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Analysis of the Colour Change in Composite Resins When Exposed to Colouring Agents Possible to Be Found in the Oral Cavity †

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Abstract: Currently, composite resins are widely used as aesthetic restorative materials. The success of any aesthetic restoration depends on the stability of the material's colour. Colour change in composite resin restorations is one of the most frequent reasons for their replacement. The aim of this study is to evaluate the change in colouration, using the CIE L*a*b* colour system, of nanohybrid and microhybrid composite resins when they are exposed to potential staining solutions over a period of 14 days.

Keywords: colour change; composite resin; aesthetics; pigmentation

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1. Introduction

Colour represents one of the most relevant aesthetic parameters in dentistry [1]. To evaluate and determine the colour, the instrumental method can be used; it is objective and can be quantified, such as by using spectrophotometers and colorimeters [2–4]. The CIE L*a*b* colour system measures the value and chroma through three parameters, "L", "a", and "b". "L" represents brightness, "a" the red–green region, and "b" the yellow–blue region [5]. The total colour difference (ΔE) is calculated using the formula $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2)]^{\frac{1}{2}}$ [5,6].

Composite resins play a key role in dental restoration, especially in anterior regions, due to their aesthetic capabilities. Inadequate colouration and chromatic instability in a composite resin restoration are among the most prevalent reasons for its replacement [6–8]. This study aims to evaluate the alteration of the colouration of composite resins when they are exposed to solutions that may cause pigmentation during a period of 14 days.

2. Materials and Methods

Three composite resins were used: Clearfil Majesty™ ES-2 Premium (Ma) (Kuraray Noritake Dental Inc.—Okayama, Japan), Elegance Composite Universal (El) (Medicaline—Castellón, Spain), and Point 4™ (Pt) (Kerr—Orange, CA, USA). For each resin, shade A2 (Vita Scale) was chosen. A control solution (Cl) (artificial saliva) and 4 potentially pigmenting solutions were used: coffee (C) (Delta Cafés—Alentejo, Portugal), red fruit juice (Fv) (Compal—Carnaxide, Portugal), chlorhexidine—0.12% (Cx) (Laboratorios KIN—Barcelona, Spain), and an energy drink (Rb) (Red Bull GmbH—Fuschl, Austria). In total, 225 resin disks (10 × 2 mm) were prepared (75 discs for each resin). For each composite resin, 5 experimental groups (n = 15) were randomly formed. In the first 24 h after its confection, each group was placed in Cl and stored at 37 °C. In the subsequent 14 days, the discs were placed in their respective solutions. The samples (apart from the control group, as it was permanently immersed in the Cl solution) were incorporated into the potentially pigmenting solutions for a period of 5 min per day, for 14 days. During the remaining 23 h 55 min, the samples were kept in Cl, at 37 °C. In total, 2 colour measurements were performed on the discs with the SpectroShade^{TM} Micro (MHT—Verona, Italia): after the discs were initially immersed in Cl for 24 h (T0) and after 14 days (T2) following their exposure to the solutions. The CIE L*a*b* colour system was then applied.

3. Results

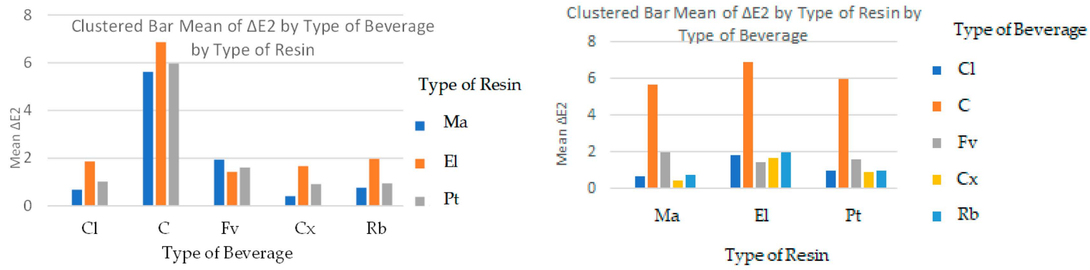
A two-way ANOVA was applied to evaluate the effect of the type of resin and the type of beverage to which the resins were exposed on the variations in four colour parameters (E, L, a, and b) between the 1st and 14th days of exposure (T = 2). The assumption of normality of the distribution of dependent variables in each subgroup defined by the two independent factors was assessed through the Shapiro–Wilk test, whose results proved its validity in the overwhelming majority of cases. Regarding the assumption of the homogeneity of variance of the dependent variables between subgroups, Levene's test revealed that this assumption was violated for all variables. However, this violation had no impact on the results because all sub-groups considered in the experimental design had the same size (n = 15). Statistical analysis was performed with the SPSS 28.0 software (IBM, SPSS Inc., Armonk, NY, USA) at a $p < 0.05$.

