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Changes in color and color coordinates of an indirect resin composite during curing cycle

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ABSTRACT

Objectives: To measure the color changes of indirect resin composites during curing cycle and to determine the influence of shade group on these changes.
Methods: One brand (belleGlass NG), divided into three shade groups (EN, OD and TL), was investigated. Resin composite was packed into a mold (BC) and was cured with a light-curing unit (C1). Secondary curing was performed in the proprietary curing chamber (C2). Color was measured at BC, C1 and C2 conditions. Changes in color and color coordinates were calculated and repeated measures three-way ANOVA was performed. Each pair of compared-condition in the curing cycle was set as a repeated variable.
Results: Net curing color change (C2-BC) was in the range of 1.0–10.1ΔE^*_{ab} units. Based on ANOVA for the color changes, ΔE^*_{ab} was influenced by the compared-condition, the shade group and the shade designation ($p < 0.01$). Changes in color coordinates varied by the shade group.
Conclusion: Changes in color during curing cycle were perceptible in several shades by the condition ($\Delta E^*_{ab} > 3.7$); therefore, clinical practice of shade matching should consider these color changes.

1. Introduction

Indirect resin composite systems have been developed to overcome the negative attributes of their porcelain counterparts and to simplify fabrication, insertion and post-delivery adjustments.[1] The use of indirect composite restorations has facilitated the fabrication of ideal anatomic form, marginal adaptation and appropriate proximal contact and contour in a restoration.[2] Since the bulk of a restoration made of a fiber-reinforced indirect resin composite is formed using a resin composite, concerns such as color stability still remain.[3] Therefore, color stability of indirect resin composites after accelerated aging, ultraviolet (UV)-irradiation or staining has been investigated.[4–6]

Shade matching of indirect resin composites with teeth is important as in other esthetic restorative materials. Most manufacturers cross-reference their shades of direct or indirect resin composites with those of the Vita shade guide (Vita Zahnfabrik, Bad Sackingen, Germany). Color of varied shade groups of direct resin composites was compared with shade guides.[7] Color difference between each shade of direct resin composites and the nearest shade tab, which showed the smallest color difference, in the cross-referenced shade guide was determined,[8] and it was reported that color differences was 0.9–12.8ΔE^*_{ab} (CIELAB color difference) units, in which 34 shades among 41 shades showed perceptible color difference ($\Delta E^*_{ab} > 3.7$). As indicated in previous studies,[7,8] since color of direct resin composites was obviously different from those of

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the shade guide tabs to which these materials were keyed, similar color discrepancy with the referenced shade guide might exist in the case of indirect resin composites.

Generally, microhybrid resin composites become darker and microfill resin composites become lighter after curing. In other words, light-curing caused an increase in translucency of microhybrids and a reduced translucency in microfills.[9] There have been varied studies on the color changes during curing of direct resin composites.[10–13] Curing color change of commercial direct resin composites was in the range 2.6–4.1ΔE^*_{ab} units,[10] and the amount of color change was influenced by the characteristics of the material and the wavelength.[14] Because the color change after curing of direct resin composites was visually perceivable for most shades of materials,[10] these changes should be considered during initial clinical shade match at the placement of unpolymerized material.[10]

Color change and shifting of color coordinates after curing in direct resin composites were influenced by the shade designation of materials.[15] A statistically significant interaction was found between the brand and the shade designation of direct resin composites for the curing color changes,[10] and lighter or less chromatic shades tended to show larger color changes than darker or more chromatic shades.[16,17] Lightness (CIE L^* coordinate) change after curing was significant, and lightness change was greater than that of chromaticity and had the greatest influence on curing color change of direct resin composites.[10]

There are concerns on the threshold levels for the color differences (ΔE^*_{ab}) that can be visually perceptible or clinically acceptable.[18–20] 3.3ΔE^*_{ab} units was considered as an acceptable threshold based on resin composite specimens.[18] The acceptability thresholds were 1.1ΔE^*_{ab} units for red-varying porcelain crowns and 2.1ΔE^*_{ab} units for yellow-varying crowns, and the mean threshold for an acceptable color difference was 1.7ΔE^*_{ab} units for a group of prosthodontists.[19] However, previous values were based on in vitro tests. As a clinical perceptible threshold, ΔE^*_{ab} value of those ratings judged a perfect match by the US Public Health Service (USPHS) criteria was found to be 3.7ΔE^*_{ab} units based on composite resin veneer restorations and their comparison teeth.[21] Therefore, color difference of 3.7ΔE^*_{ab} units will be regarded as a perceptibility threshold in the present study.

Indirect resin composites are cured with varied protocols. During these procedures, color would change because chemical composition and curing kinetics are similar to those of direct resin composites.[3] Although there have been varied studies on the curing color changes of direct resin composites and the influence of color parameters on these changes,[10–17] there were few studies on the color changes of indirect resin composites during curing cycle. The null hypotheses of the present study were: (1) the color change after curing of indirect resin composites was not perceptible ($\Delta E^*_{ab} < 3.7$) and (2) the color change after curing was not influenced by the shade group and the shade designation of this material. The purposes were to measure the color change of varied shades of a brand of laboratory resin composites during curing cycle, and to determine the influence of the shade group and the shade designation on these changes.

2. Materials and methods

One brand of laboratory resin composite (belleGlass NG, Kerr Corp., Orange, CA, USA), a total of 16 shades, was investigated (Table 1). Shades were divided into three groups such as enamel (EN), opaceous dentin (OD) and translucent (TL).

Resin composite was packed into a polytetrafluoroethylene mold (12 mm in diameter and 1 mm in thickness) on a polyethylene terephthalate strip. After packing the material, another strip was laid on the top of the specimen, and pressed with a 5 kg load for 3 min to produce a uniform thickness. Specimens were light cured for 40 s in three overlapping areas with a light-curing unit (Spectrum 800, Dentsply/Caulk, Milford, DE, USA) with an intensity setting of 400 mW/cm^2. The output of the curing light was checked with a radiometer (Kerr Corp.). After light curing, specimens were removed from

Table 1 – Shades of belleGlass NG indirect resin composite investigated

Group	Group code	Shade	Shade code	Batch number
Enamel	EN	Cuspal	CP	445488
		Gray	GR	440126
		Light	LI	441289
		Neutral	NT	445601
Opaceous dentin	OD	A2	A2	443989
		A3	A3	445091
		A3.5	A3.5	446244
		B0	B0	417283
		C2	C2	451119
		D2	D2	447153
Translucent	TL	A2	A2	452970
		A3	A3	445602
		A3.5	A3.5	445722
		B0	B0	416806
		C2	C2	441024
		D2	D2	443661

Kerr Corp., Orange, CA, USA.