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The Use of Resin Composite Layering Technique to Mask Discolored Background: A CIELAB/CIEDE2000 Analysis

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Clinical Relevance

Esthetic resin composite restorations can be achieved over a discolored tooth if the layering technique using different combination shades is correctly applied.

SUMMARY

The purpose of this study was to evaluate the ability of three resin composite systems to mask a severely discolored background by the application of a layering technique through CIELAB and CIEDE2000 analysis. Ninety 1.5-mm-thick disc specimens were produced from three different resin composite restoration systems: IPS Empress Direct (Ivoclar Vivadent), Charisma Diamond (Heraeus Kulzer), and Filtek Z350 XT (3M-ESPE). The specimens were divided into groups according to the restoration system and the resin composite shade combination used for the layering technique (enamel, body, and dentin shades). Color measurements were performed by a reflectance spectrophotometer (SP60, EX-Rite) against a C4 shade background and an inherent color background, which simulates a severely discolored background and a tooth surface with no discoloration, respectively. The total color difference between both color measurements was calculated by CIELAB (ΔE^*_{ab}) and CIEDE2000 (ΔE_{00}) formulas. The mean ΔE_{ab}* and ΔE_{00} values were analyzed by analysis of variance (general linear models) and Tukey's post hoc tests (α=0.05). Three groups presented clinically acceptable color difference values ($\Delta E^* \leqq 3.46$ and $\Delta E_{00} \leqq 2.25$): 1.5 mm dentin, 1.0 mm dentin/0.5 mm body, and 1.0 mm dentin/0.5 mm enamel; ie, all the groups from the Z350 XT restoration system. The resin composite layering technique is an effective way to mask severely discolored backgrounds. The Filtek Z350 XT system was the only restoration system capable of masking the C4 background.

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INTRODUCTION

Tooth discoloration is one of the main reasons for esthetic dissatisfaction regarding patient smile appearance. The etiology of dental discoloration is not completely understood and may affect an individual tooth or a group of teeth. Changes in individual tooth color are commonly caused by blood extravasation, trauma, or the outcome of endodontic procedures.[1] Furthermore, contaminants, such as metallic ions from amalgam restorations, and root resorption are also associated with tooth discoloration.[2]

Single tooth discoloration is considered a complex and challenging clinical situation, which requires a correct diagnosis, an understanding of the etiology, and an adequate treatment planning for a successful esthetic outcome. Despite the variety of bleaching approaches and possibilities, a satisfactory resolution is not always guaranteed in some clinical situations, especially when the etiologic causes are dentin impregnated by amalgam ions or pulp bleeding.[3] Direct and indirect resin composite restorations are a simple and fast solution to cover up darkened dental substrates that did not respond to bleaching. Resin composite restorations are a more cost-effective, viable, and comfortable treatment option for the patients.[4] Advantages, such as reversibility and a conservative procedure based on the adhesive technique, increase the acceptance of the treatment by the patients and dentists.[5,6]

Manufacturers are constantly improving the color properties of their products. Despite the improvements, composites are translucent materials, and the esthetic results can be impaired, depending on the intensity of the dental discoloration. Translucency is defined as the intermediate state between complete opacity and complete transparency.[7] The underlying discolored structure may affect the final value and lightness of the composite restoration. This situation leads to the perception of a chromatic mismatch between the restoration and the adjacent tooth structures.[4,8]

When the layer-to-layer technique is applied, an opaque and/or a body-shade can be used to cover up more intense tooth color defects, whereas a more translucent shade can be applied as a last covering layer. The correct application of the layering technique should minimize color discrepancies, such as loss of lightness, and also may promote compensatory changes in the final restoration, which may mask the discolored underlying tooth substrate.[4,9-11]

Optical properties and masking abilities of opaque-shade resin composites are well documented in the literature.[4,7,12] However, more information concerning the masking ability of different resin composite shade combinations are necessary; the effectiveness of the multilayering technique on a discolored background is still unclear. One question still needs to be answered: is it possible to mask severely discolored backgrounds by the multilayering technique using different resin composites shade combinations? The purpose of this study was to evaluate the ability of three resin composite systems to mask a severely discolored background using different shade combinations by the layering technique. The null hypothesis was that there were no differences in masking ability among the tested resin composite restoration systems and shade combinations.