The application of the two-way ANOVA model to the data of the four variables produced the results shown in Table 1. Based on these results, we concluded that, for each of the dependent variables considered, there was a significant interaction between the two independent factors (effect represented in the table by the term "Type of Resin * Type of Beverage"). This result means that the effects of exposure to different types of beverages varied according to the type of resin, so comparisons between groups defined by one of the independent factors were conducted for fixed levels of the other factor, as described below, separately for each dependent variable.

Table 1. Evaluation of the effect of the type of resin and beverage to which the resins were exposed, on the variation that occurred in the ΔE, ΔL, Δa, and Δb colour parameters between the 1st and 14th days of exposure.

Tests of Between-Subjects Effects					
Dependent Variable: ΔE2					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Type of Resin	31.375	2	15.688	66.572	<0.001
Type of Beverage	869.816	4	217.454	922.791	<0.001
Type of Resin * Type of Beverage	18.863	8	2.358	10.006	<0.001
Dependent Variable: ΔL2					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Type of Resin	47.701	2	23.851	52.352	<0.001
Type of Beverage	720.732	4	180.183	395.502	<0.001
Type of Resin * Type of Beverage	15.951	8	1.994	4.377	<0.001
Dependent Variable: Δa2					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Type of Resin	3.988	2	1.994	67.053	<0.001
Type of Beverage	69.039	4	17.260	580.360	<0.001
Type of Resin * Type of Beverage	3.642	8	0.455	15.308	<0.001
Dependent Variable: Δb2					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Type of Resin	90.391	2	45.196	347.404	<0.001
Type of Beverage	381.685	4	95.421	733.472	<0.001
Type of Resin * Type of Beverage	10.934	8	1.367	10.505	<0.001

Figure 1a shows the data of the dependent variable ΔE between the 1st and 14th days of exposure, considering the type of beverage as fixed. Figure 1b shows the data of the dependent variable ΔE between the 1st and 14th days of exposure, considering the type of resin as fixed.



(**a**) (**b**)

Figure 1. Data of the dependent variable ΔE between the 1st and 14th days of exposure. (**a**) Considering the type of beverage as fixed; (**b**) considering the type of resin as fixed.

All the composite resins showed significant colour variation. There were significant differences between the composite resins when exposed to the same solution. Similarly, there were significant differences between the solutions in their ability to cause colour changes in the same resin. The effects of exposure to the solutions differed according to the type of resin.

4. Discussion

Composite resins composed of larger inorganic particles are more susceptible to colour changes from extrinsic pigmentation (due to absorbing more water) than resins of smaller inorganic particles. This is not in line with the results obtained, since the nanohybrid composite resin El showed a greater chromatic variation than the Pt microhybrid composite resin, probably due to the difference in the composition of its organic matrix [4,9,10]. The nanohybrid composite resin Ma, which did not contain TEGDMA, showed the highest colour stability, followed by the Pt microhybrid composite resin, and finally the nanohybrid composite resin El, which contained TEGDMA, with the latter showing the lowest colour stability. The results obtained are in line with those of a study that compared a microhybrid and a nanohybrid resin, which contained TEGDMA, and the microhybrid resin showed greater colour stability [11]. Another study related a nanohybrid resin (which did not contain TEGDMA) and two microhybrid resins, and the nanohybrid resin showed higher chromatic stability [6]. This is in line with the results obtained.

There is also a study in which it was found that the evaluated microhybrid composite resin obtained greater chromatic stability compared to the nanohybrid one (which contained TEGDMA in its constitution) [9]. In the present study, these results were also verified, considering that the nanohybrid composite resin El (containing TEGDMA) demonstrated lower colour stability compared to the Pt microhybrid composite resin. Some investigations have described that resins containing TEGDMA exhibit greater colour changes, due to absorbing a greater amount of water [12,13]. This fact is in line with the results obtained in the present study, considering that the composite resins (El and Pt) containing TEGDMA in their compositions showed greater chromatic variation.

The analysis of the solutions showed that there was a highly significant difference between them. Their pigmentation capacity differed when applied to the same composite resin. The C caused the greatest alteration in all composite resins, being the only one that was perceptible through the human eye, with ΔE > 5, which agrees with other studies [4,6,9,10,14]. Other solutions did not cause a perceptible change in colour, with ΔE < 2. Regarding the red fruit solution, the values were not in line with the results of another study [14], possibly due to the different exposure times. The results obtained for the chlorhexidine solution coincided with those of another study [9], although the percentage of chlorhexidine was different (0.2%).

The results of the solution containing the energy drink were also in agreement with another study [15], although the exposure time to the solution varied.

5. Conclusions

The El resin showed the greatest chromatic change for the Cl, C, Cx, and Rb solutions. The Ma composite resin showed the greatest chromatic change for the Fv solution. The C solution caused the greatest chromatic alteration.

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