite | C4D (Dentine body) | 20 nm silica filler, non- agglomerated/non-aggregated 4 to 11 nm zirconia filler, and aggregated zirconia/ silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles). | 3M, ESPE, St Paul, MN, USA |
| **RelyX Veneer cement** | Light-cure, methacrylate resin-based luting material. | -Translucent<br>- Opaque | bisphenol-A-diglycidylether dimethacrylate (BisGMA) and triethylene glycol dimethacrylate (TEGDMA) polymer.<br>Zirconia/silica and fumed silica fillers are used to impart radiopacity, wear resistance and physical strength.<br>The filler loading is approximately 66% by weight. The average particle size for thefiller is approximately 0.6 mm. | 3M, ESPE, St Paul, MN, USA |
| **RelyX Ceramic Primer** | Ceramic primer | | prehydrolyzed silane-coupling agent, alcohol and water. | 3M, ESPE, St Paul, MN, USA |

**Fabrication of Pressable ZLC discs**

Three custom-made Teflon molds were constructed with 12-mm. diameter to standardize the diameter of disc-shaped wax patterns but with different heights. The first mold was 0.5 mm high, the second was 1 mm. While the third was 1.5 mm high. The 42-wax patterns of group I were sprued and weighted to calculate the needed quantity of Ambria HT pellets. Investing was done in a silicone ring using phosphate bonded investment powder and liquid (Vita Ambria Invest,Vita Zahnfabrik, Bad Säckingen, Germany) with the Vita Ambria muffle system. After setting of the investment, the investment ring was removed from the muffle and separated from the ring. Investment ring was preheated at 850°C for 75 minutes. Pressing was done using HT pellets (shade A1) with a disposable press plunger (Vita Ambria plunger, Vita Zahnfabrik, Bad Säckingen, Germany) in combipress unit (Vita Vacumat 6000, Vita Zahnfabrik, Bad Säckingen, Germany). After pressing the ring was removed from the furnace and allowed to cool then divestment was done. The same procedures were repeated using translucent pellets for group II (T).All samples were inspected for any imperfections. The thickness of all specimens were then checked with a micrometer (Renfert Calipretto S, Renfert GmbH, Hilzingen, Germany) to be sure that the tested thicknesses were (0.5, 1, or 1.5 mm). Finishing and polishing was done using Vita Suprinity polishing set (Vita Zahnfabrik, Bad Säckingen, Germany). The surfaces of all samples were cleaned in an ultrasonic bath with distilled water for 10 minutes and then dried using compressed air. The down surfaces of the discs that would face the cement were etched with Vita ceramic etch gel (Vita Zahnfabrik, Bad Säckingen, Germany) for 20 seconds then rinsed followed by application of ceramic primer (RelyX Ceramic Primer,3M ESPE, St Paul, MN, USA). Finally, surface glaze were applied to the upper surfaces of the discs that would face the spectrophotometer (Vita Akzent plus stain, Vita Zahnfabrik, Bad Säckingen, Germany).

**Fabrication of composite resin discs and cementation procedures**

To simulate the shade of a dark abutment, a nanohybrid composite discs of shade C4 Dentine (Filtek Z250, 3M ESPE, St Paul, MN, USA) were fabricated .They were made using a silicone mold made of Putty consistency PVS (Affinis, Coltene co., Switzerland), with the following dimensions 12 mm in diameter and 5 mm in thickness. The treated Vita Ambria specimens were cemented to composite resin discs. Light-cured resin cement (RelyX Veneer cement system, 3M ESPE, St Paul, MN, USA) with either translucent (Cem TR) or opaque (Cement Op) shades were applied and cured for 30 seconds.

To ensure that cement had standard thickness (0.1mm) in all samples, a specially designed ring stopper 6mm in thickness was fabricated. [29] Composite disc was placed inside the stopper, then the cement was applied followed by application of Vita Ambria samples with the treated surface facing the cement followed by applying a 750 gm load for 10 seconds.[3] All Samples were numbered from 1 to 7 for each division and then divided randomly by online site (www.random.org) at allocation ratio 1:1 and sealed in closed envelopes to prevent any bias.

