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Investigation of the Effect of Whitening Mouthwashes on the Translucency of Resin Composites at Different Times †

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Abstract: The aim of this study is to evaluate the effect of whitening mouthwashes on the translucency parameter (TP) at different times of resin composites after coloring with coffee. A total of 90 samples were prepared from resin materials (Estelite Σ Quick, G-aenial Anterior, Omnichroma). After being kept in coffee for 12 days, the samples were divided into three subgroups (n = 10). The initial (T0) measurement of the TP values was recorded. Control groups were kept in distilled water, and the other groups were kept in two different types of mouthwash (Listerine Advanced White and Crest 3D White). The TP values were recorded at the end of 24 h (T1) and 72 h (T2). The TP values were determined using the CIEDE2000 formula. Two-way analysis of variance and the Tukey test were used ($p < 0.05$). The lowest ΔTP value was observed in the control group at T0–T1 and T0–T2. The highest ΔTP value was observed with Crest 3D White mouthwash at T0–T2. However, there was no difference with Listerine Advanced White. Among the composites, the highest ΔTP value was found in G-aenial Anterior at T0–T2, and the lowest ΔTP value was found in Omnichroma at T0–T1. Whitening mouthwashes caused an increase in the translucency values of resin composites over time. It should be noted that long-term use of whitening mouthwashes may affect the translucency values of resin composites.

Keywords: discoloration; translucency parameter; resin composite; whitening mouthwash

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1. Introduction

One of the main goals of aesthetic dentistry is to form restoration that complements the optical properties of natural teeth. Optical properties such as translucency and color have the highest impact on natural tooth appearance, as they are the most easily observed. Translucency is defined as the middle of opacity and transparency. Translucent materials allow light to pass through but scatter light in contrast to transparent materials, preventing objects behind them from being seen clearly [1]. The translucency parameter (TP) was used to evaluate the translucency of dental materials. The TP can be measured for materials of a given thickness on an ideal black-and-white background. In most dental studies on translucency, it is measured using the CIELAB color formula [2]. In the literature, the use of the CIEDE2000 color formula, which aims to correct and improve the perceived and calculated color differences of the CIELAB formula, has been suggested [3,4]. The TP determination depends on the color, thickness, matrix composition of different composite resins, fillers particle size and contents, and type and amount of opacifiers used [2].

Nowadays, it is noteworthy that patients apply to dental clinics with increasing aesthetic expectations and demand for whiter teeth [5]. Stained restorations are a costly treatment option to correct aesthetic problems. Repolishing and the use of whitening products can be considered less costly alternative treatments. Whitening can be accomplished

with a variety of methods or systems, often categorized as office bleaching, home bleaching, or over-the-counter (OTC) bleaching [6]. Mouthwashes have become a very popular OTC bleaching product due to their ease of application, low cost, and widespread availability in supermarkets and pharmacies [7]. Although sales of whitening mouth rinses have increased in recent years, there is little information about their effectiveness. Therefore, the aim of the current study was to investigate the effect of whitening mouth rinses on the translucency change of resin composites at different times after coloring with coffee. The null hypothesis of this study is that whitening mouthwashes do not have a significant effect on translucency change.

