

# Effect of Translucency and Curing Mode of Four CAD/CAM Materials on Polymerization Efficiency of Light and Dual Cure Resin Cements

## Keywords

*In vitro*  
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## ABSTRACT

*Purpose/Aim:* To determine the effect of translucency of four CAD/CAM materials and different curing modes on the degree of conversion of resin cements. *Materials and Methods:* Disks were fabricated from IPS e.max CAD, Vita Suprinity, Vita Enamic, and DD Cube X<sup>2</sup>. Translucency was measured using a spectrophotometer. The degree of conversion of two resin cements Variolink Esthetic DC and LC were measured using a Fourier transform infrared spectrometer. For Esthetic DC, the degree of conversion was determined in self-cure and dual cure modes. ANOVA, Tukey HSD test, and Linear Regression R<sup>2</sup> were used to statistically analyze the data. *Results:* There was a significant difference in the translucency of the four materials ( $P < 0.0001$ ). The mean translucency of Vita Suprinity was significantly higher, followed by Vita Enamic, DD Cube X<sup>2</sup>, and IPS E.max CAD. Degree of conversion of resin cements cured under DD Cube X<sup>2</sup> had the highest values (25.22%), whereas those cured under Vita Suprinity showed the lowest values (17.86%). The self-cure mode had the lowest degree of conversion values (16.22%) and dual cure mode showed the highest values (26.12%). A negative linear relationship was found between degree of conversion and translucency of the CAD/CAM materials.

## INTRODUCTION

Indirect restorations are commonly used for restoring discolored, decayed, or endodontically treated teeth. Ceramics as well as indirect composites have become the most popular materials used in fabricating these types of restorations because of increasing esthetic demand. Resin cements are regularly utilized for the cementation of indirect restorations because of their mechanical behavior and superior optical properties.<sup>1,2</sup> Resin cements frequently used for cementing indirect restorations are light, dual, and self-cure resin cements.<sup>3</sup>

Several factors may interfere with the polymerization efficiency i.e., DC of resin cements. The most commonly agreed upon are the different composition (types), thickness and optical properties (translucency/opacity) of ceramic materials, the light emittance reaching the underlying resin cements and curing protocol.<sup>4-11</sup> Thus, when using light cure resin cements, incomplete polymerization occasionally occurs.<sup>12</sup> Dual cure resin cements start to polymerize with low light intensity and a chemical reaction continues the polymerization process, therefore allowing these cements to

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obtain the properties of both light and chemical cure resin cements.<sup>13</sup> Several studies were conducted comparing the DC of dual and light cure resin cements under various conditions with conflicting results pertaining to which resin cement demonstrates higher DC.<sup>7,14–18</sup> However, when comparing the DC of dual cure and self-cure resin cements it was found that over all the latter exhibited lower values.<sup>9,10,19</sup>

Over the years, researchers have shown continuous interest in the effect of ceramic type and translucency on the polymerization efficiency of underlying resin cements. The translucency of dental ceramics is affected by several factors including their unique chemical composition, grain size, crystalline formation, shade, thickness, and the presence of internal defects or porosities.<sup>6,20–25</sup> It was observed that ceramics appear more translucent when crystals are smaller than the visible light's wavelength (0.4 to 0.7  $\mu\text{m}$ ). This leads to less light scattering as it passes through the ceramic, rendering it more translucent.<sup>26</sup> Several studies showed that light transmission through and light irradiance reaching the bottom of tested CAD/CAM materials significantly varied leading to a significant influence on the polymerization efficiency of the underlying resin cements.<sup>7,27–31</sup> Runnacles *et al.* found no significant difference in the DC of the light cure cement when cured under IPS e.max Press low translucency (LT) and IPS e.max Press HT (high translucency).<sup>32</sup> However, in a study by Ilie *et al.*, there was a good correlation between ceramic translucency of leucite- and lithium disilicate-based ceramics and the hardness of underlying luting cement.<sup>2</sup> Furthermore, Oh *et al.* and Alshaafi *et al.* concluded that the effect of different translucencies on the DC was dependent on the type of ceramic.<sup>4,20</sup> Comparable results were obtained when evaluating DC of light and dual cure resin cements photopolymerized under lithium disilicate and zirconium-based crowns, where the former allowed higher DC of the resin cements.<sup>5</sup> Similarly, Mendonca *et al.* observed higher light transmittance and DC in low opacity and lighter shades of the lithium disilicate ceramics.<sup>6</sup>

