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The Effects of Fresh Detox Juices on Color Stability of Resin Adhesive Systems

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Abstract: *The purpose of the present research was to assess the effect of three different fresh detox juices on the color stability of the resin composite with three different adhesive systems. Disc-shaped resin composite specimens were prepared. Composite discs were randomly divided into 3 subgroups according to the adhesive system (Adper EasyOne, BondForce, Clearfil QuickBond), adhesive system was applied to the upper surfaces of the composite discs according to the manufacturer's instructions. The first color measurements were made with a spectrophotometer after the composite discs were kept in water for 24 h. Samples in each group were divided into 4 subgroups according to the immersion solution (n=10; brands, water). The samples, which were kept in respective detox juices, were kept for 10 minutes twice a day, at other times they were kept in distilled water. Second color measurements were performed 30 days later. Data were analyzed with two-way ANOVA and Tukey HSD tests. According to the two-way analysis of variance, the adhesive system does not affect the color change significantly (p=0.773), but the detox juices has a significant effect on the color change (p=0.01). Fresh detox juices may adversely affect the color stability of adhesive systems, regardless of their color, but this effect may not be expected to be clinically observable.*

Keywords: *adhesive, color, detox juice, color stability, resin composite*

1. Introduction

The appearance of tooth-colored restorations in the aesthetic area is affected by some factors. These factors are the colors and transparency of the restorative materials and the tooth tissue underlying the restorative material [1]. Color compatibility and color stability of these materials play an important role in the mid- and long-term clinical success of aesthetic restorations in dentistry [2, 3]. Polymeric materials such as resin composites and resin adhesives discolor over time in the oral environment [4, 5]. It has been suggested that the changes in the chemical structure of the polymeric materials and the external coloration that occurs over time cause this color change [6, 7].

Resin composites are semi-transparent materials. Therefore, the color characteristics of the tissue underlying the resin composites affect the color characteristics of the final restoration. This is particularly evident when the resin composite is applied in thin layers. Adhesive systems are used to provide retention to the dental tissues under the resin composites they were applied before. In addition, adhesive systems are also applied to the upper surface of the resin composite to increase marginal adaptation when placing the resin composite. Therefore, adhesive systems can also affect the color properties of the final restoration. In general, adhesive systems are resin solutions containing solvents, hydrophilic and hydrophobic monomers, and polymerization initiators. In addition to these complex contents, the chemical content of adhesive systems varies considerably according to the brand of the product [8]. Just like resin composites, adhesive systems are not completely transparent. Polymerization initiators such as camphorquinone play a very important role in determining the color of the adhesive system before and after polymerization [9].

Hydrophilic monomer and solvent ratios in the chemical content of today's simplified adhesive systems have gradually increased. In this way, these adhesives can better infiltrate into the microporosity of the enamel and dentin surfaces [10]. However, increased solvent and hydrophilic monomer content cause these adhesives to absorb more water over time [11]. There is an inverse relationship between the color stability of polymeric materials and their water absorption properties [12]. Therefore, there may

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be a link between the increased water absorption of adhesive systems and the color properties of the final resin composite restoration.

Previous studies have shown that the color match and color stability of final resin composite restorations are affected by the brand of the adhesive system [13-15]. Nowadays, many people are interested in the consumption of healthy drinks and juices. However, consumption of acidic foods and juices can affect the color properties of resin composites and other polymeric materials. It has been shown in previous studies that such fruit juices and other healthy beverages change the color properties of resin composites [16, 17]. However, similar studies have not yet been reported for detox juices and adhesive systems. Therefore, in this study, the effect of soaking different adhesive systems in three different detox waters on the color stability of a resin composite was evaluated. The null hypothesis of the study is that "the color stability of the resin composite is affected neither by the adhesive system nor by the detox juice".

2. Materials and methods

2.1. Study design

Three adhesive systems (Adper EasyOne, 3M ESPE, St. Paul, MN, USA; Clearfil QuickBond, Kuraray Noritake Dental Inc., Tokyo, Japan; BondForce, Tokuyama Inc., Tokyo; Japan) and three fresh detox juices (Tropic Breeze, Passion Red and Well Green, Elite Organik %100 Smoothie, Organik Gıda A.Ş., Sincan, Turkey) were tested. Details of the materials deployed in the present study are presented in Table 1.

