

Color Match Between Composite Resin and Tooth Remnant in Class IV Restorations: A Case Series

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Clinical Relevance

A minimum of 14 days was needed to achieve a color match between the composite resin and the tooth remnant. The mock-up should be kept for at least 14 days to evaluate the color match of the composite resin in Class IV restorations.

SUMMARY

Rehydration of the tooth remnant and complete polymerization of the composite resin are aspects that should be considered in shade selection of composite resin. This article presents a case series of Class IV restorations performed to evaluate the color match between the composite resin and the tooth remnant. Thirteen Class IV restorations were performed in maxillary central incisors and

evaluated according to the period following the restorative procedure: 10 minutes (baseline), 48 hours before and after finishing and polishing, and seven, 14, and 28 days. The color match of the restorations was evaluated by the ΔE values of the tooth remnant (TR) and the composite resin (CR) in each evaluation period using a spectrophotometer. The translucency, luminosity, and saturation were analyzed qualitatively in digital photographs of the restorations. The CR ΔE was statistically similar to the TR ΔE at 14 and 28 days ($p > 0.05$). The saturation and luminosity of most of the restorations remained unchanged, but there was a greater change in the translucency. The color match of the composite resin in Class IV restorations was observed after 14 days of clinical assessment in this case series.

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DOI: 10.2341/17-132-S

INTRODUCTION

The reproduction of the optical characteristics of natural teeth is a challenge in anterior composite restorations.^{1,2} The shade selection is carried out subjectively with a visual shade guide and generally under inadequate light conditions, which can lead to errors in color perception. It should be noted that color match in anterior composite restorations is obtained by rehydration of the tooth remnant and

complete polymerization of the composite resin, aspects that should be considered during restorative treatment.

Tooth dehydration occurs in restorative procedures because of operative field isolation. The absence of saliva makes the tooth lighter due to a change in the light refractive index. However, after removing the field of isolation, the tooth rehydrates and gradually returns to its original optical condition due to saliva absorption.³⁻⁶

Composite resin changes color after light curing due to a cross-linked polymerization reaction.⁷⁻¹⁰ It is known that the conversion of monomers into polymers is about 75% in the first 10 minutes after photoactivation¹¹ and can increase after 24 hours.^{12,13} Thus, the composite color change occurs during curing and as a postpolymerization reaction due to monomer conversion^{7,9,14,15} and can persist over time due to water sorption of the materials.^{8,10,13,16-20}

One method that can be used to evaluate the color match of the composite resin restoration is to measure the color of both the tooth remnant and the composite restoration with a spectrophotometer and then compare their respective values. A spectrophotometer indicates values of L*, a*, and b* in the CIELab color system. The L* parameter corresponds to the luminosity, whereas a* and b* correspond to the hue. The a* axis represents the red-green axis saturation and b* the blue-yellow saturation. The color difference (ΔE) is obtained from the individual changes in each parameter and is expressed as a single value.

It should be pointed out that because of tooth hydration and composite color change, a mock-up should be performed as a trial to assist in shade selection and ensure the predictability of the esthetic result in restorative treatment.^{21,22} Furthermore, no clinical data are available to determine how long the mock-up should be kept in the mouth to evaluate the color match of the composite resin in Class IV restorations. Therefore, this article presents a case series of Class IV restorations performed to evaluate the color match of composite resin with the tooth remnant in Class IV restorations using spectrophotometric analysis and digital photographs.

CASE SERIES

Nine patients (four males and five females) aged between 20 and 30 years were randomly chosen among by two operators in the operative dentistry postgraduate clinic at the Federal University of Santa Catarina. The Institutional Review Board of

the Federal University of Santa Catarina, Brazil, approved the study (protocol 1.197.856). Adults in need of restoration of at least one maxillary central incisor were included in the study.