Ceramics in dentistry have undergone extensive developments over the years and have shifted toward CAD/CAM technology with various materials available for indirect restorations fabrication.<sup>33,34</sup> IPS e.max CAD is a well-established material marketed for its high esthetics and strength and is widely used by restorative clinicians. Vita Suprinity is a more recently introduced material that—according to its manufacturer—combines the esthetic properties of lithium disilicate glass ceramics and the superior strength of zirconia-based ceramics. These characteristics are attributed to its glassy matrix with homogenous silicate crystals embedded within it.<sup>22,35–37</sup> DD Cube X<sup>2</sup> is a third-generation 5Y-TZP zirconia ceramic, made up of a cubic zirconia system that is based on 5 mol% yttria oxide with a final composition of approximately 53% cubic and 47% tetragonal crystals, which offers both esthetics and strength to indirect restorations and can be used anteriorly and posteriorly.<sup>38–40</sup> Vita Enamic is a polymer infiltrated ceramic network (PICN) that has established a strong reputation among its genre because of its promising performance experimentally and clinically.<sup>41,42</sup> Complete

polymerization of resin cements is crucial in achieving proper bonding between the ceramic and tooth structure and subsequently enhance the longevity of indirect restorations.<sup>43</sup> Caprak *et al.* determined the effect of translucency of monolithic CAD/CAM materials on the depth of cure (DOC) and microhardness of light and dual cure resin cements and found that DOC and hardness values of the resin cements increased when ceramics exhibited higher translucency.<sup>44</sup> Although DOC and microhardness tests are valid methods for assessing polymerization efficiency of resin cements, they are indirect methods conducted after the resin cements have been cured. A direct and more sensitive method would be to calculate DC of resin cements using a FTIR spectrometer.<sup>45</sup> The interaction between the varying translucencies and compositions of the new classes of CAD/CAM materials and the curing efficiencies of resin-based cements was not extensively investigated in the literature. Due to the fact that the translucency of ceramic systems could affect the quality of resin cements, the present study aimed to measure the translucency of four currently used light translucency CAD/CAM materials, namely, Vita Suprinity, Vita Enamic, DD Cube X<sup>2</sup>, and IPS e.max CAD. Additionally, the DC of two resin cements, Variolink Esthetic DC, a dual cure resin cement (in self-cure and dual cure modes), and Variolink Esthetic LC, a light cure resin cement, was determined. The null hypotheses were that there would be no significant difference in the translucencies of the CAD/CAM materials and in DC of two resin cements and curing modes of the dual cure resin cement.

## MATERIALS AND METHODS

### TRANSLUCENCY

Table 1 lists the materials used in the present study. Forty disk-shaped specimens were fabricated from four CAD/CAM materials ( $n = 10$ ): A zirconia reinforced lithium silicate glass ceramic (Vita Suprinity, VITA Zahnfabrik, Bad Säckingen, Germany), a polymer infiltrated ceramic (Vita Enamic, VITA Zahnfabrik, Bad Säckingen, Germany), a cubic super highly translucent zirconia (DD Cube X<sup>2</sup>, Dental Direkt GmbH, Spenge, Germany), and as a control lithium disilicate glass ceramic (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein) was used. The completed disks were 10 mm in diameter and 2 mm in thickness.

The shades used were IPS e.max CAD LT, shade A2, Vita Suprinity T translucent, shade A2, Enamic translucent (1M2-T) blocks, and DD Cube X<sup>2</sup> (white). LT was selected for the control IPS e.max CAD as it is the most documented of the materials chosen. DD Cube X<sup>2</sup> is only available in white for monolithic restorations while Vita Suprinity and Vita Enamic are available in HT and T. The T shade was selected for both as the lowest translucencies provided by the manufacturer as is LT of IPS e.max CAD. Disks 10 mm in diameter and 2 mm in thickness were scanned (Sirona inEOS Blue, Dentsply, USA) and designed and then milled using a milling machine (Sirona inLab MC XL, Dentsply, USA). IPS e.max CAD disks were crystallized using

