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Research Paper: Comparing the Translucency of several enamel and universal- shade composite resins

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ABSTRACT

Introduction: Translucency is one of the important optical properties of tooth color materials and it is greatly affected by the thickness of material. This study concerns comparing the translucency parameter (TP) of five different composite resins in different thicknesses.

Materials and Methods: Five brands of composite resins; Gradia (GC) ,Crystalline (Confi-dental) Vit-l-escence (Ultradent) in A2, and Herculite XRV (Kerr), Opallis (FGM) in enamel A2 (EA2) shades were selected to enroll the study. Color coordinates of each composite were determined at 0.5, 1, and 1.5 mm thicknesses on a white backing, the backing of material itself and a black backing were calculated by using a spectrophotometer to evaluate the translucency parameter (TP) of the study materials. The masking ability was also calculated from the specimens on the material itself and on black backing. The values under 2 were estimated as imperceptible. One-way ANOVA, T-test and Tukey HSD were employed for statistical analysis.

Results: Opallis (EA2) showed the less TP values in all thicknesses in comparison to the other materials ($p< 0.05$) but there was no statistically significant difference between TP values of Gradia and Opallis in 1.5 and 0.5 mm-thick. The masking ability values recorded for all specimens at different thicknesses, were in the range of perceptible.

Conclusion: In this study, translucency of Opallis (EA2) and Gradia(A2) was less than the other enamel /universal shade composites. For this reason, it would be concluded that if the restoration thickness is ≤1.5mm, these enamel/ universal shade composite resins cannot mask the black background color.

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Introduction

It is widely argued that duplicating color properties and characteristics of the tooth structure by dental materials are considered as great challenging responsibilities in dentistry.¬(1,2)

In some clinical situations, for example, in order to restore the cavities with backing of natural dentin or apply composite veneers of the teeth with no dark discoloration, we should choose enamel or universal shade of composite resins. More exactly, translucency is one of the most important optical properties of tooth color materials. (1-3) Moreover, hue, chroma and value are three dimensions of color and value which are profoundly relevant to translucency. (4-6)To confirm the given claims, a direct correlation has been shown between the translucency of composite resins and chameleon effect (7).

It is also worth mentioning that the translucency degree of enamel -shade composite resins can change the color perception of the underlying natural dentin or dentin-shade resins (8).

There are a lot of studies about the translucency of composite resins and the effective factors on it. Some of the factors affecting the composite resins translucency include: shade (5,6), thickness (4,7), size and content of fillers (9,10), matrix composition (11,12) and refractive index of matrix and filler particles (13).

According to previous studies, different brands of composite resin in the same shade category (enamel, dentin, body, opaque) and thickness, showed significant differences in translucency (5,14,15).

In the study directed by Balci et al. (16) the translucency parameters of seven anterior composite resins were different from each other and there was not any relationship between different classes of materials.

It is necessary to point out that the translucency of enamel color composite resins is greatly influenced by the material thickness (4-6). Therefore, it is necessary to evaluate and compare the translucency of the available composite resins in our market.

In this study, comparing the translucency parameters (TP) of several available composite resins in different thicknesses is of concern not to mention evaluating their abilities to mask black background color is also of importance to be studied.

On the basis of the purpose of the study, the following two hypotheses are supposed to be tested:

1: There are no significant differences between the TP values of each composite resin at different thicknesses or the same thicknesses of different composite resins.

2: None of the composite resins can mask black background.

Materials and Method

Five brands of resin composites; Gradia (GC; Tokyo, Japan), Vit-l-escence (Ultradent; South Jordan, USA), Crystalline (Confi-dental; Louisville, USA) in A2 shade and Herculite XRV (Kerr; Scafati, Salerno, Italy) , Opallis (FGM, Brazil) in enamel A2(EA2) shade were enrolled in this study. To be more precise, stainless-steel split plates in 0.5, 1, 1.5 mm thicknesses and with a hole of 18 mm in diameter were used as the molds to produce standardized specimens. At first, each mold was filled with resin composite material and covered with clear celluloid strips on the top and the bottom of the hole. Next, the metal plate was pressed between two glass-slides for 10 seconds. Then, the glass slides were removed. After that, the specimens were light cured for 40 seconds in eight overlapping areas with two light-curing units (Litex 680; Dentamerica, USA) simultaneously. The light intensity was 400m W/cm2 and the output of the light was checked with a radiometer. Finally, five specimens from each material thickness were made and after their storage in distilled water for 24 hours, the specimens were polished with a wet 1500-grit silicon carbide paper (3M ESPE; St. Paul, USA) on both sides.