In some cases, a diagnostic wax-up was made before conducting the restoration to obtain the palatal silicon matrix (Express XT, 3M ESPE, St Paul, MN, USA) used to layer the restorative material. After prophylaxis with prophylactic paste and a nylon brush, the shade selection was performed with a proprietary dual shade guide system, and the mock-up was used to confirm the esthetic appearance of the restoration. The mock-up was fabricated with the selected shades for each layer and was placed without etching; only the adhesive was applied. After three days, the mock-up was removed, and the teeth were restored with a nano-hybrid light-activated composite resin (IPS Empress Direct, Ivoclar Vivadent, Schaan, Liechtenstein). First, the tooth remnant was etched with 37% phosphoric acid for 15 seconds on the dentin and 30 seconds on the enamel, extending 1 mm beyond the preparation margins. After the dentin was rinsed, it was protected with a cotton pellet, and the enamel was air-dried. A Single Bond Universal adhesive system (3M ESPE) was applied with a disposable brush (Microbrush, Coltène/Whaledent, Inc, Cuyahoga Falls, OH, USA) according to the manufacturer's instructions. The cavity was photocured for 20 seconds with an LED unit (Translux Blue, Heraeus Kulzer, Hanau, Germany) with a light intensity of 876 mW/cm² and calibrated in the beginning of the study.

The restoration was performed using the layering technique with the composite shades selected previously and confirmed with the mock-up. No bevel preparation was performed. See Figure 1 for the layering technique insertion sequence.²² The finishing and polishing procedure was performed 48 hours after completing the restoration. The procedure was initiated with abrasive strips (3M ESPE) on the proximal surfaces. The facial surfaces were finished with sequential polishing discs of decreasing grit size (Sof-Lex Pop On, 3M ESPE), to improve the surface smoothness and remove small areas of excess at the interface. A carbide bur (FG 7664F, KG Sorensen, São Paulo, Brazil) was used to remove excess resin from the preparation margin. The surface texture was reproduced with a flame-shaped and tapered carbide burs (KG Sorensen) when it was needed. A felt disc (Diamond Felt Disc, FGM, Joinville, Brazil) with diamond polishing paste (Diamond Excel, FGM) was used to perform the final polishing.

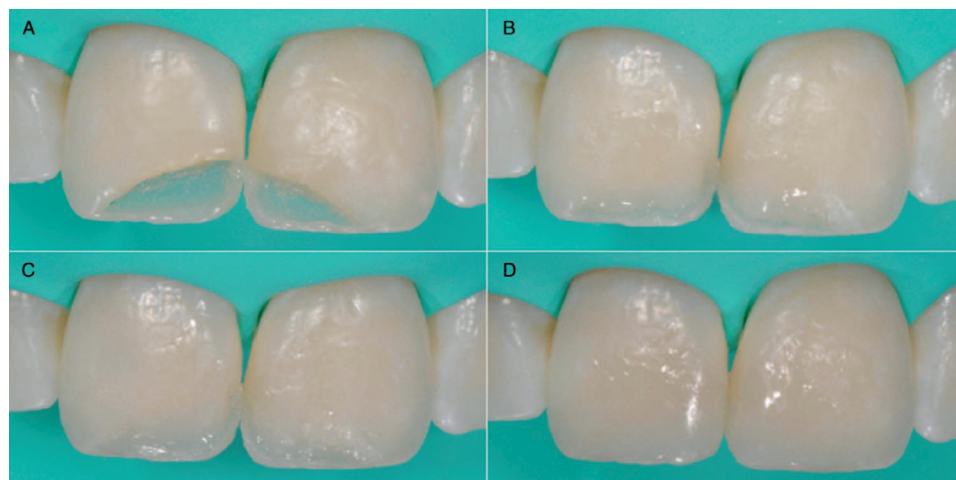


Figure 1. Stratification of the resin composite restoration. (A): Reproduction of palatal enamel and opaque halo. (B): Reproduction of dentin. (C): Reproduction of the opalescent halo. (D): Reproduction of the facial enamel.

