Translucency of Value Resin Composites Used to Replace Enamel in Stratified Composite Restoration Techniques

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ABSTRACT

Background: The translucency of enamel shade is a crucial property that affects the color of a layered restoration.

Objective: This study evaluated the translucency of high-, medium-, and low-value resin composites (4 Seasons, Ivoclar Vivadent, Schaan, Liechtenstein) used to replace enamel in stratified composite restoration techniques.

Materials and Methods: The color specimens with 12 mm in diameter and various thicknesses (0.5, 1.0, 1.5, 2.0, 3.0, 4.0 mm) were measured after polymerization on a reflection spectrophotometer over white and black backgrounds to calculate the translucency parameter (TP). The statistical analysis of TP was accomplished using two-way analysis of variance ($p < 0.05$). Significant differences were revealed by the Tukey's Honestly Significant Difference post hoc test.

Results: Translucency of the value composite resins was influenced by the value and thickness. Color of value resin composites was dependent on the background contrast at the evaluated thicknesses.

Conclusions: High-value composite resins were more translucent than medium-value composites, which were more translucent than low-value composites. The translucency decreased as the thickness of the specimens increased.

CLINICAL SIGNIFICANCE

The results suggest that special attention should be paid to the thickness of the increment of value composite resins when reproducing translucency of natural tooth enamel.

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INTRODUCTION

Munsell Color became the system of choice for color matching in dentistry due to its consistency, flexibility, and ease of use.[1] This system expresses colors in three dimensions, known as hue, chroma, and value. Hue is the quality by which we distinguish one color family from another, i.e., red from yellow, green from blue or purple. Chroma is the intensity or saturation of the hue. Value is defined as the quantity of light an object reflects when compared to a pure white diffuser (100% reflection) and a black absorber (0% reflection). Consequently, if a material reflects all the light exposed to its surface, it will have a bright appearance and a high value. A dark object will absorb a majority of the incident light, however, and have a dull appearance

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with a low value. Between these two extremes is a gradation of value termed the gray scale.[1,2]

The increasing aesthetic demands by patients led to the use of materials presenting optical properties that are similar to those of the dental structure. Enamel and dentin have different structural characteristics and, consequently, exhibit different light wave characteristics. Due to its highly mineralized prismatic structure, low organic content, and small amount of water, enamel presents higher light transmission than dentin, which has less mineral content, an organic tubular structure, higher water content, and is less translucent.[3]

According to the natural features, the composite resins used for dentin buildup are fabricated and are characterized by lower translucency, whereas the composite resins for enamel are highly translucent.[4] In an attempt to reproduce the enamel properties, high-, medium-, and low-value resin composites were introduced, and they are increasingly used for stratified restorations using direct composite resins. Unlike the conventional composite resins for enamel, with their hue based, the value enamel composites present discrete chromatic expression and their shades are based on the value.[5]

In restorative procedures, the chromatic characteristics are considered the most important factor to achieve natural results, but those characteristics might be accompanied with proper translucency to accomplish this objective.[6] The aim of this study was to evaluate the influence of the value and thickness on the translucency of value resin composites. The null hypothesis was that there are no significant differences of the translucency of value-enamel resin composites used in the evaluated thicknesses.

MATERIALS AND METHODS

High-value (lot # K27334), medium-value (lot # H25492), and low-value (lot # H15575) composite resins (4 Seasons, Ivoclar Vivadent, Schaan, Liechtenstein) were used in the current study. The specimens were built up in six different thicknesses (0.5, 1.0, 1.5, 2.0, 3.0, 4.0 mm) using a stainless steel matrix designed to produce resin composite disks. The matrix presented a 12-mm diameter circular platform that could be retracted, producing a cavity that could be filled with resin composite to different thicknesses.

To produce specimens up to 2.0 mm thickness, the central platform was retracted according to the desired thickness of increment of each value composite. A glass slab was then placed under finger pressure, and a 100-g steel block was applied for 10 seconds to achieve a uniform thickness of the disk-shaped specimens. Light curing of the composites was performed for 60 seconds (3 M Curing Light 2500, 3 M Dental Products, St. Paul, MN, USA) and light output was constantly monitored (600 mW/cm^2).

To produce the 3 mm- and 4 mm-thick specimens, a 2.0 mm-thick composite disk was produced, following the same protocol described earlier. The depth of the reservoir was increased to form a deeper cavity. The next increment of composite resin was applied, the glass slab was placed, and the increment was light-cured for 60 seconds. No polishing technique was performed in the specimens after curing.