It is worth mentioning that the CIE L*a*b*(CIELAB) technique was employed in the present study. This technique is introduced

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by the International Commission on Illumination (French Commission Internationale de l'éclairage (CIE) which is an organization that establishes the standard values used worldwide to measure color. The values used by CIE are called L*, a* and b* and the color measurement method is called CIE L*a*b* (CIELAB). L* is lightness, where 100 is completely white and 0 is completely black, and a* and b*are red-green and yellow- blue chromatic coordinates, respectively. A positive a* or b* value represents a red or yellow shade respectively (4-8).

In the current study, three backgrounds; white tile (L*=94.32, a*= -0.46, b*=1.26), black tile (L*=0.06, a*= -0.01, b*=0.01), and resin itself were used to determine the translucency parameter (TP) (between black and white backgrounds), and to mimic a black oral cavity (between black and resin backgrounds).

To determine the CIELAB values of each specimen with each background, color measurements were performed by employing spectrophotometer (Color-Eye 7000 A; Gretag Macbeth, USA). Furthermore, optical contact was achieved by using an optical fluid (refractive index =1.5) between the composite resin specimen and background. Additionally, light source illumination was matched with the average daylight (D65). The last but not the least, the translucency parameter of the material at various thicknesses was calculated using the following equation:

$$TP=[(L^*_W-L^*_B)^2+(a^*_W-a^*_B)^2+(b^*_W-b^*_B)^2]^{1/2}$$

The subscript" W" and "B" refers to the CIELAB values for each specimen on white backing and black backing, respectively. The ability of each material to mask dark oral cavity was determined by calculating the ΔE* of the specimens between the material itself and on black backing using the following equation:

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

A smaller ΔE*indicates that the specimen is less sensitive to (as in better able to mask) the black back ground color. The ΔE*value was assessed for each thickness and a value of ΔE*≤2 was considered clinically imperceptible regarding the method used by some previous studies (5,15).

To evaluate any statistical changes in the TP of different thicknesses in each composite, one-way analysis of variance (ANOVA) was conducted. To compare the TP between different materials at the same thicknesses, Tukey HSD test was performed and it was set at the 0.05 level of significance.

Result

The median values L*, a* and b* of each composite at three thicknesses and backgrounds and also the values of ΔE* for each material at different thicknesses have been specified in Table 1.

One-way ANOVA test showed significant differences in TP values in different thicknesses(0.5, 1, 1.5) of each material.

The comparison of the TP of different composite resins with the same thickness has been illustrated in Table 2.

In all thicknesses (0.5, 1, 1.5), Opallis showed the less TP values in comparison to the other materials ($p< 0.05$) but there was no statistically significant difference between TP values of Gradia and Opallis in 1.5 and 0.5 mm-thick.

The ΔE* values recorded for all composite resins were higher than 2. It means that all composites at 0.5,1 and 1.5 - mm- thicknesses may not mask the black background.

Discussion

It can be seen from the above analysis that information about the translucency of the composite resins in different thicknesses helps clinicians in choosing the appropriate and accurate material in different clinical situations (17). The result of the present study revealed significant differences of translucency between different thicknesses of the same composite. However, regardless of shade category, some of composite resins showed no significant

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difference in translucency parameter with the same thicknesses. Consequently, the first null hypothesis was partially rejected.

These findings are consistent with the findings of the other researchers who demonstrated that the thicker composite resins were less translucent (3-5,18).

In our study EA2shade of opallis showed lower translucency than A2(universal) shade of Crystalline and Vitalecence at the same thicknesses. And also, translucency parameter of A2 shade of Vitalecence(which is recommended as substituted of dentin by its manufacturer) was similar to enamel EA2 shade of Herculite. These findings are in consistent with the other studies which showed there was no standard shade category among the manufactures (14,18,19).

In our study, Tp values of Opallis and Gradia were lower than the others. That is to say, the most important difference between the composite resins in our study is their matrix composition. In other words, the matrix of composite resins in this study, except Opallis and Gradia, were based on Bis-GMA. In addition, Opallis is a nanohybrid composite resin and i ts matrix contains Bis-GMA, Bis-EMA, UDMA, TEGDMA and matrix composition in Gradia which is UDMA-based (20,21). Azzopardi et al (11). reported that Bis-GMA containing resin were more translucent than UDMA- and TEGDMA-based composite resins. In a study by Pereira et al (12), the UDMA-based materials showed the lowest TP value.