METHODS AND MATERIALS

Specimen Preparation

Three resin composite restoration systems (IPS Empress Direct, Ivoclar Vivadent, Schaan, Liechtenstein; Charisma Diamond, Heraeus Kulzer, Hanau-Hessen, Germany; Filtek Z350 XT, 3M-ESPE, St. Paul, MN, USA) were tested in this study. The systems are available commercially with enamel shades (more translucent) and dentin shades (less translucent) as basic options. Both Filtek Z350 XT and IPS Empress Direct follow the Vitapan Classical shade guide. The Charisma diamond shade guide is an adaptation from Vitapan Classical, being that the opaque-shades are compatible with more than one Vitapan shades. Additionally, the Z350 XT system offers a body shade with an intermediate opacity (between enamel and dentin translucency). The chemical composition, manufacturers, shade, and batch numbers of the materials used in this study are listed in Table 1.

Specimens were prepared by using a stainless steel split matrix with 0.5, 1.0, or 1.5 mm thickness and 11 mm inner diameter. Single-layered (SL) specimens were produced with a 1.5-mm-thick matrix. The composite was placed in one increment, and the top and bottom surfaces were flattened with Mylar strips and glass plates over 1 Kgf static load. Dual-layered (DL) specimens were built from a previously obtained 1.0 mm increment, placed inside a 1.5-mm-thick matrix. The resulting 0.5 mm depth cavity was then filled with other shades of the composites and light-cured. Triple-layered (TL) specimens were prepared following similar procedures, using 0.5-, 1.0-, and 1.5-mm-thick matrixes. The device used for specimen preparation is presented in Figure 1A-C. Each layer was light-cured

Table 1: *Composition and Information of Studied Restoration Systems*

Restoration system	Composition[a]	Manufacturer	Shades	Batch number
IPS Empress Direct	Dimethacrylate, Ba-Al-SiO4 glass silicate, oxide silicates, YbF3	Ivoclar Vivadent, Schaan, Liechtenstein	A1 Enamel A1 Dentin	A1-010040 OL-010030
Z350 XT	Bis-GMA, UDMA, TEGDMA, Bis-EMA, PEGDMA, BHT, silcate, zirconia	3M-Espe, St. Paul, MN, USA	A1E A1B A1D	1415300268
Charisma Diamond	UDMA, TCD-DI-HEA, Ba-Al-F glass silicate, YbF3, SiO2	Heraeus Kulzer GmbH, Hanau-Hessen, Germany	A1 Universal Opaque Light	A1-010040 OL-010030

[a] *Data provided by manufacturers. Abbreviations: Bis-GMA - bisphenol A-glycidyl methacrylate, BHT – butylated hydroxytoluene, YbF3 – ytterbium fluoride nanoparticles, SiO2 – Silicon dioxide, UDMA - urethane dimethacrylate, TEGDMA - triethyleneglycol dimethacrylate, Bis-EMA - bisphenol-A dimethacrylate, PEGDMA - polyethylene glycol dimethacrylate, TCD-DI-HEA - 2-propenoic acid, (octahydro-4,7 methano-1H-indene-5-diyl) bis(methyleneiminocarbonyloxy-2,1-ethanediyl) ester*

for 40 seconds with a 1200 mW/cm^2 irradiance-monitored light emitting diode (LED; Bluephase, Ivoclar Vivadent). Thereafter, the specimens were stored in distilled water for 24 hours at 37°C for additional composite translucency, lightness, and camphorquinone conversion, before performing the color measurements.

Ninety resin composite disc-shaped specimens (11 mm in diameter, 1.5 mm in thickness) were prepared and divided into 18 groups (n=5) to consider all possible layering shade combinations of each restorative system, including SL specimens, DL specimens, with a combination of two different opacities of the same system, and TL specimens, with combinations of the three opacities, which in this case, were available only in the Z350 XT system (Table 2).

Color Measurement

The color measurements were performed by a reflectance spectrophotometer (SP60, EX-Rite, Grand Rapids, MI, USA), against a C4 shade background (C4; L*=69.18; a*=6.80; b*=23.61) and an inherent color background (IC/Empress Direct: L*=82.99; a*=2.46; b*=17.88/Charisma: L*=81.87; a*=4.31; b*=18.55/Z350: L*=83.72; a*=1.52; b*=16.98). These two backgrounds simulate two different clinical conditions. The first one is a 2-mm C4-shade opaque ceramic tile and represents a severely discolored background. The latter is the inherent color of the resin composite and represents a tooth surface with no discoloration. Kamishima and others[13] reported that a 4-mm-thick resin-based composite disc is not affected by the underlying background color, regardless of shade and degree of translucency of the material, and could be considered the resin composite inherent color. Thus, the instrumentally measured color of a 4 mm resin composite disc could be considered the inherent color of the resin composite.[12] In the present study, a 4-mm-thick disk of each resin

