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Effect of two luting resin cements on translucency and transparency of ceramic laminate veneer

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Highlights

- **Color matching as well as good translucency give excellent aesthetics of the restoration.**
- **To select a good color and proper translucency of veneer restoration, the underlying resin cement should be carefully selected to avoid clinically unacceptable restoration.**
- **The resin luting cement found to be slightly affecting the translucency of veneer material.**

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ABSTRACT

Statement of problem: Different types of resin cements may harmfully affect the translucency and transparency of esthetic restorations particularly for thin ceramic laminate veneers.

Aim: To assess the effect of using two resin cements as luting agent on the transparency and translucency of laminate veneer prepared from IPS Empress ceramic.

Materials and methods: Two dual-cured resin cements systems from different manufacturers were used for this study (MetaCem and Totalcem). Fifteen samples of laminate veneers (LVs) were fabricated from IPS e.Max Empress using a ready-made mould to standardize the form and dimension of prepared samples, then the samples were divided into three groups (n=5). Group (Gp1) was e.Max veneer samples without luting cement (control group), and the other two groups (Gp2 and Gp3) were using two cements (test groups). The resin cement was prepared according to the manufacturers' instructions, and then a layer of luting agent was applied on the fitting surface of the veneer samples and cured by light. The translucency and transparency of all samples were evaluated using a spectrophotometer.

Results: e.Max veneers without luting cement (Gp1) showed slightly higher absolute translucency (76.8 ±3.3) than MetaCem samples (Gp2) (74.9±3.8), while veneers cemented with Totalcem (Gp3) displayed the lowest value (70.8±3.9). Statistically, found no significant difference between e.Max veneer (Gp1) and the two luting cements (Gp2 and Gp3) (P 0.066) in the absolute translucency. However, a significant difference between the tested groups in their relative translucency was detected (P .047). T-test showed no significant differences between the luting cements types (Gp2 and Gp3) in their absolute and relative translucency (P 0.134 and P 0.178 respectively).

Conclusions: The luting cement slightly affect the translucency of the veneer material, however, both cements found to be acceptable and no significant effect on the translucency and transparency of IPS e.Max Empress LVs.

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1. Introduction

Recent improvements in ceramic systems and resin cements make them possible to create restorations with optical properties mimic those of the natural teeth. Laminate veneer is an esthetic restoration of a thin layer placed on the facial surface of anterior teeth to enhance their aesthetics or to correct their malformation shapes, may also shield the facial surface of the tooth from destruction (Dhir, 2015). Porcelain laminate veneers (PLV) are very conservative restorations permit superior translucency and consist of 0.5 to 1.0 mm thick ceramic bonded to prepared or unprepared teeth with luting resin cement (Heffernan *et al*., 2002). When tooth surface exposes to light, the tooth will reflect, diffuses, absorbs and transmits light. Therefore, the color property of veneer restoration should be similar to natural tooth structures (Raptis *et al*., 2006). Consequently, the dentists have to do their effort to construct restorations that have the same shape, function, and aesthetics of neighboring natural tooth. Human eyes are able to discriminate between natural and artificial one even in slight differences in color and translucency (Heffernan *et al.,* 2002, Llie and Hickel 2008). There are three-color coordinates (hue, chroma, and lightness) have been usually considered; however, translucency ruminates another essential factor in the choice of clinical uses of restorative materials (Baldissara *et al*., 2010, Shiraishi *et al*., 2011). Translucency is defined that part of the light is transmitted through the material and known as a state between full opacity and transparency (Powers, 2006). The translucency of ceramic restorations was found to be affected by thickness of the ceramic layer, where that thinner ceramics layer more translucency as reported by Shokry *et al.,* (2006), scattering and absorption coefficients of the light, voids and holes, ceramic type, crystal number, and their size also found to effect in translucency of ceramic materials (Azer *et al*., 2006). In addition, ceramic, luting cement shade, and thickness can also influence translucency (Vichi *et al.,* 2000, Turgut and Bagıs 2011, Alqahtani *et al.,* 2012, Turgut and Bagıs 2013). The translucency of a subject is often considered using translucency parameter (TP), which known as the color variance of a material with a specific thickness in regard to white and black backgrounds when light