**Table 1. List of materials, composition, and shade.**

Material	Company	Composition	Shade
IPS e.max CAD	Ivoclar Vivadent	Lithium disilicate glass ceramic	LT, A2
Vita Suprinity	Vita Zahnfabrik	Zirconia reinforced lithium silicate glass ceramic: ZrO <sub>2</sub> (zirconia), SiO <sub>2</sub> (silicon dioxide) and Li <sub>2</sub> O (lithium oxide)	T, A2
Vita Enamic	Vita Zahnfabrik	Polymer infiltrated (TEGDMA, UDMA) glass ceramic (SiO <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub> , Na <sub>2</sub> O, K <sub>2</sub> O, CaO, and TiO <sub>2</sub> )	1M2-T
DD Cube X <sup>2</sup>	Dental Direkt GmbH	Highly translucent zirconia: ZrO <sub>2</sub> +HfO <sub>2</sub> and Y <sub>2</sub> O <sub>3</sub>	HT, White
Variolink Esthetic DC	Ivoclar Vivadent	Monomer matrix: UDMA and further methacrylate monomers. Inorganic fillers: ytterbium trifluoride and spheroid mixed oxide. Particle size: 0.04–0.2 µm. Inorganic fillers: approximately 38% volume.	Neutral
Variolink Esthetic LC	Ivoclar Vivadent	Monomer matrix: UDMA and further methacrylate monomers. Inorganic fillers: ytterbium trifluoride and spheroid mixed oxide. Particle size: 0.04–0.2 µm. Inorganic fillers: approximately 38% volume.	Neutral

Programat P500, following the manufacturer's instructions (Ivoclar Vivadent, Schaan, Liechtenstein) with a standby temperature of 403°C, a closing time of 6 min, a heating rate of 90°C/min, and a firing temperature of 840°C for 7 min. Vita Suprinity disks were crystalized while DD Cube X<sup>2</sup> disks were sintered using the same furnace, following the manufacturer's instructions (VITA Zahnfabrik, Bad Säckingen, Germany) (Dental Direkt GmbH, Spenge, Germany). Vita Suprinity disks were crystalized with a maximum temperature of 840°C for 8 min. DD Cube X<sup>2</sup> disks were sintered with a maximum temperature of 1450°C for 120 min. Vita Enamic does not require sintering as it can be used as a chairside material. Disks were finished using a fine diamond bur.

The Commission Internationale de l'Eclairage (CIE) color illuminants and the CIE standard illuminants are commonly applied when evaluating the optical properties of materials.<sup>46</sup> A spectrophotometer (LabScan XE Spectrophotometer, HunterLab, VA, USA) was used to measure the translucency of the CAD/CAM materials tested. The illuminance (Y) and color (CIE L\*a\*b\*), where L\* represents brightness (white-black), a\* is for redness-greenness, and b\* is for yellowness-blueness, of each specimen were measured over white and black backgrounds. The Y value in Yxy color space represents the illuminance, where x is the value of hue and y is the value of chroma. The translucency parameter (TP) was obtained automatically by calculating the color difference of the tested materials over ideal white and black backgrounds following the equation below.<sup>2,47</sup>

$$TP = [(L_B - L_W)^2 + (a_B - a_W)^2 + (b_B - b_W)^2]^{1/2}$$

## DEGREE OF CONVERSION

For measuring DC, two resin-based cements in neutral shades were used: Variolink Esthetic DC (Ivoclar Vivadent, Schaan, Liechtenstein) and Variolink Esthetic LC (Ivoclar Vivadent, Schaan, Liechtenstein). Using a LED curing unit: Bluephase G4 (Ivoclar Vivadent, Schaan, Liechtenstein), polymerization was obtained. Bluephase G4 is a polywave LED with a broadband spectrum ranging between 385 and 515 nm and with a light intensity of 1,200 mW/cm<sup>2</sup>, making it suitable for curing all types of initiator systems.

Metal split molds 10 mm in diameter and 1 mm in thickness were fabricated for the placement of the resin-based cement while covering each side with polyester films and compressing the material between two glass slabs to allow extrusion of excess cement. Resin cements were mixed and placed according to the manufacturer's instructions (n = 5). Radiometer (Bluephase meter, Ivoclar Vivadent, Schaan, Liechtenstein) was used before photopolymerizing in order to ensure consistency of the light intensity delivered by the curing unit. The photocuring of the resin-based cements was conducted via the CAD/CAM disks for 40 s while maintaining direct contact with the light curing tip. For the dual cure cement, DC measurements were conducted in both self-cure and dual cure modes where measurements were conducted at 8 min after mixing in self-cure mode and 7 min and 20 s after curing in dual cure mode. For the light cure cement, DC of conversion was measured immediately after light curing. DC measurements were conducted using an FTIR spectrometer (Nicolet iS10 FT-IR, Thermo Scientific, Waltham, MA USA) at 4 cm<sup>-1</sup> resolution and 100 scans with a range of 4000–800 cm<sup>-1</sup>. All

readings were taken from the bottom of the specimens. DC was calculated in % using the following equation:<sup>23-25</sup>

$$DC (\%) = [1 - (*R \text{ polymerized} / *R \text{ non-polymerized})] \times 100$$

where \*R is the ratio between the absorbance peak at 1637 and 1608  $\text{cm}^{-1}$