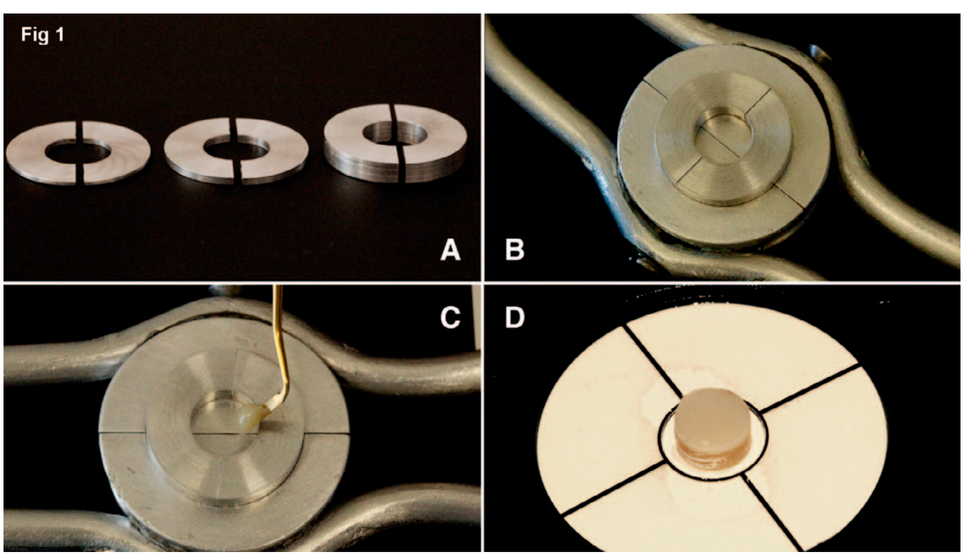

Figure 1. *Device used for specimen layering preparation and color measurements. (A): Split matrix with different thickness. (B): Split matrix positioned and stabilized inside the support base. (C): Resin composite being inserted inside the matrix. (D): Specimen positioned over the C4 background for color measurement.*

Table 2: *Possible Layering Combinations, Single Layered (SL), Dual Layered (DL), and Triple Layered (TL), of Resin Composite Systems*

Manufacturer	Shades	Layering technique (n=5)	
IPS Empress Direct (n=5)	A1E: A1 Enamel (E) A1D: A1 Dentin (D)	1.5 mm E	SL
		1.0 mm E + 0.5 mm D	DL
		0.5 mm E + 1.0 mm D	DL
		1.5 mm D	SL
Charisma Diamond (n=5)	A1U: A1 Universal E OL: Opaque light D	1.5 mm E	SL
		1.0 mm E + 0.5 mm D	DL
		0.5 mm E + 1.0 mm D	DL
		1.5 mm D	SL
Filtek Z350 XT (n=5)	A1E: A1 E A1B: A1 Body (B) A1D: A1 D	1.5 mm E	SL
		1.0 mm E + 0.5 mm B	DL
		1.0 mm E + 0.5 mm D	DL
		1.5 mm B	SL
		0.5 mm E + 1.0 mm B	DL
		1.0 mm B + 0.5 mm D	DL
		1.5 mm D	SL
		0.5 mm E + 1.0 mm D	DL
		0.5 mm B + 1.0 mm D	DL
		0.5 mm D + 0.5 mm B + 0.5 mm E	TL

composite system was made using the dentin shade of that system. The disc was used as the background for IC measurements. All the measurements were conducted according to the International Organization of Standardization (ISO) for color measurements.[14]

The CIELAB (ΔE^*_{ab}) color system[15] relative to standard illuminant D65 was used for the output of color measures. The CIE L*a*b* color system is a three-dimensional color measurement; L* refers to lightness, with values ranging from 0 (black) to 100 (white); a* and b* are considered chromatic coordinates: a* for red (+) and green (–) and b* for yellow (+) and blue (–). The specimens were positioned over the background with a coupling medium (glycerin) to simulate the oral environment color evaluation conditions[16] and then measured six times: three times against IC and C4 backgrounds (Figure 1D). All color measures followed the clinical layering pattern, with the enamel layers facing up, even when the enamel layer was the thickest layer in the shade combinations. Groups with body and dentin shade combinations followed the same evaluation as performed for enamel, with the body shade layer facing up for color reading. The average value of L*, a*, and b* of each background reading was calculated. The spectrophotometer was calibrated according to the manufacturer's instructions before conducting the color measurement.

The color difference of the same specimen against the backgrounds was calculated by the use of two different equations. The first one is the CIELAB color difference (ΔE^*_{ab}) equation, which was calculated as follows[15]:

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

where ΔL^*, Δa^*, and Δb^* refers to lightness, green-red, and blue-yellow differences of C4 and IC backgrounds color measurements.