passes through the material (Johnston *et al.*, 1995). Zero value of TP indicated a very opaque material. A high TP value indicates a large actual translucency of the material. The translucency of PLV materials very important factor in the color-matching process due to that ceramics allow light transmission and scatter, which will influence the shade of restoration (Chaiyabutr et al., 2011).

The clinical success and longevity of these ceramic restorations is partly depended on the dental cements and cementation technique (Hitz et al., 2012). Applications of dental cements are to bond restoration to tooth structure and offered to maintain the restorations into their stable position in the oral environment. Different types of resin cements are indicated for cementation of ceramic restorations. These cements are classified into three types according to methods of the polymerization process; 1-chemically-activated cements, 2-light-cured cements, 3-dual-cured cements. It has been reported that success of all-ceramic restorations depends mainly upon the light-cured resin-based cements that were developed to overcome drawbacks of chemically cured, non-resinous cements (Manso *et al.*, 2011). Light-cured resin based cements have the clinical advantages of color stability, low solubility, low radiopacity, good esthetic and biocompatibility (Braga *et al.*, 2002; Soares *et al.*, 2005). The benefits of dual-cured resin cements are; working time that can be controlled and ensure polymerization in areas that are unreachable to light. In addition, this system offers actual, strong bond and well marginal adaptation between tooth structure and filling materials (Soares *et al.*, 2005). However many researchers have reported that luting resin cements underlying porcelain restorations with different shades can affect the appearance of ceramic veneer restorations and some of them showed varying degrees of intrinsic discoloration which may show-through and affect the outlook of translucent all-ceramic restorations (Vichi *et al.*, 2000; Nathanson and Banasr, 2002; Chang *et al.*, 2009; Kilinc *et al.*, 2011; Chen *et al.*, 2015; Herandes *et al.*, 2016). Hence, clinicians should take most care to achieve a good color match for PLVs because of their high translucency and small thickness. On the other hand, other studies reported that resin cement has no remarkable effect on the color of final restorations. (Vichi *et al.*, 2000; Azer *et al.*, 2006). The present study was aimed to assess the effect of two luting agents on the translucency and transparency of IPS e. Max Empress esthetic ceramics laminate veneers.

2. Materials and methods

2.1. The materials, which used in this study composed

Two dual-cured resin cements systems from different manufacturers (Metacem, CO. LTD, Republic of Korea, and TotalCem, Itena Clinical, Paris-France). Ceramic veneer material, IPS e. Max Empress (Ivoclar Viadent, Schaan, Liechtenstein-Germany).and readymade mould represented maxillary central incisor (3M ESPE, Seefeld, Germany). These materials are shown in Table 1.

Table 1

Materials used in the current study.

Material	Brand name	Material type	Shade	Manufacturer
Resin cements	Metacem	Dual-cure	Translucent	META BIOMED, CO. LTD, Republic of Korea
	TotalCem	Dual-cure	Translucent	ITENA CL.INICAL, Paris – France
Ceramic	IPS e.max Empress	Lithium-disilicate based	A1	IPS e.Max Empress, Variolink Veneer, Ivoclar Vivadent, Schaan, Liechtenstein

2.2. Sample preparation

Fifteen of IPS e. Max Empress veneers samples (LVs) were fabricated using a readymade mould represent maxillary central incisor (3M ESPE, Seefeld, Germany) (Fig. 1), thickness and the dimension of all the tested samples were standardized.

Fig. 1. A ready-made mould of laminate veneer (3M ESPA).