## STATISTICAL ANALYSIS

Using statistical software SPSS 24.0 (IBM Inc., Chicago, USA) the collected data were analyzed. One-way and two-way analyses of variance (ANOVAs) followed by the Tukey HSD test ( $p=0.0001$ ) were used to compare the mean values of translucency across the four materials used and to calculate differences in DC between the two resin cements as well as the two modes of curing for the dual cure cement. Finally, using linear regression analysis  $R^2$ , the relationship between the DC of resin cements and the translucency of the tested materials was identified.

## RESULTS

### TRANSLUCENCY

Table 2 shows the mean percentages and corresponding standard deviations of the TP indicating significant differences across the materials tested. One-way ANOVA demonstrated a significant difference in the TP between the four tested materials ( $P < 0.0001$ ) (Table 3). Among the four CAD/CAM materials, the mean TP values of Vita Suprinity was significantly higher, followed by Vita Enamic, DD Cube X<sup>2</sup>, and IPS E.max CAD.

### DEGREE OF CONVERSION

Two-way ANOVA showed highly significant differences in the mean values of the DC among the three modes of curing of the resin cements ( $P < 0.0001$ ) and also among the four CAD/CAM materials ( $P < 0.0001$ ). Furthermore, there was a statistically significant interaction between the CAD/CAM materials, type, and curing modes of the resin cements ( $P < 0.0001$ ). Table 4 provides the descriptive statistics of the DC and the significant differences between the degrees of conversion among the three curing modes of resin cements for the four CAD/CAM material. For all combinations except for IPS e.max CAD and Vita Enamic, the multiple pairwise comparison of mean values of DC of resin cements cured under the four CAD/CAM materials [IPS e.max CAD (22.53), Vita Suprinity (17.86), Vita Enamic (23.01), and DD Cube X<sup>2</sup> (25.22)] showed statistically significant differences in the DC of resin cements ( $P < 0.0001$ ). Among the four CAD/CAM materials, the mean values of DC of resin cements cured under DD Cube X<sup>2</sup> were significantly higher than of those cured under the other three CAD/CAM materials ( $P < 0.0001$ ). Conversely, the mean values of DC of resin cements cured under Vita Suprinity were significantly lower than of those cured under the other three CAD/CAM materials ( $p < 0.0001$ ). No significant difference was found in the mean values of DC of resin cements cured under IPS e.max CAD and Vita Enamic groups (Figure 1).

### REGRESSION ANALYSIS

Three regression models were developed for the three modes of curing (dual, light, and self-cure) to determine the relationship between the DC of resin cements and the translucency of the four CAD/CAM materials (Figure 2).

**Table 2. Results of One-Way ANOVA showing mean ( $\pm$  SD) of TP% and significant differences between the four CAD/CAM materials.**

Material	Mean	SD	95% Confidence interval for Mean		Minimum	Maximum
			Lower limit	Upper limit		
Vita Suprinity	73.41 <sup>a</sup>	.79	72.84	73.97	72.24	74.77
Vita Enamic	69.72 <sup>b</sup>	.19	69.58	69.85	69.32	69.91
DD Cube X <sup>2</sup>	65.98 <sup>c</sup>	1.92	64.60	67.36	60.88	67.63
IPS e.max CAD	64.21 <sup>d</sup>	.41	63.92	64.50	63.30	64.61