**Shade measurements**

All measurements were performed by a well-trained clinician (M.F.) to evaluate the shade. Samples' shade were measured using spectrophotometer (Vita Easyshade Advance, Vita Zahnfabrik, Bad Säckingen, Germany). Before measurements, Vita Easyshade Advance was calibrated using its tile according to the manufacturer's instructions, Easyshade screen displayed the L* a* b* coordinates for the measured shade, CIELab values were recorded for the ceramic discs thicknesses and these measurements were kept as base readings. Then, Vita Easyshade measured each ceramic disc complex (Vita Ambria disc + cement +composite disc) three times; disc's color was determined by calculating the average of the three readings (Fig.1). All recorded values in CIELab coordinates of ceramic discs and ceramic disc complex were transferred to a personal computer (Dell latitude E5540, Dell co., USA). The CIELab measurements can evaluate the amount of perceptible color variations in each sample. The total color difference (ΔE) between the two readings was calculated with the following equation [30]:

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

The L coordinate is the amount of lightness-darkness in the samples (from 0 =black to 100=perfect white). The a coordinate is a degree of the chroma along the red-green axis. A positive a: indicates the redness of the sample, while a negative a: indicates its greenness. The b coordinate is the extent of chroma along the yellow-blue axis, a positive b: denotes the amount of yellowness; a negative b: denotes the amount of blueness of the sample. ΔL, Δa, and Δb signify dissimilarities between two colors in CIE color-space parameters.[30] It is worth to mention that if the value of ΔE > 3, no masking will be found and change in color will be noticed clinically. [31]

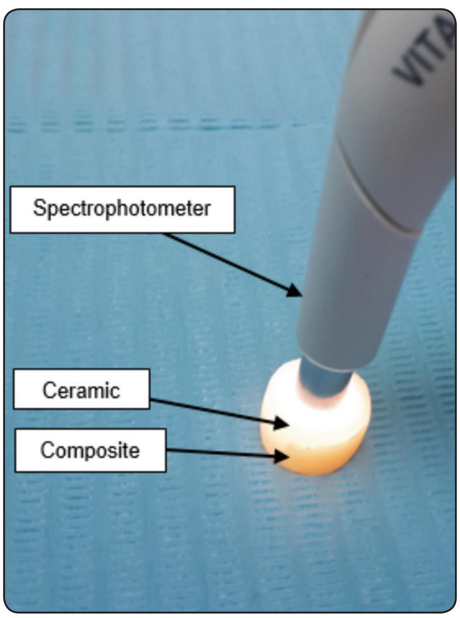


Fig. (1) Color measurement for ceramic disc complex using spectrophotometer.

**Statistical Analysis**

All color difference measurements [mean and standard deviation (SD) of ΔE] were collected and tabulated. Data were examined with Shapiro-Wilk test for normality and found to be normally distributed among all groups. Comparison of all groups were analyzed using independent t-test, one-way Analysis Of Variance (ANOVA) test, followed by Tukey HSD test to determine any statistical significant difference between the individual groups. For statistical analysis, Statistical Package for the Social Sciences (SPSS version 22.0, IBM Corporation, New York, USA) was used. *P*-value <0.05 was considered to be statistically significant.

## RESULTS

Mean and standard deviation (SD) of ΔE of different tested groups and interactions between different tested variables are presented in tables (3, 4, 5) (Fig.2). Statistical analysis using unpaired-t test showed that there was a highly statistically significant difference of ΔE values between the two main groups of high translucent Ambria and translucent Ambria discs (P<0.0001). The highest mean ΔE values were recorded for High Translucent Ambria with 0.5 mm thickness and cemented by translucent cement (ΔE=5.2±0.29), while, the lowest mean ΔE values was recorded by Translucent Ambria with 1.5 mm thickness and cemented by opaque resin cement (ΔE=1.93±0.38). However, ΔE differences between groups were highly significant only when the thickness of the veneer was 0.5 mm. As the thickness of the veneer increased to 1 and 1.5 mm, these differences became statistically insignificant. All ΔE values were less than 3, except for High translucent group with 0.5 mm thickness cemented by translucent or opaque cements and Translucent group with 0.5mm cemented with translucent cements; ΔE values were (5.2±0.7, 4.1±0.64 and 3.65±0.57) respectively (Fig.2)