The IPS e. Max Empress samples were constructed in the laboratory from ingot medium, (opacity) shade A1. The LV was fabricated from the wax pattern and then invested with the refractory material. The invested wax pattern placed in electrical furnace and burnout as the same conventional process. The ingot of IPS e. Max material was heated until melting and injected into the mould. After cooling down, the veneer was taken out from the mould then finished and polished. By using cutback technique thin layer was removed from labial surface followed by application of a layer of neutral-shade glaze and fired at 765 °C (Ivoclar furnace E.P. 300 Swiss). All samples were checked to exclude any sample that has any surface defects under a magnified lens. Using digital caliper (Electronic Digital Caliper, Shan,mChina) all samples were measured at three points in the center of the cervical, middle, and incisal third of the facial surface. The thickness of each LV was intended to be approximately 0.3 mm. All samples of LVs were divided into three experimental groups (n=5). Group1 (Gp1): The e.Max veneer samples without luting cement served as a control group. Group2 (Gp2); e. Max veneer samples with luting cement (MetaCem resin cement). Group3 (Gp3); e. Max veneer samples with luting cement (Total Cem resin cement).

2.3. Application of the luting agent

The luting agent/resin cement was applied according to manufacturer's instruction; the fitting surface was washed by water spray and drying with oil-free air pressure. Monobond Etch and Prime was dispensed on all fitting surface for 20 seconds using a micro brush. After that, the Monobond Etch and Prime was rinsed with water spray until the color of conditioner disappear from the fitting surface then dried with air pressure (oil- and moisture-free) for 10 s. Then after, a layer of Monobond plus bonding agent was painted on the treated fitting surface using a micro brush and stay for 60 s to react with the surface. Then a stream of air pressure was applied for 10 s. For each one of the two resin cements, a layer of the resin cement was dispensed directly from the syringe onto the fitting surface of the LV samples, and micro brush was used to spread out uniformly the resin material. Metacem resin bond cement (Gp2) was applied on the fitting surface of some of the experimental sample and TotalCem resin bond cement (Gp3) applied on another experimental sample. Vaseline was applied as separating medium on the lower part of the readymade mould. Then the lower part of the mould pressed firmly over the facial surface of the mold and light-cured by LED curing device (SDI radii Plus Australia). The curing distance was about 10-15 mm; the polymerization light was moved in a circle (clockwise direction) for 20 seconds. Then the thickness of LVs was measured using digital caliper (Electronic Digital Caliper, Shan, China) to be approximately 0.3 mm in three different area of the LV.

2.4. Measurement of translucency and transparency

Translucency and transparency of veneer samples were measured by a spectrophotometer (Visible and UV/Visible Spectrophotometer- Shimadzu mini 1240- Japan). The operating light in the range of 400-700 nm equipped with integrating sphere. The measurements parameters for each sample were done nine times in different areas; incisal, middle and cervical; and the mean reading was calculated plotted and tabulated.

2.5. Statistical Analysis

Statistical analysis was performed using SPSS IBM V.22. P value ≤0.05 was stated to be a statistically significant difference between tested groups. Firstly, descriptive statistics were performed for each group. One-way ANOVA variance was used also for more comparison between groups Post-hoc Tukey's tests were used. For comparison between two pairs groups, the paired sample t-test was performed.

3. Results

The results of effect luting cement layer on translucency of ceramic veneer material are shown in Table 2. The e. Max sample without resin luting cement (control group-Gp1) showed slightly higher absolute translucency (76.8±3.3) compared with Metacem samples (Gp2) (74.9±3.8), whereas TotalCem samples (Gp3) displayed the lowest value (70.8±3.9). The mean values of absolute translucency are shown in Fig. 2. Statistically, there was no significant difference between e.Max group (Gp1) and two luting cement groups (Gp 2 and Gp3) (P 0 .066) in their absolute translucency. When comparing between groups, Gp1 and Gp2 showed no significant difference (P 0.703), also there was no significant difference between Gp1 and Gp3 as well (P 0.060). Regarding the relative translucency (Contrast ratio CR) (Fig. 3), the e.Max samples (Gp1) showed higher contrast ratio (0.87±0.03) compared with the Metacem and TotalCem samples that showed lower values (0.82±0.04 and 0.85±0.03) respectively. In addition, the relative translucency found to be significantly different among the tested groups (P 0.047). More comparison between groups using post hoc HSD Tukey's test showed a significant difference between Gp1and Gp2 (P 0.039), whereas there was no significant difference between e. Max and Totalcem samples (P 0.448) (Table 2). In addition, the comparison between the two types of cements showed in Table 3, it could be seen that there was no significant difference between the two tested groups in their absolute and relative translucency (P 0.134 and P 0.178 respectively).