Color measurements were made according to the CIELAB[7] color scale (CIE, standard illuminant D65) over a white background ($L^* = 91.38$, $a^* = 1.31$, $b = -1.56$) and a black background ($L^* = 28.99$, $a^* = 0.40$, $b^* = -0.29$) on a reflection spectrophotometer with specular component excluded geometry (CM-3500d, Minolta, Osaka, Japan). The L^*-axis indicates the achromatic coordinate or the lightness of the object, with a range from 0 (absolute black) to 100 (absolute white). The a^*- and b^*-axes indicate the three-dimensional positioning of the object in color space. The a^*-axis represents the amount of red (positive a^* value) or green (negative a^* value). The b^*-axis represents the amount of yellow (positive b^* value) or blue (negative b^* value).

Five specimens ($N = 5$) were made for each value resin composite at the evaluated thicknesses in a total of 90 specimens. To exclude eventual relative inconsistencies

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from the device and the operator, three different spectrophotometric measurements were accomplished consecutively in each specimen and the results obtained by acquiring the average of the measurements. Translucency parameter (TP) was obtained by calculating the color difference between the specimen on a white background and on a black background with the following formula[8,9]:

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

where B refers to the color coordinates over the black background and W refers to those over the white background. If the material is absolutely opaque, TP value is zero. The greater the TP value, the higher the actual translucency of the material.

The statistical analysis of TP was accomplished using two-way analysis of variance (ANOVA) with the following variables: composite resins (three modalities: high, medium, and low value) and increment thickness (six modalities: 0.5 mm, 1.0 mm, 1.5 mm, 2.0 mm, 3.0 mm, and 4.0 mm). Statistical differences were revealed by the Tukey's Honestly Significant Difference post hoc test. All statistical testing was performed at a preset alpha of 0.05.

RESULTS

CIELAB measurements of high-, medium-, and low-value composites at the various thicknesses over white and black backgrounds are described in Table 1. The TPs of the samples in the different thicknesses and the standard deviations are described in Table 2. ANOVA results indicated that there were significant differences between different composites, thicknesses, and their interaction ($p < 0.00001$).

The high-value composite specimens were more translucent than the medium-value and low-value composite specimens, regardless of the thickness. The greater the thickness of the specimens, the lower the

TABLE 1. CIELAB measurements of high-, medium-, and low-value composite resins at various thicknesses over white and black backgrounds

		0.5 mm			1.0 mm			1.5 mm			2.0 mm			3.0 mm			4.0 mm		
		*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**
HV	W	86.6	0.2	5.4	80.6	0.4	7.6	76.4	0.2	8.0	72.5	0.6	8.6	68.7	0.6	7.0	65.8	–0.1	5.6
	B	57.9	–1.9	–4.6	59.5	–2.6	–3.1	60.7	–2.7	–1.3	61.1	–2.4	–0.1	61.5	0.5	0.1	61.7	–2.1	0.9
MV	W	84.1	0.2	5.6	77.1	0.5	7.4	73.4	0.3	7.5	69.8	0.3	7.4	64.6	0.1	5.6	60.6	–0.4	3.6
	B	56.6	–1.9	–4.6	57.4	–2.5	–2.3	58.1	–2.7	–1.8	58.1	–2.6	–0.9	58.2	–2.3	–0.2	56.9	–2.3	–0.1
LV	W	81.0	0.4	6.8	72.4	0.7	8.8	65.3	0.6	11.2	61.0	0.5	10.5	56.5	–0.1	7.4	53.4	–0.6	4.8
	B	54.8	–2.0	–2.9	55.1	–2.2	–0.6	53.5	–2.6	1.8	52.3	–2.3	2.7	51.2	–2.2	2.6	51.1	–2.1	2.3

TABLE 2. Translucency parameters for each value at various thicknesses (standard deviation in parentheses)

	0.5 mm	1.0 mm	1.5 mm	2.0 mm	3.0 mm	4.0 mm
HV	28.8 (0.4)	21.7 (0.5)	17.7 (0.4)	14.3 (0.2)	10.0 (0.6)	6.5 (0.5)
MV	27.6 (0.3)	20.4 (0.3)	16.5 (0.2)	13.6 (0.4)	8.7 (0.4)	5.4 (0.4)
LV	26.5 (0.2)	19.2 (0.3)	15.2 (0.4)	11.9 (0.4)	7.4 (0.2)	3.7 (0.7)

The results indicate that every mean of every factorial group is statistically significantly different from every other mean.

translucency observed, regardless of the value. Statistically significant differences were observed between the composites and thicknesses. The results indicate that every mean of every factorial group is statistically significantly different from every other mean.