The second is the CIEDE2000 color difference (ΔE_{00}), and it was calculated as follows[17]:

$$\Delta E' = [(\Delta L'/K_L S_L)^2 + (\Delta C'/K_C S_C)^2 + (\Delta H'/K_H S_H)^2 + R_T(\Delta C'/K_C S_C)(\Delta H'/K_H S_H)]^{1/2}$$

where $\Delta L'$, $\Delta C'$, and $\Delta H'$ are considered lightness, chroma, and hue differences between color measurements. K_L, K_C, and K_H are the parametric factors for viewing conditions and illuminating conditions influence, which in this study were set to 1.[17] R_T is the function for the hue and chroma differences interaction in the blue region. S_L, S_C, and S_H are the weighting functions for the color difference adjustment considering the location variation of L*, a*, and b* coordinates.[17,18]

Lower ΔE^*_{ab} and ΔE_{00} values indicate that the specimen is less sensitive to the influence of the

Table 3: L*, a*, and b* Coordinate Mean Values Against IC and C4 Backgrounds and ΔE^*_{ab} and ΔE_{00} Color Difference Mean Values of All Studied Resin Composite Combinations[a]

Brand	Shades combination	IC color measure			C4 color measure			ΔE* (SD)	ΔE_{00} (SD)
		L*	a*	b*	L*	a*	b*		
IPS Empress Direct	1.5 E	82.89	3.07	20.45	76.42	3.75	16.12	7.83[a] (0.13)	5.26[A] (0.12)
	1.0 E + 0.5 D	83.09	3.04	19.98	77.41	3.27	15.80	7.05[b] (0.31)	4.62[B] (0.24)
	0.5 E + 1.0 D	83.48	2.94	19.10	78.18	2.95	15.09	6.64[b,c] (0.10)	4.32[B,C] (0.04)
	1.5 D	84.78	2.78	19.53	80.31	2.54	15.38	6.10[d,e] (0.20)	3.81[D,E] (0.16)
Charisma Diamond	1.5 E	82.77	3.57	19.30	77.42	3.41	17,13	5.60[f] (0.36)	3.89[D,E] (0.18)
	1.0 E + 0.5 D	82.76	3.57	18.86	77.43	3.30	16.83	5.70[e,f] (0.12)	3.85[D,E] (0.08)
	0.5 E + 1.0 D	83.56	3.80	18.61	77.89	3.57	16.44	6.07[d,e] (0.16)	4.08[C,D] (0.12)
	1.5 D	83.57	3.90	19.19	78.40	3.75	17.10	5.58[f] (0.09)	3.73[E] (0.07)
Filtek Z350 XT	1.5 E	83.60	1.46	16.48	77.66	2.96	13.10	7.00[b] (0.25)	5.07[A] (0.20)
	1.0 E + 0.5 B	82.79	1.60	16.29	77.72	2.78	12.73	6.29[c,d] (0.14)	4.50[B] (0.11)
	1.0 E + 0.5 D	83.67	1.69	16.75	79.74	2.06	13.71	4.99[g] (0.26)	3.31[F] (0.20)
	1.5 B	82.83	1.91	18.09	78.53	2.60	14.36	5.73[e,f] (0.22)	3.85[D,E] (0.17)
	0.5 E + 1.0 B	82.67	1.91	17.07	78.09	2.75	13.51	5.87[d,e,f] (0.11)	4.05[C,D] (0.08)
	1.0 B + 0.5 D	82.77	2.02	18.14	79.62	2.03	15.31	4.23[h] (0.12)	2.70[G] (0.08)
	1.5 D	84.68	1.61	16.82	83.34	1.33	15.33	**2.03[k] (0.15)**	**1.27[J] (0.10)**
	0.5 E + 1.0 D	83.63	1.72	17.12	81.28	1.47	14.72	**3.30[i] (0.20)**	**2.12[H] (0.12)**
	0.5 B + 1.0 D	82.64	1.73	17.84	80.69	1.49	15.80	**2.83[j] (0.26)**	**1.77[I] (0.16)**
	0.5 E + 0.5 B + 0.5 D	82.17	1.68	16.43	79.49	1.63	13.76	3.78[i] (0.05)	2,44[G] (0.04)

[a] Bold ΔE* and ΔE_{00} values are considered clinically acceptable. Means that do not share a letter are significantly different. Lowercase letters are related to comparisons among CIELAB (ΔE^*_{ab} mean values, and uppercase letters are related to comparisons among CIEDE2000 (ΔE_{00}) values).

background color, and consequently, has a greater masking ability. The clinical acceptance threshold considered in this study for CIELAB calculation was $\Delta E^*_{ab} = 3.46$ and for CIEDE2000 calculation was $\Delta E_{00} = 2.25$. Any color difference value higher than these thresholds can be distinguished by an unskilled individual and cannot be considered as clinically acceptable.[14,18]

The mean ΔE^*_{ab} and ΔE_{00} values were analyzed by analysis of variance (general linear model) and Tukey's post hoc tests (α=0.05). Statistical analysis was performed using Minitab software (Minitab, Inc., State College, PA, USA).