Table 1. Materials used in the study

Material	Chemical composition	Application technique
Adper EasyOne (3M ESPE, St. Paul, MN, USA) #4747900	HEMA, Bis-GMA, methacrylated phosphoric esters, 1,6 hexanediol dimethacrylate, metha-crylate, functionalized polyalkenoic acid, silica filler, ethanol, water, initiators, stabilizers	Apply adhesive to tooth surface for a total of 20 s; air-dry the adhesive for 5 s; light cure for 10 s.
Clearfil QuickBond (Kuraray Noritake Dental Inc., Tokyo, Japan) #700042	HEMA, Bis-GMA, MDP, Hydrophilic amide monomers, Colloidal silica, Silane, Sodium fluoride, Ethanol, Water	Apply with a rubbing motion then no waiting time after applying; dry for 5 s; light cure for 5 s.
BondForce (Tokuyama Inc., Tokyo, Japan) #144	Methacryloyloxyalkyl acid phosphate, HEMA, Bis-GMA, TEGDMA, camphorquinone, purified water, alcohol	Apply adhesive and agitate for 20 s; air-dry gently until there is no water movement, then dry with strong air for 5 s; light-curing for 10s.
Herculite Classic (Kerr Italia S.r.L., Scafati, Italy) #5517381	Bis-GMA, TEGDMA, camphorquinone, amine, iron oxide pigments, aluminum borosilicate glass, colloidal silica (SiO_2) 79% of filler content	2 mm application max, gently adapt the product and light -cure for 20 s
Tropic Breeze, Elite Organik %100 Smoothie (Organik Gıda A.S., Sincan Türkey) #20131	Banana, Orange, passion fruit, mango, apple, peach, carrot, coconut	Color: Orange
Passion Red, Elite Organik %100 Smoothie (Organik Gıda A.S., Sincan Türkey) #20132	Watermelon, strawberry, banana, apple, pear, black mulberry, red beet, black carrot	Color: Red
Well Greens, Elite Organik %100 Smoothie (Organik Gıda A.S., Sincan Türkey) #20131	Black cabbage leaf, cucumber, spinach leaf, apple, lettuce leaf, mint leaf, pear, lemon, parsley leaf	Color: Green
MDP: 10-methacryloxydecyl dihydrogen phosphate, MDPB: 12-methacryloyloxydodecylpyridinium bromide, HEMA: 2-hydroxyethyl methacrylate, Bis-GMA: bisphenol-A glycidyldimethacrylate, TEGDMA: triethyleneglycol dimethacrylate.		

2.2. Specimen preparation

One hundred and twenty disc-shaped specimens from a microhybrid resin composite (shade A2, Herculite Classic, Kerr Italia, Scafati, Italy) were prepared. Resin composite discs were randomly allocated into three groups according to adhesive system (n = 40). The inner dimensions of an elastic

mold, which was used to prepare the resin composite discs, were 8 mm diameter and 1.25 mm depth. A transparent polyester strip was placed on a glass slide. The elastic mold was fixed on the translucent polyester strip by using a piece of double-faced adhesive band. The resin composite was condensed into the mold. The top of the elastic mold was shielded with another translucent polyester strip and a second glass slide was placed slightly over the composite to achieve flat surface. Polymerization was done on top surface of resin composite with a LED curing unit (Elipar S10, 3M Espe, St. Paul, MN, USA) with an intensity setting of 1200 mW/cm^2 from 5 different areas each for 20 s. The LED curing light intensity was checked by a radiometer. After the resin composite discs were left in the dark for 24 h to complete the polymerization, both sides of the discs were polished with 600-, 800-, 1200-, 1500-grit SiC (silicon carbide) papers under water cooling. For distinction of the bottom and top sides of specimens, little notches made with a dental bur on the edge of the bottom side of the composite discs. Final thicknesses of resin composite disks were measured by a digital caliper (1.2±0.1). Resin composite discs were kept in black bottles until color measurements were done.

2.3. Color analysis

A clinical spectrophotometer (VITA Easyshade V, VITA Zahnfabrik, Bad Säckingen, Germany) was used for the color measurement. All the measurements made from the top sides of the discs. CIE *L*a*b** color system is shown in the display of the clinical spectrophotometer. CIE *L*a*b** color system states color space by *L**, *a**, and *b** coordinates. *L** symbolizes black/white character or the lightness of the color. The coordinates *a** and *b** define the chromatic features of the color. The *a** coordinate symbolizes the red-green axis and *b** coordinate symbolizes the yellow-blue axis [18].