2. Materials and Methods

In this study, three different composite resins (Estelite Σ Quick (A2), Tokuyama Dental, In this study, three different composite resins (Estelite Σ Quick [A2], Tokuyama Dental, Tokyo, Japan; G-aenial Anterior [A2], GC Corp, Tokyo, Japan; Omnichroma, Tokuyama Dental, Tokyo, Japan) were used (Table 1). Resin samples were prepared using disc-shaped Teflon molds with a diameter of 8 mm and a depth of 2 mm. Resin materials were placed in the mold with the help of a hand instrument. A Mylar strip was placed at the top, and slightly pressured with cement glass was applied. The resin material was polymerized for 40 s with a LED light device (3M Elipar DeepCure-S, 3M ESPE, Saint Paul, MN, USA) at a power density of approximately 1200 mW/cm^2. A total of 90 disc-shaped samples were prepared from the resin composite groups, with 10 samples selected randomly in each group. A polishing system (OptiDisc, KerrHawe, Bioggio, Switzerland) was applied to a single surface of the samples in each group. As stated in the previous study [8], 3.6 g of coffee (Nescafé Classic, Nestle Turkey, Bursa, Turkey) was dissolved in 300 mL of hot water. The immersion solution was stirred and refreshed every 12 $\pm$ 1 hour [8]. The studies reported that the immersion time of the samples in coffee should be 12 days to one year of drinking coffee [8,9]. After being colored in coffee, the L*a*b* values of the samples were measured with a spectrophotometer (Lovibond RT Series, Tintometer Group, UK). Three measurements were made from each sample, and the average of these measurements was recorded as a single value. Measurements were made on black-and-white backgrounds for the TP under lighting conditions in D65 standards. The TP values (TP00) of the samples were calculated using the CIEDE2000 color formula [2]. Ten samples from each group were determined to be kept in distilled water as the control group. Other groups were formed to be kept in two different whitening types of mouthwash (Listerine Advanced White, Johnson & Johnson, Maidenhead, UK, and Crest 3D White, Procter & Gamble, Cincinnati, OH, USA). The TP values of all groups were recorded after 24 h (T1) and 72 h (T2).CIEDE2000 color formula was used to calculate TP values (TP_{00}): [2]

$$TP_{00} = [(L_B\text{-}L_W/K_L.S_L)^2 + (C_B\text{-}C_W/K_C.S_C)^2 + (H_B\text{-}H_W/K_H.S_H)^2 + R_T.(C_B\text{-}C_W/K_C.S_C).(H_B\text{-}H_W/K_H.S_H)]^{1/2}$$

The formula content was as described in the previous study [2]. In the present study, the parametric factors of the CIEDE2000 color difference formula were set to one [2].

Table 1. Details of investigated materials.

Composite Material/Manufacturer	Type	Component	Filler Concentration: Weight %–Volume %	Lot
G-Aenial Anterior (A2), (GC Corp, Tokyo, Japan)	Microhybrid	UDMA, dimethacrilat co-monomers, prepolimerized organic filler, silica, stronsiyum, lanthanoid florid, fumed silica (0.1–17 μm)	76/63	190603B
Estelite Σ Quick (A2), (Tokuyama Dental, Tokyo, Japan)	Submicron filler composite	Spherical submicron filler (0.1–0.3 μm) Bis-GMA, TEGDMA, silica-zirconia	82/71	271E79
Omnichroma (Tokuyama Dental, Tokyo, Japan)	Supra-nano filler composite	UDMA, TEGDMA, Uniform size supra-nano spherical filler (260 nm spherical SiO2-ZrO2), composite filler (260 nm spherical SiO2-ZrO2)	79/68	021E10

Bis-GMA: bisphenol A glycol dimethacrylate; TEGDMA: triethylene glycol dimethacrylate, UDMA: urethane dimethacrylate

Table 1. *Cont.*

Mouthwashes/Manufacturer	Ingredients
Listerine Advanced White (Johnson & Johnson Consumer Services EAME Limited, Maidenhead, UK)	Aqua, alcohol, sorbitol, tetrapotassium Pyrophosphate, Pentasodium Triphosphate, Citric Acid, poloxamer 407, sodium benzoate, eucalyptol, thymol, menthol, sodium saccharin, sodium fluoride, tetrasodium pyrophosphate, propylene glycol, sucralose, aroma, disodium phosphate,
Crest 3D White (Procter & Gamble, Cincinnati, OH, USA)	Water, glycerin, hydrogen peroxide, propylene glycol, sodium hexametaphosphate, poloxamer 407, sodium citrate, flavor, sodium saccharin, citric acid (alcohol-free)

Statistical Analysis

SPSS Statistics for Windows, Version 22.0 (IBM Corp, Armonk, NY, USA), was used for data analysis. Data were checked for normal distribution (Kolmogorov-Smirnov test/skewness kurtosis). The ΔTP data were analyzed using a two-way analysis of variance. The Tukey test was used for multiple comparisons. Partial eta squared (η^2) values were evaluated to understand how much effect the independent variables had on the dependent variables. The statistical significance level was accepted as $p < 0.05$.