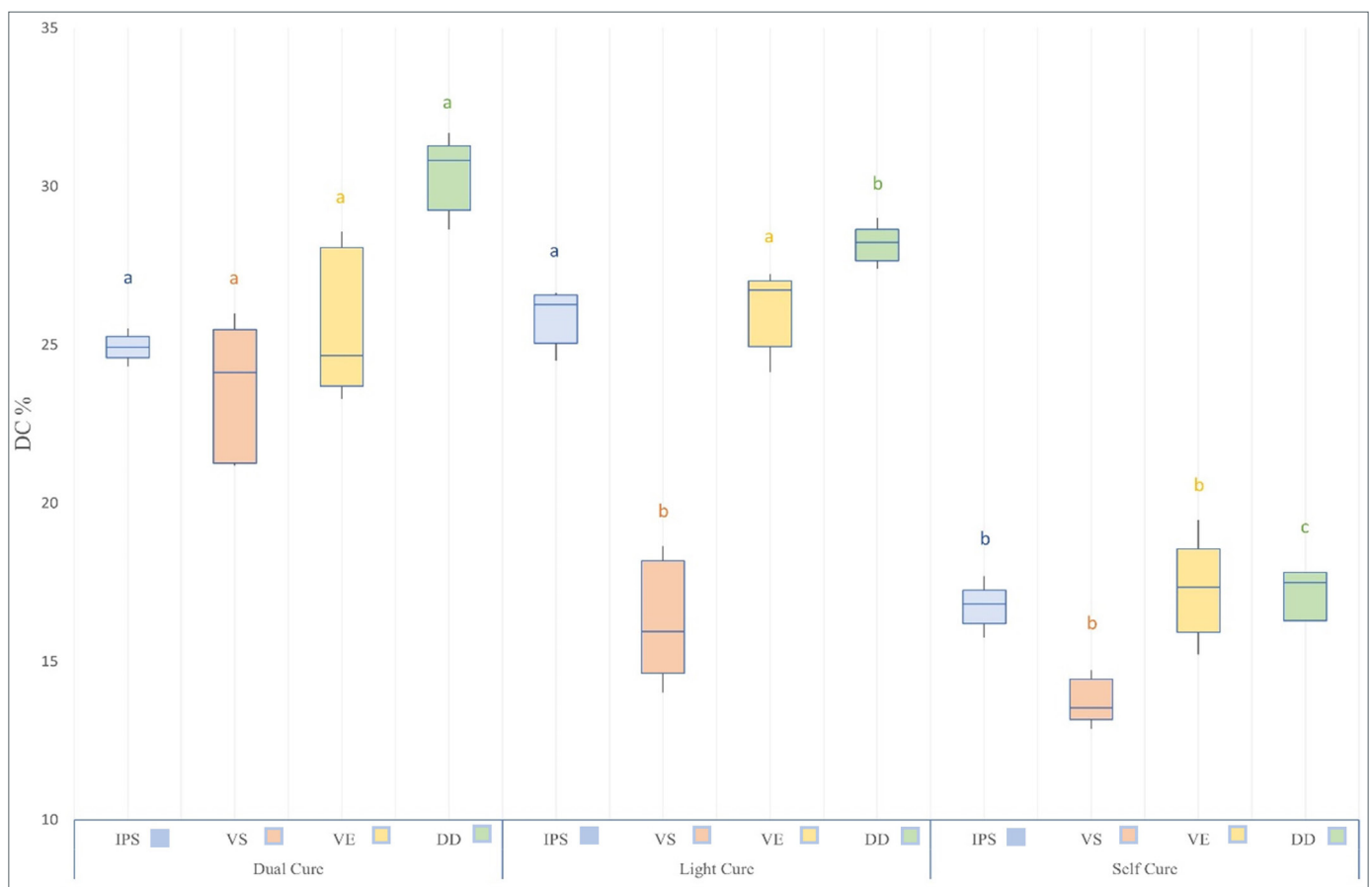
\*Different letters indicate significant differences for each material (Tukey HSD test)

**Table 3. Result of One-way ANOVA to compare mean values of TP% among the four CAD/CAM materials.**

	Sum of Squares	dff	Mean Square	F-value	P-value
Between groups	501.930	3	167.310	147.577	<0.0001
Within groups	40.814	36	1.134		
Total	542.744	39			

**Table 4. Results of Two-way ANOVA comparing the degree of conversion among the four CAD/CAM materials in relation to the type and mode of curing of the resin cements.**

Source	Type III Sum of Squares	dff	Mean Square	F-value	P-value
Corrected model	1692.147	11	153.832	85.083	<0.0001
Intercept	29457.012	1	29457.012	16292.504	<0.0001
Material	430.663	3	143.554	79.399	<0.0001
Type of Cement	1095.602	2	547.801	302.986	<0.0001
Material * Mode of Cure	165.882	6	27.647	15.291	<0.0001
Error	86.784	48	1.808		
Total	31235.944	60			