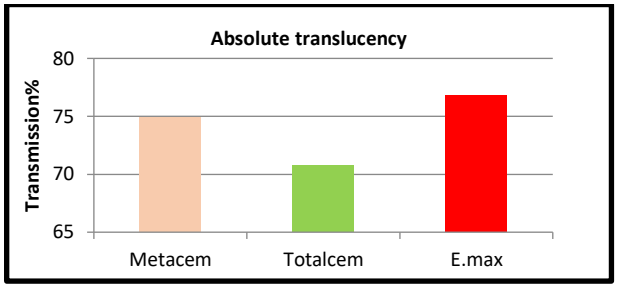

Fig. 2. The absolute translucency of the tested groups.

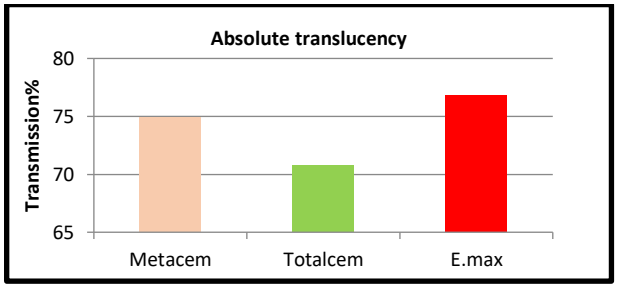

Fig. 3. The relative translucency (contrast ratio) of the tested groups.

Table 2

Comparison between the tested groups in their absolute translucency/transmission and relative translucency (Contrast ratio) (One-Way ANOVA test).

Absolute translucency (Absolute transmission)	**Gp1**		**Gp2**		**Gp3**		***P*-V**alue
	Mean	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**	
	76.8	±3.3	74.9	±3.8	70.8	±3.9	
*P*1			0.703		0.060		*P*<0.066
*P*2	0.703				0.227		
*P*3	0.06		0.227				
Relative translucency (Contrast ratio)	**Gp1**		**Gp2**		**Gp3**		
	0.87	±0.03	0.82	±0.04	0.85	±0.03	
*P*1			0.039*		0.448		*P*<0.047
*P*2	0.039*				0.298		
*P*3	0.448		0.298				

SD: standard deviation, P: Probability, *: significance<0.05, ***: high significance<0.001
P1: significance relative to Group 1; **P2**: significance relative to Group2; **P3**: significance relative to Group 3

Table3

Comparison between the two luting cements using paired sample t-test.

Sample	**Transmission %**		***t- test***	**Contrast Ratio**		***t- test***
	Mean	**SD**		**Mean**	**SD**	
Metacem (Gp2)	74.9	±3.8	*P*<0.134	0.82	±0.04	*P*<0.178
Totalcem (Gp3)	70.8	±3.9		0.85	±0.03	

SD: standard deviation, P: Probability, *: significance 0.05, ***: high significance 0.001

P1: significance relative to Group 1; **P2**: significance relative to Group2; **P3**: significance relative to Group 3