3. Results and Discussion

For the ΔTP, the main effects and interaction between the factors are shown in Table 2. The two-way analysis of variance showed no significant interaction between the factors (mouthrinse*composite) at different time intervals in this study. The lowest ΔTP value was exhibited in the control group at T0–T1 and T0–T2 ($p = 0.001$). The highest ΔTP value was exhibited in Crest 3D White mouthwash at T0–T2 ($p = 0.001$). However, there was no difference with Listerine Advanced White. Among the composites, the highest ΔTP value was found in G-aenial Anterior at T0–T2, and the lowest ΔTP value was found in Omnichroma at T0–T1 (Table 3).

Table 2. Two-way ANOVA results for translucency change the main effects and interactions between composite and mouth rinse (f1:composite f2:mouthrinse). Partial eta squared (η^2) values were examined to understand how much effect the independent variables had on the dependent variable.

Translucency Change T_1–T_0						
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
f1	5.275	2	2.638	59.515	0.014	0.100
f2	8.131	2	4.065	151.345	0.002	0.146
f1 * f2	0.828	4	0.352	7.92	0.842	0.017
$R^2 = 0.230$ (Adj. $R^2 = 0.154$)						
Translucency Change T_2–T_0						
f1	12.250	2	6.125	9.787	<0.001	0.195
f2	13.270	2	6.635	10.602	<0.001	0.207
f1 * f2	3.097	4	0.774	1.237	0.302	0.058
$R^2 = 0.361$ (Adj. $R^2 = 0.298$)						
Translucency Change T_2–T_1						
f1	1.478	2	0.739	1.305	0.277	0.031
f2	0.626	2	0.313	0.553	0.577	0.013
f1 * f2	1.778	4	0.267	0.471	0.757	0.023
$R^2 = 0.065$ (Adj. $R^2 = -0.028$)						

Table 3. Means and standard deviations at different times for translucency change (Δ*TP).*

	Composites			
Mouthrinses* T_1–T_0	**G-Aenial**	**Estelite**	**Omnichroma**	**Total**
Control	0.17 ± 0.54	0.01 ± 0.65	−0.31 ± 0.72	−0.04 ± 0.65 ^{a}
Listerine Advanced White	0.60 ± 0.76	0.25 ± 0.87	0.17 ± 1.01	0.34 ± 0.88 ^{ab}
Crest 3D White	1.18 ± 0.70	0.52 ± 0.83	0.35 ± 0.66	0.69 ± 0.79 ^{b}
Total	0.65 ± 0.77 ^{A}	0.26 ± 0.79 ^{AB}	0.07 ± 0.84 ^{B}	0.33 ± 0.83
Mouthrinses* T_2–T_0				
Control	0.45 ± 0.87	0.04 ± 0.75	−0.39 ± 0.69	0.03 ± 0.83 ^{a}
Listerine Advanced White	0.77 ± 1.00	0.49 ± 0.53	0.31 ± 0.89	0.52 ± 0.83 ^{b}
Crest 3D White	1.81 ± 0.81	0.60 ± 0.93	0.49 ± 0.39	0.97 ± 0.94 ^{b}
Total	1.01 ± 1.05 ^{A}	0.38 ± 0.77 ^{B}	0.13 ± 0.77 ^{B}	0.51 ± 0.94
Mouthrinses* T_2–T_1				
Control	0.28 ± 0.43	0.03 ± 0.63	−0.08 ± 0.75	0.07 ± 0.61
Listerine Advanced White	0.17 ± 0.90	0.23 ± 0.94	0.13 ± 0.88	0.18 ± 0.87
Crest 3D White	0.62 ± 0.72	0.07 ± 0.74	0.14 ± 0.60	0.28 ± 0.71
Total	0.35 ± 0.71	0.11 ± 0.76	0.06 ± 0.73	0.17 ± 0.74

If the interaction between independent variables was not significant, the parameters of the analyzed variables on the main effects were evaluated by examining the total values, and differences between interacting parameters were noted. Means followed by distinct lower letters represent statistically significant differences in each column ($p < 0.05$). Means followed by distinct capital letters represent statistically significant differences in each row ($p < 0.05$).