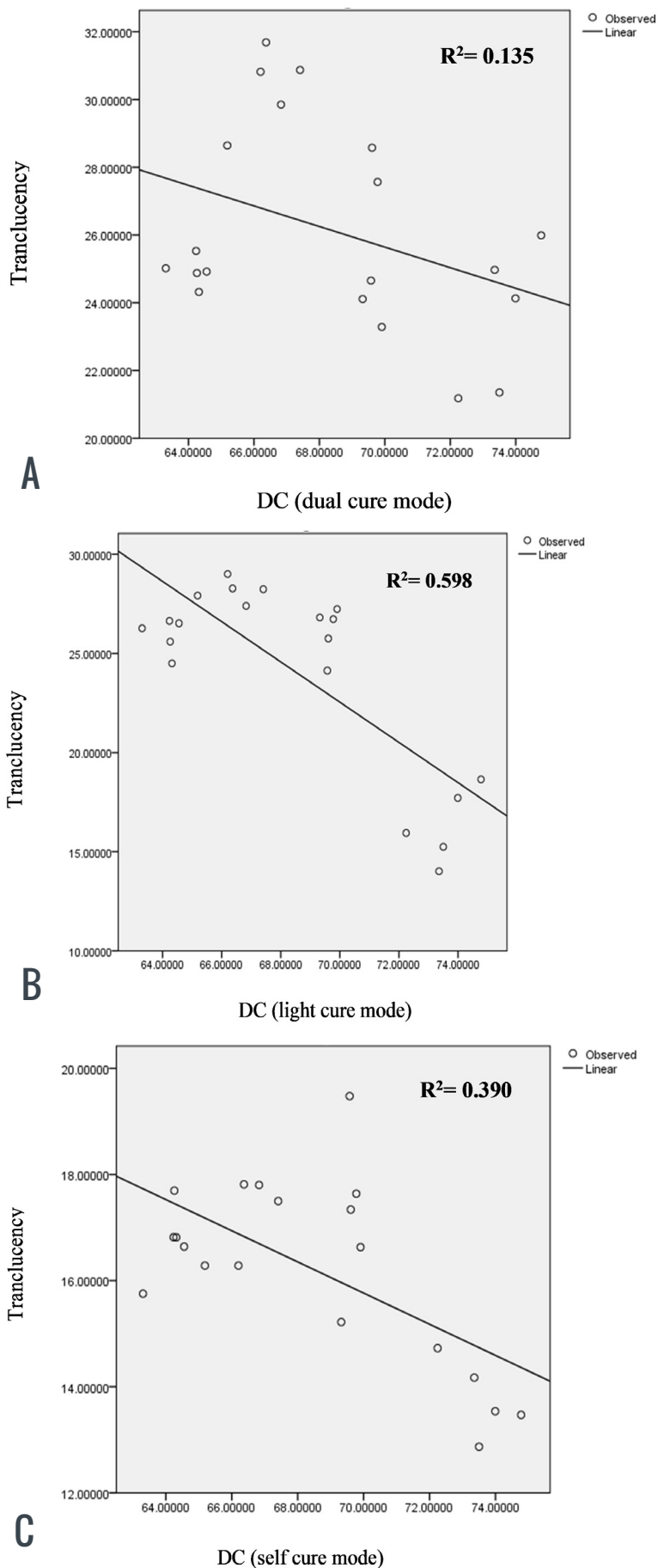
**Figure 1:** Mean values of degree of conversion of resin cements in three modes of curing in relation to the four CAD/CAM materials.

### DUAL CURE MODE

A negative relationship between DC and translucency was found; however, it was not statistically significant ( $R = -0.367$ ;  $P = 0.112$ ). The  $R^2$  value of 0.135 indicates that 13.5% of the change in values of DC are explained by TP values of CAD/CAM materials, which is not significant (Figure 2A). This suggests that no linear relationship is found between DC and translucency of CAD/CAM materials when the dual cure mode was used.

### LIGHT AND SELF CURE MODES

A statistically negative relationship between DC and translucency was found to be significant for the light and self-cure modes. The  $R^2$  value for light cure mode was 0.598 which indicates that 59.8% of the change in values of DC are explained by TP values ( $R = -0.773$ ;  $P < 0.0001$ ). The  $R^2$  value for self-cure mode was 0.390 which indicates that 39% of the change in values of DC are explained by TP values ( $R = -0.625$ ;  $P = 0.003$ ).