The ΔE* values of different composites for masking the black background in this study showed a negative relationship with their thickness. This result is in agreement with previous studies (14,15,17.22). The threshold for clinically acceptable color difference has been reported as ΔE*≤2 (4,15,23,24), ΔE*≤2.7 (25), ΔE*≤3.3 (26), ΔE*≤3.7 (27). It should be noted that the clinically acceptable threshold of ≤2 was used in this study. Based on this, the values of ΔE*between 0 and 2 are imperceptible and values of ΔE*in the range of 2 to 3 are just perceptible, 3 to 8 are moderately perceptible and values above 8 are markedly perceptible. [23] According to this category, none of the composite resins in our study could completely mask the black background, so the second hypothesis was accepted. Therefore, using them to restore a through-and-through class III or IV cavity would probably lead to a show-through appearance.

Among the composite resins in our study, Opalliss and Gradia at 1.5 mm thicknesses showed the less TP value and a 3 >ΔE>2, making them as a material of choice to mask slight tooth discoloration. However, further investigations are needed using different background colors for example C2, C3, C 4.

In natural dentition, translucency value varies among individuals, tooth type and age. (8) To reproduce the optical properties of natural teeth, each part of the tooth must be replaced by the material with properties similar to those of tooth. Lee (2) stated that translucency of human teeth should be the reference in the translucency assessment of restorative materials. About the translucency of human teeth, limited reports are available. In the study conducted by Ryan et al (14), the mean TP value of human enamel at 2 mm thicknesses was 11.6(±0.3). Yu et al. (28) reported the translucency parameter of 1- mm -thick human enamel and dentin 18.7and 16.4, respectively. A recent study also reported the mean in vivo TP of vital incisor enamel at 2 mm thicknesses, 10.1(±3.6). (29) However, in our study, TP values of 1- mm –thick composite resins ranged from 4.32(SD 0.07) to 5.89(SD 0.02) which was much lower than those reported for human enamel at the same thickness. In consistent with our results, in a study by Ryan et al. [14] enamel – shade composite resins obtained lower TP values in comparison to human enamel. Nevertheless, the data obtained from different studies cannot be directly compared due to the differences in experimental conditions, methods and materials (1).

To recapitulate, more investigations are needed to compare TP values of composite resins, human enamel and dentin at the same conditions.

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However, the result of this in vitro study should be cautiously extrapolated to clinical situations because of some other factors such as surface texture and degree of polishing which may affect the optical properties of the restoration.

Conclusion

Within the limitations of this study such as low masking ability of these composite resins and in through-and-through class III and IV restorations, dentin/opaque shade composite resins had better be used as a backing in a layering technique. Moreover, among the studied composite resins, Opallis and Gradia showed lower translucency, subsequently, they can be used to cover minor tooth discoloration or restore an area with less translucency.

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None

Authors'contributions

Farideh Darabi: Conceptualization, Methodology, Writing - Review & Editing **Maryam Tavangar:** Resources, Investigation, Visualization Vanya Rasaie: Methodology, Visualization **Reza Tayefeh Davaloo:** Writing - Original Draft, Data Curation **Maryam Ghamgosar:** Funding acquisition, Project administration, Supervision **Fateme Moosazadeh Hassan Kiadeh:** Writing - Review & Editing Resources **Aref Khosravian:** Writing - Review & Editing Investigation

Conflict of Interests

The authors declare no conflict of interest.

Ethical declarations

Not applicable

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None

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Table 1: Mean (SD) of CIE l*, a*, b* and ΔE values in 0.5, 1 and 1.5 mm thickness of resin composites over backgrounds