A total of nine subjects with 13 Class IV restorations were enrolled. Two trained operative dentistry operators performed all the restorative procedures. The composite resin restoration and tooth remnant colors were measured with a spectrophotometer (Vita Easyshade, Vident, Brea, CA, USA) at different evaluation periods (n=13): 1) 10 minutes after completing the restoration (baseline), 2) 48 hours before finishing and polishing, 3) 48 hours after finishing and polishing, 4) seven days after the restorative procedure, 5) 14 days after the restorative procedure, and 6) 28 days after the restorative procedure. The remaining tooth area and the restoration were standardized for shade taking with two silicone matrixes (Express XT, 3M ESPE) fabricated for each patient: matrix 1 (a perforation in the tooth remnant region) and matrix 2 (a perforation in the central area of the restoration) (Figures 2 and 3). The perforation was compatible with the size of the device tip (6-mm diameter) and was made using a metallic device with well-formed borders. All assessments were made by an independent and calibrated evaluator. Evaluations were performed using the silicone matrixes positioned in the tooth, and spectrophotometric analysis was conducted without any colored background. Figures 4 through 9 represent clinical cases of restored teeth showing the before and after clinical images.

The color difference (ΔE) at each evaluation period was obtained from the $L^* a^* b^*$ values for each tooth and restoration according to the following formula:^{23,24} $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$, where $\Delta L = L_{\text{final}} - L_{\text{initial}}$, $\Delta a = a_{\text{final}} - a_{\text{initial}}$, and $\Delta b = b_{\text{final}} - b_{\text{initial}}$. Initial values were obtained at the baseline evaluation (10 minutes). The nonparametric Mann-Whitney test was used to compare the ΔE

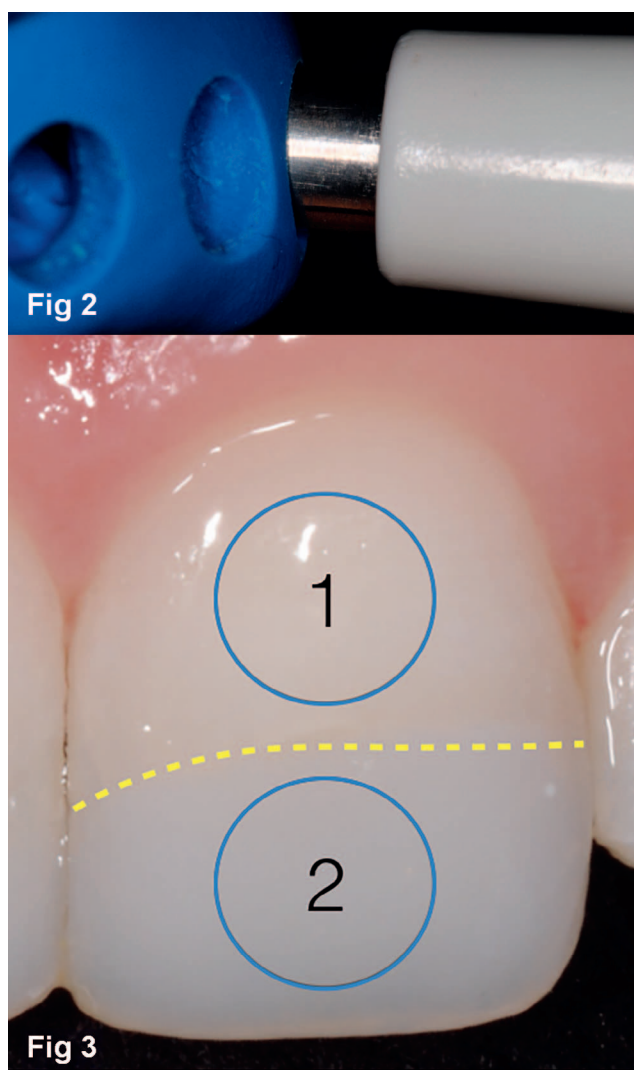


Figure 2. Tip of the spectrophotometer placed in the labial perforation of the silicone matrix. Two matrixes were made for the same tooth. The first was used for individual evaluation of the tooth remnant and the second for the restoration.

Figure 3. Illustration of the measurement sites on the tooth remnant (1) and the restoration (2).



Figure 4. (A): Photo of the case 1 before treatment. (B): Photo of the case 1, 28 days after restorative procedures.