RESULTS

The L*, a*, and b* coordinates values against each background and ΔE^*_{ab} and ΔE_{00} values of each shade combination are shown in Table 3. Three groups presented $\Delta E^*_{ab} \leqq 3.46$ and $\Delta E_{00} \leqq 2.25$. There was a statistically significant difference ($p<0.05$) between these three groups when they were compared with the other experimental groups: 1.5 mm dentin (ΔE^*_{ab}=2.03/ΔE_{00}=1.27), 1.0 mm dentin + 0.5 mm body ($\Delta E^*{}_{ab}$ =2.86/ΔE_{00}=1.77), and 1.0 mm dentin + 0.5 mm enamel (ΔE^*_{ab}=3.3/ΔE_{00}=2.12), all of them being part of the Z350 XT system. Empress Direct 1.5E (ΔE^*_{ab}=7.83) presented the highest ΔE^*_{ab} when analyzed through the CIELAB equation and when it was compared with the single-layered enamel Z350XT (ΔE^*_{ab}=7.00) and Charisma (ΔE^*_{ab}=5.60) groups ($p<0.05$). Comparisons among CIELAB values of experimental groups are shown in Figure 2.

Considering CIEDE2000 analysis, statistically significant differences were not found among Z350XT 1.5B (ΔE_{00}=3.85), Charisma 1.5D (ΔE_{00}=3.74), Charisma 1.5E (ΔE_{00}=3.89), and Empress Direct 1.5D (ΔE_{00}=3.81) ($p>0.05$). The combination of Z350XT 1B/0.5E (ΔE_{00}=4.05) also showed similar ΔE_{00} values compared with Charisma 1D/0.5E (ΔE_{00}=4.08) and Empress Direct 1D/0.5E (ΔE_{00}=4.32) ($p>0.05$). Overall ΔE_{00} value comparisons among all the study groups are presented in Figure 3.

DISCUSSION

Among all tested shade combinations and through both color difference analyses, three Z350 XT groups showed values under the clinical acceptance threshold, and these three groups were also statistically different compared with the other experimental groups ($p<0.05$). None of the shade combinations of Empress Direct and Charisma