ANOVA test showed no statistically significant color differences between (high translucent 1mm thickness samples cemented with translucent cement) and (translucent samples 0.5 mm in thickness cemented with opaque cement) and between High translucent discs 1 mm in thickness cemented with opaque cement and translucent ones with similar 1 thicknesses cemented with opaque cement. Statistical comparison by Tukey's HSD multiple comparison to analyze Interactions between different groups showed that both cement shades (translucent, opaque) had no significant effect on ΔE values when the thicknesses of ceramic veneer were 1.0 mm or 1.5 mm (*P* values=0.495 and 0.265 respectively). While the resin cement shades had a highly significant effect on ΔE values when disc thickness was 0.5 mm (*P* value<0.0001).

For all subgroups, the mean ΔE values decreased significantly (P<0.0001) as the veneer thickness increased (table 4).

TABLE (3) Mean and standard deviation of ΔE values of different thicknesses of (T, HT) Vita Ambria laminate veneer with translucent (Cement TR) and opaque (Cement Op) cements

| | **High Translucency(HT)** | | **Translucency(T)** | | *P*- value |
|---|---|---|---|---|---|
| | **Cement TR** | **Cement OP** | **Cement TR** | **Cement OP** | |
| | Mean ±SD | Mean ±SD | Mean ±SD | Mean ±SD | |
| **0.5 mm** | 5.2±0.29 [a] | 4.1 ±0.19 [a] | 3.65±1 [a] | 2.53±0.37 [a] | 0.0001* |
| **1 mm** | 2.53±0.44 [b] | 2.29±0.19 [b] | 2.3±0.44 [b] | 2.28±0.26 [a,b] | 0.495 |
| **1.5 mm** | 2.3±0.33 [b] | 2.12±0.34 [b] | 2.11±0.28 [b] | 1.93±0.38 [b] | 0.265 |
| *P*- value | 0.000* | 0.000* | 0.000* | 0.000* | |

**** Similar superscript letters indicate statistically insignificant differences between the different thicknesses in each subgroup.***

**** Different superscript letters indicate statistically significant differences between the different thicknesses in each subgroup.***

TABLE (4) Pairwise comparison between the groups regarding ceramic thickness by Tukey's test

| | **0.5mm** | | **1mm** | | **1.5mm** | |
|---|---|---|---|---|---|---|
| | Mean range | *P*- value | Mean range | *P*- value | Mean range | *P*- value |
| **TCT vs HTCT** | 1.6 | 0.00* | 0.23 | 0.618 | 0.37 | 0.197 |
| **TCT vs HTC0** | 1.3 | 0.004* | 0.01 | 1 | 0.19 | 0.72 |
| **TCT vs TCO** | 1.1 | 0.005* | 0.02 | 1 | 0.01 | 1 |
| **TCO vs HTCT** | 2.7 | 0.00* | 0.25 | 0.553 | 0.19 | 0.72 |
| **TCO vs HTCO** | 1.6 | 0.00* | 0.01 | 1 | 0.01 | 1 |
| **HTCT vs HTCO** | 1.1 | 0.006* | 0.24 | 0.585 | 0.18 | 0.751 |

**** Indicates significant difference between groups (P<0.05)***

TABLE (4) Pairwise comparison between the groups regarding cement shade by Tukey's test

| | High Translucency | | | | Translucency | | | |
|---|---|---|---|---|---|---|---|---|
| | Cement TR | | Cement OP | | Cement TR | | Cement OP | |
| | Mean range | *P*- value | Mean range | *P*- value | Mean range | *P*- value | Mean range | *P*- value |
| **0.5mm vs 1mm** | 2.67 | 0.00* | 1.81 | 0.00* | 1.35 | 0.004* | 0.25 | 0.303 |
| **0.5mm vs 1.5mm** | 2.9 | 0.00* | 1.98 | 0.00* | 1.72 | 0.00* | 0.42 | 0.049* |
| **1mm vs 1.5mm** | 0.23 | 0.192 | 0.17 | 0.433 | 0.37 | 0.562 | 0.17 | 0.564 |