Figure 5. (A): Photo of the case 2 before treatment. (B): Photo of the case 2, 28 days after restorative procedures.

Figure 6. (A): Photo of the case 3 before treatment. (B): Photo of the case 3, 28 days after restorative procedures.

Figure 7. (A): Photo of the case 4 before treatment. (B): Photo of the case 4, 28 days after restorative procedures.

Figure 8. (A): Photo of the case 5 before treatment. (B): Photo of the case 5, 28 days after restorative procedures.

Figure 9. (A): Photo of the case 6 before treatment. (B): Photo of the case 6, 28 days after restorative procedures.

values of the composite resin with those of the tooth remnant at each evaluation period. All the analyses were conducted at a significance level of 5% ($\alpha=0.05$) using SPSS statistical software (version 20.0 for Mac, SPSS Inc, XXXX).

When the mean ΔE values of the composite resin were compared with those of the tooth remnant according to the evaluation period, a statistically significant difference was observed at the following evaluation periods: 48 hours (before polishing), 48 hours (after polishing), and seven days after the restorative procedure ($p<0.05$). At the 14-day and 28-day periods, the ΔE values of the composite were statistically similar to those of the tooth remnant ($p>0.05$) (Table 1).

Qualitative analysis of the restoration color was carried out with a digital photograph at each evaluation period. A digital camera (D90, Nikon,

Tokyo, Japan) with a medical 120-mm lens (Nikon Sigma, Ronkonkoma, NY, USA) and configured at V125, ISO 150, and F32 was used to standardize the images. The images were assembled in a computer program (Keynote, Apple, Cupertino, CA, USA) and analyzed by an examiner according to translucency, saturation, and luminosity. Analysis of these criteria was best achieved by comparing the photographs in pairs according to the evaluation periods. In this procedure, an examiner compared the image of the analyzed period with the image of the previous period. Scores were established for each criterion: A (equal), B (decreased), and C (increased). These scores were respectively assigned to each restoration, after which the number of restorations for each score was obtained.

The qualitative analysis indicated that saturation was equal during the 28-day period in most restorations. Furthermore, the luminosity remained unchanged in most restorations; however, in the cases with a significant amount of restoration, luminosity decreased during the 48 hours prior to finishing and polishing and during 14 days and also during 28 days, after which it increased. Moreover, 48 hours before finishing and polishing, translucency increased in most of the restorations and remained the same in the following periods. After seven and 14 days, the translucency remained unchanged in half of the restorations and increased in the rest, whereas at 28 days, most of the restorations presented the same translucency as the previous period (Table 2).

Table 1: Mean and Standard Deviation Values of ΔE for Tooth Remnant and Composite Resin According to the Evaluation Period ^a			
Period of Evaluation	Tooth	Composite Resin	p-Value
48 h (before polishing)	4.94 \pm 1.36 A	3.69 \pm 0.99 B	0.011
48 h (after polishing)	4.50 \pm 1.53 A	3.15 \pm 0.90 B	0.015
7 d	4.36 \pm 1.26 A	3.09 \pm 0.73 B	0.005
14 d	4.62 \pm 1.36 A	3.98 \pm 1.46 A	0.209
28 d	3.84 \pm 1.12 A	3.07 \pm 1.13 A	0.058

^a Comparisons are valid only within rows. Means with identical letters on the same line for each period of evaluation are not statistically different (Mann-Whitney, $p>0.05$).

Table 2: Number of Restorations (n) and Score Results for Saturation, Translucency, and Restoration Luminosity According to the Evaluation Period^a

Score Evaluation Period	n	A	B	C	A	B	C	A	B	C
		Saturation			Translucency			Luminosity		
48 h (before polishing)	13	10	3	—	4	—	9	8	5	—
48 h (after polishing)	13	12	1	—	6	3	4	12	—	1
7 d	13	12	1	—	6	1	6	11	2	—
14 d	13	11	2	—	5	3	5	8	4	1
28 d	13	10	—	3	9	2	2	8	—	5

^a Score key: A (equal), B (decreased), C (increased).