Internal factors as a result of physicochemical reactions in the deep layers of the material and external factors as a result of accumulation and absorption of surface colorants on the surface of the material are effective in color change [10]. Absorption of pigments in a coloring liquid such as coffee causes the coloring of the resin composites [11]. Coffee is considered a coloring agent that can penetrate the organic phase in composite resins and release low-polarity yellow pigments that can cause coloration [12]. In our study, translucency values were measured after the resin composites were kept in coffee for 12 days. It has been stated that the translucency values of some materials increase and some decrease after aging in different resin composites [13]. It is assumed that whitening mouthwashes, mainly agents such as hydrogen peroxide, offer a whitening effect on teeth [14]. It is important to understand how whitening mouthwashes affect the translucency property of the material in tooth-colored restorations and to advise patients accordingly. In this study, composite samples were kept in whitening mouthwashes at different immersed times, and their translucency change values were evaluated at different time intervals. In this study, resin composite materials immersed in whitening mouthwashes for different immersion times (24 and 72 h) were investigated. It was stated that the daily use of mouthwash for 2 min was equivalent to 2 and 6 years of 24 and 72 h immersion times evaluated in the study [15]. In our study, two whitening mouthwash products with different formulas were evaluated. The Omnichroma resin composite, which has been introduced with a monochromatic structure in recent years, and resin materials with two different contents used in the anterior region were selected. Because of the increasing popularity of these materials, they were preferred for this study.

In our study, the initially measured translucency values were observed less in G-aenial Anterior (microhybrid) and Estelite Σ Quick (submicron) composite resins; higher translucency values were observed in the Omnichroma (supranano filler) composite resin. Differences between composite resins can be attributed to the chemical structure of the materials, the intensity of particles, or the particle size. The translucency changes of whitening mouthwashes at 24 and 72 h were significantly greater than in the control groups. Higher ΔTP values were found in the G-aenial Anterior resin material kept in Crest 3D White mouthwash in the T0–T2 interval. It is thought that H_2O_2 in Crest 3D White provides more effective penetration into the resin matrix, and therefore, a greater translucency change occurs. The Crest 3D White formula used in this study includes hydrogen peroxide as a

bleach/stain remover. In the Listerine Advanced White formula, tetrapotassium pyrophosphate and tetrasodium pyrophosphate are used as bleach/stain-removing components. Sodium hexametaphosphate, known as polypyrophosphate, chemically removes external stains [16]. In our study, it was observed that the translucency values of the samples, which were kept in distilled water and whitening mouthwash after being stained with coffee, increased in all groups except the Omnichroma control group. This finding is in parallel with another study stating that whitening agents increase translucency values [17]. In another study, it was reported that Bis-GMA has higher translucency than UDMA and TEGDMA [18]. The reason was that the refractive index of Bis-GMA and the refractive index of silica filler were close. However, the higher translucency values of Omnichroma, which has a one-shade material and does not contain Bis-GMA, may affect these values due to the monomers and fillers in its content. According to the manufacturer, Omnichroma is pigment-free, and its color characteristics are based on structural colors and chromatic technology to control optical properties. This approach responds to light waves of a specific frequency by reflecting a specific wavelength within the tooth color area. Omnichroma's compositional design consists of a round-shaped composite filler mixture of silicon dioxide (SiO2) and zirconium dioxide (ZrO2) with a particle size of 260 nm, with the same properties as an equal-sized suprananospheric filler [19]. The absence of color pigments may be one of the factors in the lower translucency change values of Omnichroma.

In this study, it was concluded that whitening mouthwash had a higher effect on the change of translucency than the composite resin because when the partial eta squared was evaluated, it was determined that the mouthwash had a greater effect on the T0–T1 and T0–T2 intervals in the change of translucency. In this context, it shows that the short- and long-term use of whitening mouthwashes may have an effect on the translucency changes of the materials. Therefore, the hypotheses tested within the scope of the findings of our study were rejected. We focused on the effect of different whitening agents on the translucency of resin materials. However, the alcohol in the content may affect some differences in the analyzed parameters, which is an important limitation of this study. Tooth brushing, saliva, beverages, and pH levels in the oral environment can also affect the optical property of resin materials.

4. Conclusions

Whitening mouthwashes caused an increase in the translucency values of resin materials over time. Material contents caused differences in translucency values. The effect of mouth rinse in daily use should be evaluated clinically on the influence on the optical property of resin composite restorations over time. It should be noted that long-term use of whitening mouthwashes may affect the translucency values of resin composites.

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