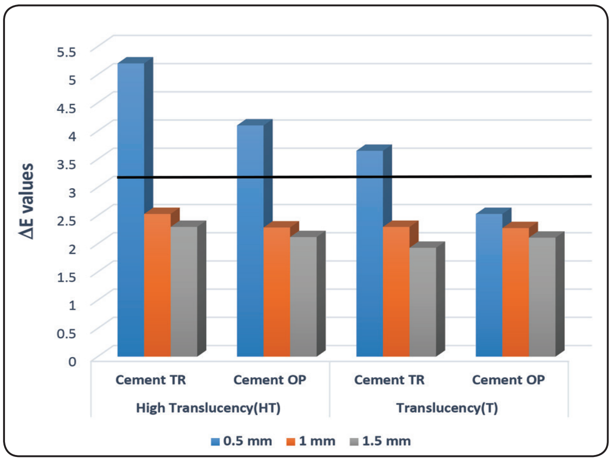


Fig. (2) Mean ΔE values of different thicknesses of Vita Ambria HT, T discs cemented with Translucent and opaque cements

## DISCUSSION

Results of the current study revealed that increasing the veneer thickness significantly decreased color change and that ceramic translucency and cement shade had an influential effect on color only in veneers less than 1 mm in thickness, with translucent ceramics and opaque cements showing superior color masking abilities. Hence, the null hypothesis could be partially rejected.

The desire for enhanced esthetics has resulted in increased acceptance and extensive use of ceramic fixed restorations. [32,33] ZLC has a uniform glassy matrix which contains crystalline elements of elongated grains of lithium orthophosphates and lithium metasilicates. Increasing its strength was done by incorporation of zirconia tetragonal fillers[34].

The optical characteristic of ZLC restorations are determined by series of factors including: ceramic layer thickness, cement shade and tooth structure shade.[11] Teeth shade may be changed due to intrinsic or extrinsic stains; intrinsic stains may be due aging, intra-pulpal hemorrhage, pulp necrosis, tetracycline or certain diseases while extrinsic tooth stains may resulted from colored food or beverages as tea, coffee and tobacco. [35]

Teeth discolorations may be treated either by bleaching or laminate veneers. Teeth reductions for laminate veneers are very conservative remaining within the enamel tissues allowing better bond strength than dentine.[36] Preparation in enamel necessitates minimum ceramic thickness and accepted translucency. Selection of a translucent laminate veneer to produce an ideal shade match is a critical factor especially over darkened abutment as it may influence the final color of the restorations. [37,38] that is why this study was designed to investigate the effect of laminate's thickness, cement shade and underlying structure darkness on post-cementation color of HT, T Vita Ambria discs. Final color changes of Vita Ambria specimens (HT,T) with three different thicknesses (0.5 mm, 1 mm, 1.5 mm) cemented either with translucent or opaque composite resin cements were observed. In this study, laminate veneers are not a single ceramic layer, but rather involve a whole component of ceramic layer, cement shade and a background mimicking the tooth shade. The selected shade for the Vita Ambria pellets was A1 as it is the most commonly used shade for all-ceramic restorations in addition, it was used in many similar studies [39-45]. The selection of using a chromatic background was planned to simulate a classical clinical condition in which the abutment was dark; C4 shade was used, as it is one of the darker shades. The thickness of cement was chosen to be 0.1 mm to imitate clinical situations allowing better stress distribution at ceramic resin interface[29,46]. Vita Easyshade spectrophotometer was used to measure all samples as recommended by previous studies [3,27,31], it is simple, easy and accurate. Dozić et al[47] reported that Vita Easyshade was the most reliable appliance of shade matching in both in vivo and in vitro situations. CIELab system was used to record color changes in previous studies,[29,31,36,38] ΔE values was an indicator if this color change would be detected clinically or not.