DISCUSSION

Composite resin color change is usually evaluated under laboratory conditions without considering the color match between the composite and the tooth remnant structure. The results of this study suggest that the color match of the composite resin in Class IV restorations occurred 14 days after the restorative procedure, considering that there was a statistical similarity of ΔE values between the composite resin and the tooth remnant at the evaluation periods of 14 and 28 days.

This result is probably attributed to the tooth rehydration time³⁻⁵ and the postpolymerization period of the composite.^{8-10,17,19} Teeth with excessive dehydration recover their color after a period ranging from one month⁶ up to 12 months due to water absorption in the mouth.^{4,5} Thus, after completing Class IV restorations, the teeth gradually return to their original color over time. With respect to composite resin, laboratory studies show that different composite resins change color after photoactivation,⁷⁻⁹ after water storage,^{8,10,18,19} after thermocycling,¹⁷ and after artificial aging.^{13,15,16,20} This composite color change may be related to the color of the materials used and depends on the brand.^{7,8,10,16,17,20}

The color match in Class IV restorations is also influenced by small variations in the thickness of the composite layers since the composite used to reproduce the enamel is more translucent than the dentin composite.^{22,25} A thick translucent composite on the facial surface makes the restoration grayish because of differences in the index of light refraction of natural enamel and that of the restorative material.²⁶ In this study, the restorations were made with a minimum thickness of enamel composite, and the thickness of the artificial dentin provided adequate opacity without interfering with the restoration value.

The layering of the resin composite was conducted in this study based on the concept of natural stratification, which proposes the combination of optical properties from different resin layers,²² and it allows achieving the esthetic result without needing a bevel.^{27,28} Also, the finishing and polishing procedure was performed 48 hours after the restoration because as the degree of cure continues after the initial polymerization,¹² the delayed polishing time may improve the composite surface roughness and microhardness.^{29,30}

Luminosity, saturation, and translucency are the color dimensions that most influence the appearance of natural teeth.^{1,2,21} The results of the qualitative analysis showed that the saturation of most restorations remained unchanged over 28 days. Moreover, the luminosity of most restorations remained unchanged for 28 days. However, there was an increasing tendency for greater translucency in most restorations and a consequent reduction in luminosity, shown by some restorations over time, considering that greater translucency of composite dentin may reduce the luminosity of the restorations.^{22,31}

The current study showed that the color difference (ΔE) of the composite among the evaluation periods ranged from 3.07 to 3.69 and that that of the tooth remnant ranged from 3.84 to 4.94 among the same periods (Table 1). Some of these color shifts go over the threshold value ($\Delta E=3.3$) and may be noticeable.^{32,33} This may attributed to the baseline color being measured 10 minutes after completion of the restoration, at which time the tooth may be dehydrated³ and the composite not completely polymerized;¹¹ this could explain the expressive color differences between the natural tooth and the composite. Yet the resin composite colors used in this study were brighter colors: DA1, DB1, DBL-L, DBL-XL, EB1, EBL-L, and EBL-XL (IPS Empress Direct). Is it important to consider that the more luminous or less chromatic the

composite resin, the greater the tendency to change color.^{14,16,18,20}

Despite the different color values obtained, the aim of this study was to evaluate the color match of composite resin with the tooth remnant at the evaluation periods and not the color change of the composite or of the tooth remnant over time. Future randomized double-blinded clinical studies with a greater number of restorations and evaluators are needed to confirm the results obtained.

CONCLUSION

A minimum period of 14 days was needed for the color match of composite resin in Class IV restorations. There was an increase in translucency at the 28-day time period; however, the restorations remained clinically satisfactory. Accordingly, it could be recommended that a mock-up be performed and kept for at least 14 days to check the shade selection.

Acknowledgement

The authors thank Ivoclar Vivadent for the kind donation of materials for this study.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Ethics Committee of the Federal University of Santa Catarina. The approval code for this study is 1.197.856.

Conflict of Interest

The authors of this article 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.

(Accepted 6 August 2017)

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