4. Discussion

Transparency and translucency are critical factors in controlling the esthetic of anterior ceramic restoration, mainly related to the light transmission and the efficiency of the polymerization reaction of the resin-based luting cement (Llie and Hickel, 2008). In addition, the translucency is influenced by thickness of LV, ceramic type and shade; therefore to eliminate adverse effects; all these variables were maintained constant in this study. Only one type of ceramic material was used for veneers fabrication, which is IPS e.Max Empress with almost uniform and limited thickness of approximately 0.3 mm. However, in a clinical situation, it is not always possible to get LV of that exact measure. The luting resin cements used in the current study were dual-cure resin cement of the same shade, which commonly used in the daily clinical practice; as well, they are available at a local supplier. However, they have different brands. The ceramic veneer material used in the current study was the IPS e .Max Press ceramics, which have commonly been favored for PLVs in latest years, have a translucent structure with a dissimilar crystalline form. The IPS e. Max Empress ceramic material is a castable ceramic; mainly contain a modified lithium desilicated glass ceramic. It can be used as a core build-up, full crown, inlay and onlay restorations or to construct very thin labial veneers due to their higher translucency (Etman and Woolford, 2010). Dental practitioners usually used shade guides for color matching of ceramic restorations. Determination of exact tooth shade in clinical conditions sometimes is difficult, due to many factors such as fluorescence, metamerism and translucency, which affect shades of natural teeth (Reich and Homberger, 2002). Hence, varieties of measuring tools were used to asses color and translucency of dental restoration, such as spectrophotometers, spectroradiometers and colorimeters. The uses of color measuring devices have become popular due to their accuracy, standardization, and numerical assessment of colors (Llena *et al*., 2011; Igiel *et al*., 2016). In this study, spectrophotometer was used to measure absolute translucency (% of light transmission) and relative translucency (transparency) or contrast ratio (CR) of the IPS e-Max LVs without any cement and cemented with two different brands of resin cements. Spectrophotometers are extensively used devices for surface color measurements. These devices reported being the most accurate and suitable instruments for measuring color in dentistry (Chu *et al*., 2010; Öngül *et al*., 2012; Mohamed *et al*., 2016). These instruments able to measure the percentages of the light reflected from a sample to the light reflected from a white reference within visible spectrum at a period of 5, 10, or 20 nm. The given results are determined by spectral reflectance function. Spectrophotometers are able to analyze the principal components of a series of spectra and convert the spectrophotometric reading to diverse color measures. (Chu *et al*., 2010). The translucency of dental porcelain often evaluated by translucency parameter (TP) or the relative translucency/contrast ratio (CR) (Johnston *et al.,* 1995; Mohamed *et al.,* 2016). The contrast ratio is known as the ratio of illuminance (Y) of the experimental material when located over a black background (Yb) related to the illuminance of the same material when it located over a white background (Yw). The translucency parameter is known as the dissimilarity in the color (ΔE) between uniform thicknesses of tested material over a white and a black background (Johnston *et al*., 1995). The difference of the color between two dissimilar experimental samples can be evaluated by [comparing the coordinate values of each respective material. A lesser ΔE value means a closer color match between tested [sample and target color (Chu *et al*., 2010; Öngül *et al*., 2012). The present study showed no significant difference between IPS e. Max group (Gp1) and two luting cement groups in the absolute translucency, however, IPS e. Max samples before cementation showed slightly higher values than the other two groups of veneers cemented with MetaCem and Totalcem resin cements. The reason of the results may be attributed to the nature of the IPS e.Max sample and the non-uniform in the distribution of the phases, defects and voids at grain boundaries, which decrease the translucency of the esthetic materials. Furthermore, the difference in reflective ability within the particles and the chemical nature of tested samples may effect in light scattering and diversity in translucency measurements (Bubteina *et al*., 2017). Regarding the contrast ratio (CR) (Fig. 3), the IPS e. Max samples showed higher contrast ratio (0.87 ±0.03), compared with the Metacem and TotalCem samples that showed lower values (0.82±0.04 and 0.85±0.03) respectively. This also could be accredited to the chemical composition and nature of the resin cements. (Bubteina *et al*., 2017), though the resin cement could mask the color of the veneer material.