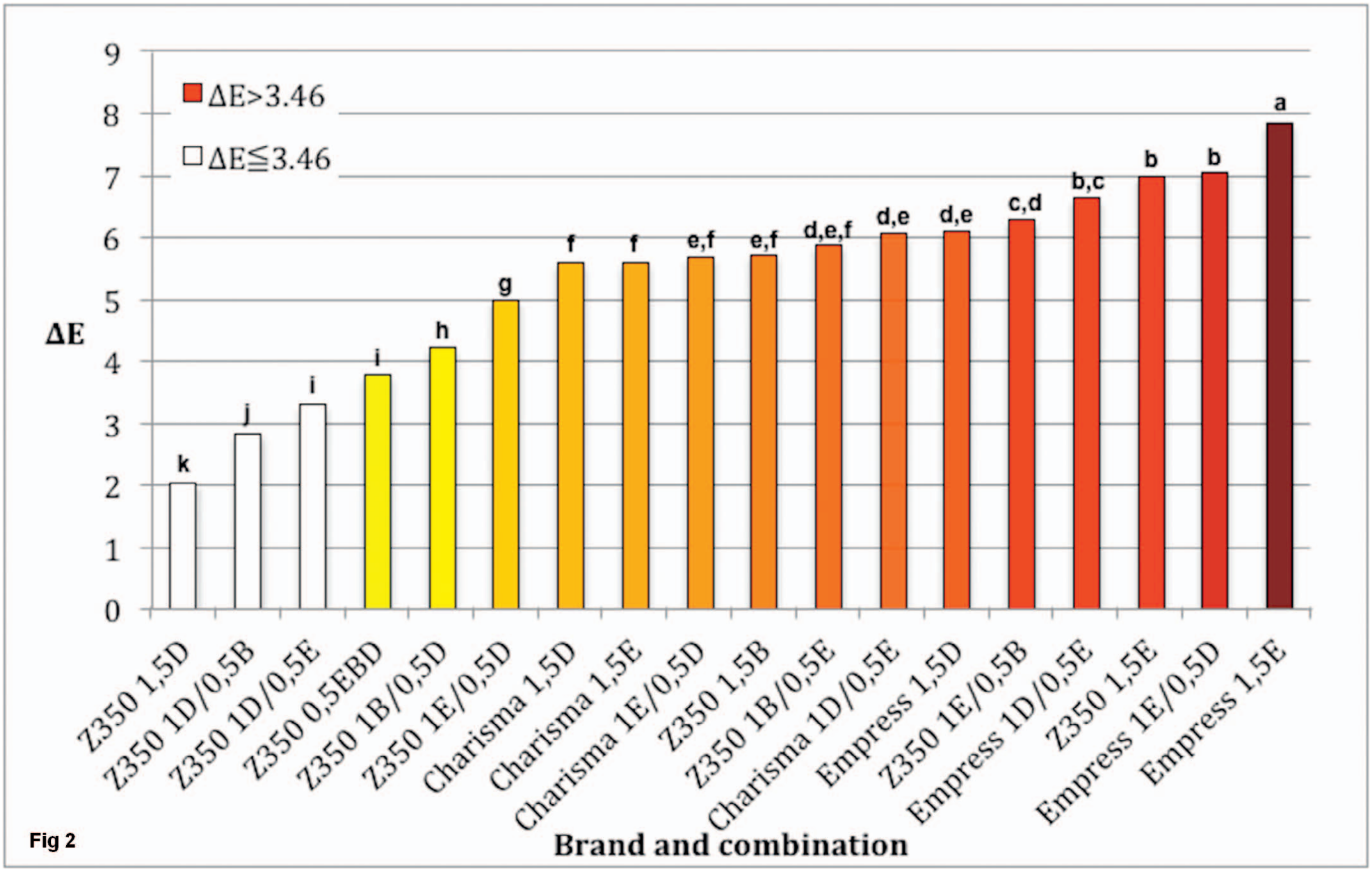

Figure 2. *Mean ΔE^*_{ab} values graph of the resin composite combinations. White color bars ($\Delta E^* \leqq 3.46$) indicate clinically acceptable values. Darker colors are related to lower masking ability. Groups that do not share a letter are statistically different.*

Diamond systems were capable of masking the C4 background. The null hypothesis was totally rejected, because the masking ability was different among tested combinations and resin composite restoration systems. In this sense, the masking ability of the resin composites may be affected by the formulation components of the material, such as opacifiers, pigments, and fillers.[4] The fact that only the Z350 XT shade combinations were considered clinically acceptable against C4 background could be explained by the noticeable formulation difference observed through the restoration systems, especially by the filler particles size, composition, and monomer composition.[11,19-22] Thus, ideally, a resin composite restoration system for any clinical situation should balance these composition properties aforementioned to provide either translucent or opaque shades for an adequate layering technique.

The reference used for ΔE^*_{ab} and ΔE_{00} calculation was the color measurement of the specimens of each group positioned over the representative inherent color of the resin composite system. The final measurement used for the color differences calculation was the color of the specimens for each group, positioned over the C4 ceramic background. For discoloration analysis, ΔE^*_{ab} values above 3.46 and ΔE_{00} above 2.25 were considered clinically unacceptable, because color shifts over this threshold value might not be considered acceptable in more than 50% of the time.[17,18] The sample size of this study ($n=5$) was established based on color measurement standards and previous studies that assessed color differences on resin-based specimens.[7,22,23] Although this study evaluated only resin composite restoration systems, other restorative materials, such as ceramics, could be assessed through this method regarding its masking ability.

Important differences were observed between CIELAB and CIEDE2000 results in the color difference calculation. The masking performance of Charisma Diamond and Empress Direct dentin SL groups were statistically similar through