As mentioned earlier, the results of the present study showed that color difference (ΔE) of high translucent (HT) discs are higher than translucent (T) ones. Usually when light passes through a translucent material, intensity of light is reduced and light rays are scattered by small-sized particles as filler and internal voids. The amount of incident light that appears as diffuse transmission is important for color observation and appearance of dental ceramics. [48,49]

The higher ΔE of Translucent discs may be attributed to the fact that Vita Ambria translucent pellets have more lithium disilicate crystals than high translucent pellets. Crystals decrease the inner scattering of light as it passes through the disc. This means that when the background has a darker color or the abutment is greatly discolored, the use of high translucency pressable ZLC may lead to limited success [43, 50-52]. Pires et al [45] reported similar results after comparing low opacity ceramic with the high opacity one and concluded that the latter showed lower color difference values. Al Hamad et al [53] concluded that the color of the background affected the final color of lithium disilicate ceramic restorations and recommended using low translucency or opaque materials to hide the backgrounds darkness. In addition, Skyllouriotis et al [54] reported that low translucency lithium disilicate ceramic crowns were better at masking dark backgrounds than high translucency lithium disilicate ceramic crowns. Hence, prosthodontists should think about decreasing translucency to mask the tooth color. It is worth mentioning however that most of the recorded color difference values were under the threshold of 3 which means that they were clinically acceptable.

To date, little data is known about properties of pressable ZLC due to limited available studies. Nonetheless, it is known that increasing ceramic thickness will increase its opacity [37, 51, 55]. When the thickness is increased, the diffused reflection influences of the background abutment is reduced, and majority of diffused reflection happens in the laminate veneer. The lowest color change values were recorded for the 1.5 mm thickness in all studied groups. Ceramics with either thickness of 1 and 1.5mm. had non-significant differences between their groups meaning that 1 mm. thick veneer preparation is enough to mask the underlying color of dark abutments. Ge et al [56] found that using gold shaded posts and cores did not affect the color of 1.5 mm thick Empress 2 crowns, and that the color difference was under the patients' normal perception level (ΔE = 1.8). Many studies correlate increasing ceramic thickness with better color results [18,41,43,44,50,51] hence support the findings of the current study.

It was concluded that the type of polymerization could affect the color of the restoration; light cured resin cements are preferable in cementation of translucent and thin ceramic restorations because they have superior optical properties and color stability than dual cured cements.[57]. In this study, light cured, translucent and opaque resin cements were used to exclude the possibility of color change. As shown in table 2, RelyX veneer cement does not contain camphorquinone which lead to a yellowish shade after light polymerization. [58] Nor amine compound which causes discolorations as a result of oxidation reaction during its auto-polymerization.[59] For all veneer thicknesses, opaque resin cement recorded lower color change values than the translucent cement in both translucent and high translucent ceramic groups. However, this superiority was significant only with the 0.5 mm veneer thickness. It seems that using opaque resin cements would be beneficial to mask dark or discolored abutments if laminate veneer thickness was 0.5mm and will have no influential effect if the thickness increased to 1 or 1.5 mm. Similar results were reported by Czigola et al[60] who studied the effects of dark backgrounds and cement shades on the final color of lithium disilicate crowns and found that opaque shade cements and low translucency ceramic crowns might be beneficial in masking dark abutments. Similarly, results of many studies showed that the influence of resin cement shade on the final color is less considerable than other factors when the ceramic thickness was from 1.0 to 2.0mm. [51, 61]

**Study limitations**

This study was carried under in vitro conditions without aging procedures. Only one shade (A1) was used, and all tested materials were from two manufacturers (VITA, 3M) only. Further studies should be conducted considering more thicknesses of ceramics, various shades from different manufacturers, as well as more resin cement types, thicknesses and shades.

## CONCLUSIONS

Within the limitations of the present study, the following conclusions were drawn:

- Increasing veneer thickness from 0.5 to 1 to 1.5 mm significantly decreased color change in pressable ZLC veneers.
- Ceramic translucency and cement shade significantly influence the final color of pressable ZLC veneers only if the thickness is less than 1 mm, hence laminate veneers with at least 1mm. thickness can mask the color of even dark abutments regardless of ceramic translucency and cement shade.

**Clinical Significance**

To mask the color of discolored abutments, it is recommended to use translucent pressable ZLC veneers with opaque resin cements if the veneer thickness is less than 1 mm. However, if the veneer thickness is 1 mm or more, using high translucency veneers and translucent resin cements would still be clinically acceptable.

**Conflict of interest**

No conflicts of interest and no funding was received for the research that could have influenced its results.

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