A study by Barath *et al*., (2003) evaluated the effect of luting cement color on the ultimate shade of IPS Empress-II and VITA In-Ceram Alumina. They used zinc phosphate (PhospaCEM PL), resin luting cement (COMP) and glass ionomer (Ketac-Cem). The authors reported that IPS Empress-II displayed more translucent parameter than In-Ceram Alumina. Also, found that luting cement with the effect of the background shade influence the color of final restoration. Regarding luting agent type, they reported that zinc phosphate cement showed the least translucent materials, while resin cement was the most translucent luting agent, whereas glass ionomer found to be intermediate translucent material. Chu *et al*., (2007) were comparing the contrast ratios (CR) and color difference (ΔE) of three types of ceramic veneer materials (Procera, Empress-II and Vitadur Alpha). The dimensions of tested samples were 8 mm in diameter and 0.7 mm in thickness) constructed from shade A2. A colorimeter was used to evaluate the illuminance (Y) and color difference (ΔE) in regards to white and black backings. They found that the contrast ratio was significantly different within the ceramics tested sample: Procera (0.50±0.02) Empress 2 (0.46±0.05) Vitadur Alpha (0.39±0.02).

The effect of resin luting cements on ceramic restorations' translucency had been investigated by various studies; Terzioglu *et al*. (2009) studied the effect of different colors of luting agent materials with different thicknesses of IPS Empress ceramic materials. The color of the tested samples was measured by a colorimeter. They found that there was a significant difference in ΔE values between baseline and cemented samples. However, they found no significant difference between two shades of the luting cement (A1, A3). The authors reported that increase of ceramic thickness and types of resin luting cement were reduced specimens illumination and finally affected the color of ceramic veneers materials.

Herandes *et al*. (2016) reported that darker luting resin cement produces more distinct changes in the translucency, chroma, and shade of porcelain veneer materials. However, these changes may be insignificant in clinical applications. Nevertheless, luting cement should be carefully selected to get better clinical results. This is in particular when using high translucent ceramic laminate veneers. In this condition, darker shade of resin cement should be avoided. Silami *et al*. (2016) investigated the effect of accelerated aging (AAA) on the color stability of resin cements used with IPS e-max Ceram laminate veneers (LVs) of diverse thicknesses. They reported that the thickness of the laminate veneer material affected the color and translucency of conventional cement, dual-cured cement and light-cured cements. Bubteina *et al*. (2017) have studied the effect of luting cement on different types of ceramic veneer materials, they found that the luting cement reduced the translucency and the aesthetic outcome of ceramic veneer restorations.

Light wavelength was found to affect the translucency of tooth structure (enamel and dentin); the larger translucency value resulted from the higher wavelength (Yu *et al*., 2009). Consequently, the experimental work of the current study included the use of the ready-made mould for veneer fabrication and the resin luting cements were bonded to ready-made veneers instead of bonding to a natural tooth structure. The natural tooth translucency is presented when a visible amount of light passes through its structure; a high content of enamel, which is more translucent, and underlying dentin, in the area of the cervical third of the teeth, where the dentin is thicker, therefore the light transmission will be less in this area.

Acceptable color matching as well as good translucency, usually give excellent aesthetics of the restoration. Clinicians should take the most care to select a good color and proper translucency of ceramics and the underlying resin cement to avoid clinically unacceptable color alteration and to achieve excellent aesthetics of the restoration. (Chu *et al.,* 2007). Further investigations are required to assess the translucency of LVs using different types and shades of resin cements utilizing different instruments.

5. Conclusion

Contained by the limits of this study; it can be concluded that; the resin luting cement slightly affect the translucency of veneer material, however, the two resin cements found to be acceptable and no significant effect on the translucency and transparency of esthetic IPS e.Max empress veneers. The *clinical significance* of the choice of resin cement is important in obtaining the excellent esthetics of laminate veneers.

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