DISCUSSION

When light strikes on an object, a number of interactions can occur depending on the characteristics of the wavelength of the light and the object. The object is responsible for the determination of the distribution of light spectrum, through reflected, absorbed, or transmitted energy.[10] Opaque objects block completely the light, whereas transparent objects allow total transmission of light. The translucent objects are between these two opposites. Translucency could be described as partial opacity or a state between complete opacity and complete transparency. It is defined as the relative degree to which materials permit or prevent any underlying color from affecting the appearance of a colorant layer.[9]

The translucency may contribute to shade matching with a tooth by allowing the shade of the adjacent and underlying tooth structure to shine through. Clinicians have commonly observed this "chameleon" effect of resin composites.[11] However, in situations where there is no tooth structure to provide a backing for the restoration, such as in large class III or IV, translucent materials may provide relatively poor color matches. More specifically, a grayish shade is often seen in comparison to the surrounding tooth structure, as relatively translucent materials are probably affected by the darkness of the oral cavity. In such situations, dentin shades resin composites have been used.[11,12]

The statistical analysis revealed statistically significant differences of translucency and, as a consequence, the null hypothesis was rejected. The translucency of the value composite resins was influenced by the value and the thickness. However, the influence of the thickness was noticeable. That is to say, increasing the thickness produced a great variation in translucency, regardless of the value. On the other hand, slight variations in translucency were observed between resins with different values, regardless of the thickness. The current findings corroborate other laboratory study addressing the influence of increasing the thickness of translucent superficial layers of composite on the reduction of translucency of the composite resin specimens.[13]

The influence of a number of variables could explain the small differences in translucency of the value composite resins, regardless of the thickness. According to Johnston and Reisbick,[9] the shade and translucency of restorative materials results are not only due to macroscopic phenomena such as type and amount of inorganic filler and organic matrix, they are also due to the addition of dyes and other chemicals. The coloring material, or pigments, within the object will absorb various wavelengths of light, allowing other wavelengths to scatter out of the object.[14] In other words, the wavelengths that are not absorbed are seen. The light is called scattered when it is deflected in many different directions within the object because of reflection and refraction of the light at the internal interfaces. When many internal particles are present, the light may be scattered, that is, its transmission is diminished exponentially.[15]

In the present study, 0.5-, 1.0-, and 1.5-mm thicknesses were used to evaluate the translucency of value composite resins, similar to dimensions of natural enamel, whereas 2.0-, 3.0-, and 4.0-mm thicknesses were used in an attempt to find out the thickness of composite required to mask the background contrast, an essential condition to evaluate the inherent color of the material.[15] The maximum thickness of 4.0 mm was based on a study by Kamishima and colleagues,[16] who reported that enamel composite resins were not influenced by the background contrast at this thickness. The current authors set a TP value of <2.0 as the limit where the translucency of the object was not perceptibly influenced by the background contrast when viewed with the human eye. Considering this value, none of the specimens of this present study were able to eliminate this influence.

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In a recent study, some authors evaluated the chromatic influence of high-, medium-, and low-value resin composites on a dentin composite substrate (A2 shade) using spectrophotometric analysis.[5] The specimens with high-value composite presented greater brightness than medium- and low-value composites, and they were statistically different from each other. However, an inverse relationship was observed between the thickness and brightness, regardless of the value of the primary composite. In other words, an increased thickness of value resin led to lower L^* values observed. Those authors[5] attributed the lower L^* values to the dispersion of the luminous energy which is inherent to translucent objects. When this dispersion occurs, the energy is reflected diffusely, returning randomly from the specimen surface, commonly beyond the observation range of the spectrophotometer. This limitation was called edge loss.[17,18]

To match tooth color, various shades of yellow and gray pigments are blended to white base material of traditional resin composites. In darker shades (low lightness or high chroma shade), more pigments might be incorporated, which may influence the translucency of the shade.[19] Yu and Lee[15] analyzed the influence of color parameters of resin composites on their translucency using a reflection spectrophotometer. The results indicated a high correlation between translucency and L^* value, with darker shades presenting lower translucency. The current results demonstrated that value resin composites present similar translucent parameters as the resin composites reported by those authors. This observation is based on the positive relationship between L^* values and translucency of both types of resins.

The results of this in vitro study should be extrapolated with caution to the clinical practice because several factors such as the type of light source, surface morphology, and moisture can also affect the appearance of the restorations. Nevertheless, the TP is frequently used to evaluate the translucency of composite resins and other restorative materials.[20–22] While there are defined levels of clinical acceptance for chromatic changes, there are no studies regarding the clinically acceptable levels of translucency. However, separating the results in three distinct groups is a common practice.[23] In the current study, the specimens classified in the low translucency group were those that presented a maximum TP of 10.0 and a minimum TP of 3.7 (3.0 mm- and 4.0 mm-thickness value composite resin specimens), mean translucency specimens presented a maximum TP of 17.7 and a minimum TP of 11.9 (1.5 mm and 2.0 mm-thickness specimens), and high translucency specimens presented a maximum TP of 28.8 and a minimum TP of 19.2 (0.5 and 1.0 mm-thickness specimens).

CONCLUSION

Within the limits of this study, the results suggest that special attention should be paid to the thickness of the increment of value composite resins when reproducing the translucency of natural tooth enamel.

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