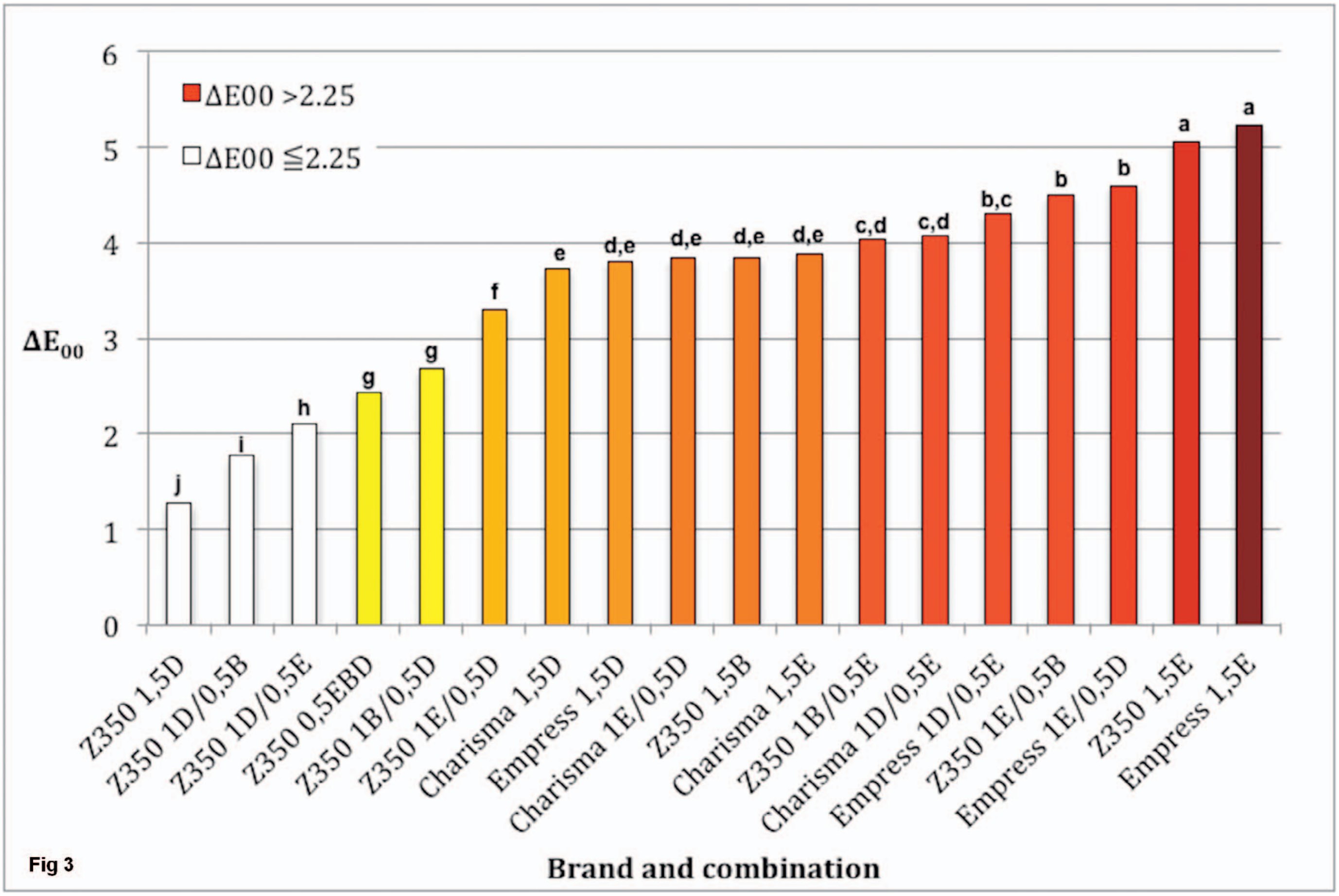

Figure 3. *Mean ΔE_{00} values graph of the resin composite combinations. Groups with white color bars ($\Delta E_{00} \leqq 2.25$) indicate clinically acceptable values. Groups that do not share a letter are statistically different. Same letter indicates similar masking performance.*

CIEDE2000 analysis but different at CIELAB calculation. For Z350 XT and Empress Direct enamel SL groups, the same pattern was observed: similar masking ability when using the CIEDE2000; however, a statistically significant difference was observed through CIELAB. Also, a similar masking ability among SL groups Empress Direct 1.5D, Charisma Diamond 1.5D and 1.5E, and Z350 XT 1.5B could be observed for CIEDE2000 but not for CIELAB. These discrepancies in results can be explained by the differences between equations. Although CIELAB calculates the total color difference, with equal weight for all color coordinates in the formula, CIEDE2000 makes important adjustments that approximates the analysis in a manner similar on how the human eye perceives the color differences. The weighting functions (S_C, S_H, and S_L) adjust the weight of color coordinates related to chroma, hue, and lightness in the total ΔE value. In addition, the rotation function (R_T) weights the interaction between hue and chroma differences in the blue region of visible color spectrum.[15,18,24] These adjustments may result in an adequate fit with the visual judgments[18] and could produce numerical differences in ΔE values and thresholds.