Material	Shade	Thickness	L* (SD)			a* (SD)			b* (SD)			ΔE
			White	Material itself	black	White	Material itself	black	White	Material itself	black	
Gradia direct	A2	0.5	68.45(2.36)	67.21(2.40)	63.05(2.34)	1.71(0.09)	1.31(0.1)	0.92(0.04)	16.52(0.3)	15.89(0.35)	13.41(0.3)	4.29(0.16)
		1	69.4(1.08)	66.43(0.83)	64.58(0.38)	2.84(0.19)	2.24(0.2)	1.04(0.06)	15.82(0.04)	15.28(0.39)	12.45(0.37)	3.69(0.32)
		1.5	74.30(0.13)	73.89(0.21)	71.42(0.37)	3.87(0.06)	2.20(0.008)	1.28(0.008)	13.28(0.14)	12.20(0.03)	10.99(0.04)	2.91(0.2)
Herculite	EA2	0.5	63.46(0.36)	63.03(0.36)	58.19(0.25)	3.03(0.27)	2.16(0.27)	1.44(0.33)	15.62(0.32)	14.6(0.32)	11.75(0.37)	5.66(0.06)
		1	69.81(0.38)	67.21(0.3)	63.4(0.21)	3.55(0.22)	2.46(0.26)	1.62(0.34)	10.52(0.5)	10.41(0.43)	7.79(0.26)	4.7(0.16)
		1.5	65.97(0.81)	65.58(1.72)	61.83(0.31)	3.40(0.14)	2.78(0.05)	1.89(0.04)	11.69(0.2)	10.09(0.08)	9.29(0.31)	3.95(1.76)
Crystal-line	A2	0.5	7.39(0.36)	76.6(0.36)	71.56(0.4)	2.72(0.07)	2.13(0.05)	3.3(0.11)	10.11(0.29)	9.45(0.83)	7.98(0.35)	4.27(0.17)
		1	68.87(0.28)	66.38(0.37)	61.66(0.38)	2.49(0.35)	2.6(0.45)	3.45(0.35)	11.75(0.44)	9.69(0.26)	8.01(0.24)	5.08(0.1)
		1.5	68.22(0.15)	66.94(0.19)	63.76(0.16)	1.74(0.09)	1.06(0.06)	0.75(0.1)	14.89(0.11)	12.93(0.22)	11.69(0.13)	3.42(0.08)
vitales-cence	A2	0.5	77.41(0.27)	74.43(0.26)	70.24(0.31)	3.14(0.1)	3(0.16)	2.38(0.73)	8.14(0.16)	7.15(0.19)	6.98(0.12)	4.85(0.13)
		1	79.24(0.4)	78.12(0.38)	75.42(0.41)	1.73(0.3)	1.84(1.4)	2.27(1.25)	7.86(0.37)	4.47(0.37)	3.07(0.31)	4.97(0.09)
		1.5	69.72(0.27)	67.91(0.22)	64.22(0.19)	2.47(0.36)	1.74(0.62)	1.05(0.04)	8.48(0.2)	7.79(0.03)	6.94(0.06)	3.88(0.07)
Opallis	EA2	0.5	21.12(0.27)	80.38(0.3)	76.16(0.15)	6.02(0.04)	5.44(0.06)	4.95(0.01)	21.12(0.27)	19.78(0.14)	19.75(0.44)	4.27(0.17)
		1	72.68(0.32)	70.54(0.43)	67.46(0.46)	1.46(0.46)	1.1(0.39)	0.62(0.38)	16.10(0.35)	16.13(0.33)	12.25(0.41)	3.74(0.28)
		1.5	72.54(0.1)	70.86(0.08)	69.47(0.15)	1.07(0.07)	1.39(0.14)	0.39(0.57)	17.65(0.16)	16.51(0.19)	14.72(0.26)	2.53(0.1)

L*lightness; a*, redness (positive +a*) or greenness(negative -a*); b*, yellowness(positive + b*) or blueness(negative - b*). EA2, Enamel A2; A2, universal A2

Table2: Mean (SD) TP values of different materials

Material	Color	TP (SD) Thickness		
		0.5	1	1.5
Gradia Direct	A2	6.27(0.03)^{b}	6.18(0.42)^{a}	4.56(0.1)^{b}
Herculite	EA2	7.43(0.22)^{a}	6.72(0.03)^{a}	5.02(0.47)^{a}
Crystalline	A2	7.51(1.07)^{a}	6.23(0.17)^{a}	5.58(0.07)^{a}
Vitalescence	A2	7.33(0.09)^{a}	6.2(0.03)^{a}	5.89(0.02)^{a}
Opallis	EA2	5.25(0.28)^{b}	5.01(0.16)^{b}	4.32(0.07)^{b}

Note: Different superscript letters in each column show a significant difference among the investigate materials

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