**Figure 2:** (A) Regression line for the DC in dual cure mode and the translucency of CAD/CAM materials. (B) Regression line for the DC in light cure mode and the translucency of CAD/CAM materials. (C) Regression line for the DC in self-cure mode and the translucency of CAD/CAM materials.

This suggests a statistically linear relationship between the DC and the translucency of CAD/CAM materials when the light and self-cure modes were used (Figure 2B and C).

## DISCUSSION

This *in vitro* study measured the TP of 2 mm-thick disks fabricated from four different classes of CAD/CAM materials to examine the interaction between translucency and curing efficiency in three curing modes. Based on the results of this study a significant difference in TP was found among the four CAD/CAM materials. Thus, the first null hypothesis was rejected. The highest TP% were observed in Vita Suprinity followed by Vita Enamic and DD Cube X<sup>2</sup> while the control IPS e.max CAD exhibited the lowest translucency. This is expected as LT shade was selected for IPS e.max CAD. Vita Suprinity is comprised of glassy matrix embedded with homogenous smaller silicate crystals.<sup>22,35-37</sup> Additionally, the refractive indices of Vita Suprinity crystals closely match its glassy matrix allowing light to pass through uninterrupted.<sup>33</sup> A study by Caprak *et al.* and another by Sen *et al.* also investigated the translucency of CAD/CAM monolithic materials including Vita Suprinity, IPS e.max CAD, and Vita Enamic. Their results also found that Vita Suprinity exhibited the highest TP % and their lowest TP % were attributed to Vita Enamic. Similarly, Awad *et al.* found that lithium disilicate ceramics demonstrated higher TP% when compared with Vita Enamic. It was proposed that the low TP% of Vita Enamic are due to its relatively high Al<sub>2</sub>O<sub>3</sub> content (20%–23 %wt.).<sup>22,23,44</sup> To the best of our knowledge, there are no studies regarding the optical properties of DD Cube X<sup>2</sup>. DD Cube X<sup>2</sup> is one of the HT zirconia ceramics presently available in the market. In addition to its high cubic phase, it has a low Al<sub>2</sub>O<sub>3</sub> content reaching approximately <0.1% of its chemical composition.<sup>39</sup> It was shown that increasing the cubic phase and reducing the Al<sub>2</sub>O<sub>3</sub> content allows more light to pass, substantially enhancing the translucency of these materials with TP% comparable to those of lithium disilicate ceramics.<sup>23,38,40</sup>

Regarding DC, our results demonstrated a significant difference between the two resin cements and between the curing modes; hence, the second null hypothesis was rejected. Similar to several studies, our results showed dual cure resin cements exhibited higher DC% when compared with their light cure counterparts. This can be explained by the fact that the polymerization of dual cure resin cements is not solely reliant on light initiation but combines light and chemical curing with the latter continuing even in the absence of the light source resulting in higher DC%.<sup>5,7,15,16</sup> However, some studies have reported contradictory results where light cure resin cements demonstrated higher DC% than dual cure resin cements.<sup>14,17,18</sup> Differing results may be attributed to the various methodologies and techniques implemented, including curing time and mode, type and power of light curing units, thickness, and type of overlying ceramic disks, immediate or delayed measurements of DC, and brand of luting resin cement tested. In the present study, DC for dual cure resin cement was measured