The layering technique for resin composite restorations is often used to reduce shrinkage stress on the adhesive interface and for better tooth shade matching.[25] Physical properties of the resin composite, such as light transmission, dispersion, and reflection, can be affected by the layering technique, because each layer independently applied leaves an organically rich zone on the surface, affecting light transmission by enhancing light dispersion and diffusion.[25] Consequently, this technique reduces the translucency of the restoration and minimizes the interference of background color.[25] In the present study, the combination of 1.0 dentin shade and 0.5 body shade of the Z350 XT system showed the lowest CIELAB (ΔE^*_{ab}=2.83) and CIEDE2000 (ΔE_{00}=1.77) color differences values among multilayered groups ($p<0.05$). Likewise, the Z350 1.0D/0.5E group presented clinically acceptable values for CIELAB (ΔE^*_{ab}=3.30) and CIEDE2000 (ΔE_{00}=2.12) color difference calculation. The layering technique with 1.0 mm Z350 XT dentin + 0.5 mm of any relatively more translucent composite (body or enamel shades) resulted in lower ΔE values, in comparison with the same shade combination with a thicker translucent layer (1.0 mm enamel shade). These results suggest that esthetic restorations capable of masking extreme discolored background can be achieved by correct layering shade combinations if the adequate opaque-translucent proportion is applied: a thinner enamel shade layer with a thicker opaque shade layer.[26] Friebel and others stated that combinations between thinner layers of enamel shades and thicker layers of dentin shades promote more harmonic restorations.[26] As demonstrated in the present study, this resin composite shade combination pattern can also be applied over discolored teeth and is capable to mask the color discrepancies.

Masking discolored background requires minimal opaque-shade thickness, which depends on the resin composite brand, composition, and translucency.[4,7] Three combinations in the present study were considered clinically acceptable by both color difference analysis. All those groups commonly had the Z350 XT dentin shade, with thickness of 1.0 mm combined with body and enamel shades or with 1.5 mm thickness in the SL group. The latter also presented the lowest ΔE^*_{ab} and ΔE_{00} values among the groups. Kim and others[7] and An and others[4] pointed out that different resin composite opaque shades require a minimal thickness to mask darker backgrounds. In the present study, 1.0 mm Z350 XT dentin shade was necessary to mask the C4 background.[4,7] This finding is supported by An and others,[4] who established that an opaque shade thickness ranging from 0.8 to 1.45 mm has to be used to mask a C4 shade background.

The Z350 XT dentin shade can be considered less susceptible to color background interference than the dentin shades of the other two systems. Both Empress Direct and Charisma Diamond dentin shade composites had ΔE^*_{ab} values over 3.46 and ΔE_{00} values over 2.25, even with 1.5 mm in thickness. An and others[4] reported that a correlation may exist between translucency and masking ability and that both are affected by the brand and the shade of the resin composite. These findings are in agreement with the present study, where Filtek Z350 XT was the only system capable of masking the discolored background. Empress and Charisma composite systems could not mask a C4 background, not even when only a dentin shade was applied over it.

The Filtek Z350 XT restoration system is composed of three different translucencies: enamel, body, and dentin. The handling of this system is considered complex in comparison with the other restoration systems. Proper knowledge about the optical properties (color and translucency) is essential for an adequate restoration.[7] The CIEDE2000 analysis showed that there were no statistically significant differences between the SL Z350 XT body shade group and the SL dentin shade of the Charisma and Empress groups. This finding suggests that the Z350 XT body shade behaves similarly to the dentin shades of the other restorative systems, especially in situations where the background color is an important issue.

SL and multilayer combinations of Charisma Diamond and Empress Direct showed insufficient masking ability against a C4 backing. This background color is considered an extreme discoloration; C4 is the darkest Vitapan Classical shade guide color.[27] The present study addressed masking ability only against a C4 background, but not over other lighter shade backgrounds. Also, only A1 opaque shade composites were used in the present study, without chromatic variations. This does not mean that the same results could also be applied to a less critical discoloration; however, it suggests that both systems should be used carefully in restorations for covering up severely discolored structures. Likewise, the substrate color and available thicknesses should be considered when deciding which composite restoration system should be used. More studies on masking ability against different and lighter backgrounds, varying composite hue and chroma, may be necessary to clarify this issue.

CONCLUSIONS

Based on this study results, the following can be concluded:

1. The resin composite layering technique may be applied on restorations over severely discolored backgrounds.

2. Among the opaque resin composites, Z350 XT dentin shade showed the best masking performance. This composite can be covered by more translucent composites in the layering technique and should be recommended when masking a dark background, especially when little space is available for restoration.
3. The CIEDE2000 formula is recommended as the equation for dental materials color differences calculation, especially for masking ability assessment.
4. Masking ability and color matching alone cannot guarantee an adequate harmonization of the restoration with the natural adjacent teeth. Optical properties like natural enamel and dentin translucency, superficial textures, and restoration form must be considered, especially in esthetic restorations in anterior teeth.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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