at 7 min and 20 s after light curing for 40 seconds in dual cure mode and 8 min after mixing for self-cure mode. For the light cure cement, DC of conversion was measured immediately after light curing. These timings were decided on to identify the DC of the cements immediately after curing when theoretically they should be sufficiently cured. The specimens were not stored over a period of time before measurements were conducted as was done in previous studies. Another measurement after 24h would have been beneficial in comparing immediate and delayed DC values. This is due to the fact that the polymerization process of the resin cements continues after the initial curing/mixing and does not end immediately. Our readings were taken from the bottom of the specimens as opposed to the top. This was done to evaluate the polymerization efficiency of the resin cement at the deepest level, which would clinically correspond to the layer of resin cement closest to the bonded tooth structure and directly involved in the adhesion process. When cementing ceramic veneers Sampaio *et al.* found the thickness of resin cements tested ranged between 0.15- and 0.32-mm.<sup>48</sup> However, the previous study was conducted on veneers in which the geometry facilitates escape of excess cement allowing a very thin cement layer, in crowns the geometry of the preparation is more complex and the escape of the cement is hampered leading to a thicker cement layer especially with at the occlusal part of the preparation. Pilo *et al.* conducted a retrospective *in vivo* study and found that the mean cement thickness at the occlusal walls were significantly higher than buccal and lingual walls, the mean thickness of Zinc phosphate cement on buccal and lingual walls were similar (116 microns and 109 microns, respectively), but much smaller than on occlusal walls (310 microns), the cement thickness might be more with resin cements.<sup>49</sup> Various *in vitro* studies determining the polymerization efficiency of resin cements namely DC, implemented a resin cement thickness of 1 mm.<sup>8,27,28</sup> A 1 mm resin cement thickness was also selected in this study which allowed for easier handling of the specimens. Additionally, according to manufacturer instructions, the cements were cured for 40 s using a polywave LED light curing unit with a light intensity of 1200 mW/cm<sup>2</sup>, whereas other studies opted for longer curing times and some with units of higher light intensity. The thicknesses of ceramic disks in other studies ranged between 0.3- and 1.5-mm.<sup>14,17,18</sup> The thickness of CAD/CAM materials selected for this study was 2 mm, which was based on the maximum thickness that manufacturers have indicated their cements would be adequately cured through. All these factors may also explain the DC% attained, ranging from 16.31% to 30.37%, which are noticeably lower than 50% to 75% values found in other studies.<sup>9,14,19</sup>

Similar to previous studies, our results demonstrated that dual cure resin cements polymerized in dual cure mode achieved higher DC% than dual cure resin cements polymerized in self-cure mode.<sup>9,10,19</sup> Dual cure resin cements have the advantage of both chemical and photopolymerization where light curing initiates the setting reaction and chemical curing

continues the polymerization process allowing further conversion to occur.<sup>10,13</sup> Self cure resin cements polymerize at a lower rate and therefore will not achieve the same DC as would dual cure resin cements.<sup>10</sup> Furthermore, self-cure resin cements require up to 2 weeks to fully polymerize, and in the present study, the DC measurements for the dual cure resin cement in self-cure mode were conducted at 8 min after mixing.<sup>19</sup>

The results of TPs for the different ceramics did not vary to a considerable extent with values ranging between 64.21 to 73.41%. Although Vita Suprinity showed the highest TP among the tested materials in this study and therefore should have allowed higher DC of resin cements, the opposite was found contradicting results exhibited by Çetindemir *et al.*<sup>7</sup> According to the manufacturer, Vita Suprinity is available in two degrees of translucency, namely, T and HT. For the present study, a T/A2 was chosen whereas Çetindemir *et al.* selected a HT/A1 shade. The differences in shade and translucency may explain the contrary results. The composition of 5Y-TZP zirconia ceramics such as DD Cube X<sup>2</sup> allows smoother light transmittance.<sup>23,38,40</sup> This may explain why resin cements cured under it exhibited the highest DC values.

Our results showed a negative linear relationship between DC of resin cements in three curing modes and TP% of the CAD/CAM materials. Among the three curing modes, a statistically significant negative relationship was observed in light cure and self-cure method. These results emphasize that factors other than translucency come into play with respect to the amount of light transmitted through ceramics and the polymerization efficiency of resin cements. Such factors include the type of ceramic, cement shade, light attenuation, light source, and curing protocol. All of which affect the DC of resin cements.<sup>4-8,11</sup> The minimal variability in the TP result might have accentuated the effect of the other factors related to ceramic composition. On the basis of these results, we can deduce that materials' translucency is not related to the DC of resin cements; rather, it is related to the passage of light and its attenuation as it travels through the material and how sufficient it was in the initiation and propagation of the curing reaction. Similarly, Salgado *et al.* concluded that translucency did not influence the cure efficiency of resin-based composites but rather had an influence on their color stability.<sup>25</sup>

## CONCLUSIONS

Based on the limitations of this study, the following conclusions can be made:

- The type of CAD/CAM material significantly affected the DC values of resin cements, with those cured under Vita Suprinity exhibiting the lowest values and those cured under DD Cube X<sup>2</sup> displaying the highest values.
- Variolink Esthetic DC should be used in its dual cure mode since the lowest DC values observed were in its self-cure mode.

- Careful consideration in selecting materials for indirect restorations and resin cements used to lute them is of paramount importance to ensure the optimum performance of the final restoration.

## MANUFACTURERS' DETAILS:

- Ivoclar Vivadent, Schaan, Liechtenstein.
- Vita Zahnfabrik, Bad Säckingen, Germany.
- Dental Direkt GmbH, Spenge, Germany.

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