Baseline color readings (T_0) were made in a custom-built light box with D65 illumination (KES 123 Led Bulb 12 W, K2 LED Systems, Istanbul, Turkey). Resin composite discs were placed on a white tile. The spectrophotometer was standardized conferring to the manufacturer's instructions. For each specimen, three repeated readings were made and mean *L**, *a**, and *b** values were obtained [18]. Color values (*E**) were calculated with the following formula:

$$E^* = (L^{*2} + a^{*2} + b^{*2})^{1/2}$$

2.4. Adhesive system application and immersion in detox juices procedures

After baseline color (E_0) measurements, adhesive systems application procedures were performed at the bottom surface of each resin composite discs according to respective manufacturer's instruction for each group (Table 1). Then, the discs in each group of adhesive systems were randomly distributed to be soaked in 4 different immersion solutions (Tropic Breeze, Elite Organik %100 Smoothie (Color: Orange), Passion Red, Elite Organik %100 Smoothie (Color: Red), Well Greens, Elite Organik %100 Smoothie (Color: Green) and distilled water as a control). The samples, which were kept in respective detox juices, were kept for 10 min twice a day, at other times they were kept in distilled water. After the first measurements, resin composite discs were stored in distilled water for 30-day in separate dark bottles according to their groups. Distilled water in the dark bottles was changed every week. After 30-day immersion period, color (E_1) measurements were re-performed as in the first measurement from top surface of the resin composite discs. Color change values (ΔE) of resin composite discs between baseline and after immersion procedures were calculated with the following formula:

$$\Delta E\ (L^*\ a^*\ b^*) = ((\Delta\ L^*)\ 2 + (\Delta\ a^*)\ 2 + (\Delta\ b^*)\ 2)\ ½$$

2.5. Statistical analysis

The effects of adhesive system and detox juices on ΔE values were analyzed by using two-way analysis of variance (ANOVA). Tukey tests were used for post-hoc comparisons among adhesive systems. All tests were performed by SPSS 16 ($p = 0.05$).

3. Results and discussions

The changes in ΔE values in different groups after 30 days of immersion in fresh detox juices are summarized in Table 2. According to the two-way analysis of variance, the adhesive system does not affect the color change significantly (p=0.773), but the detox juices has a significant effect on the color change (p=0.01). There was no significant interaction between both factors (p=0.757). These findings showed that all detox juices, regardless of color, caused a significant change in the color of all adhesives tested.

Table 2. Color changes of adhesive systems according to fresh detox juices after 30-day immersion

	Adper EasyOne	Clearfil QuickBond	BondForce
Distilled water	1.35 ± 0.6^{Aa}	0.93 ± 1.11^{Aa}	0.79 ± 1.09^{Aa}
Tropic Breeze	2.55 ± 1.2^{Ba}	1.94 ± 1.4^{Ba}	1.86 ± 1.1^{Ba}
Passion Red	2.63 ± 1.4^{Ba}	2.19 ± 1.6^{Ba}	2.75 ± 1.7^{Ba}
Well Greens	2.45 ± 1.5^{Ba}	2.46 ± 1.2^{Ba}	2.84 ± 1.4^{Ba}
Different upper superscripts show significant difference in the same column. Different lower superscripts show significant difference in the same column (p<0.05).			

Since the resin composite material is semi-translucent, the last color of resin composite restorations is influenced by the transparency and depth of material and color of background. The clinical success of aesthetic restorations depends on color matching and color stability. As the adhesive system is a material used under resin composite material, it can be considered as a factor affecting the color of resin composite restorations. In particular, the possible influence of the color stability of hydrophilic adhesives on the color of the final resin composite restoration may be significant.

Drinking of cold-pressed juices and detox agents produced from a mixture of different vegetables and fruits has rised in current years. Colorants and acids and in these plant-derived drinks may have some effects the resin composite material and the adhesive system used. To our knowledge, how fresh detox mixtures affect the color stability of adhesive systems has not been previously investigated in the literature. Therefore, in this study, the effect of three different fresh detox juices on the color stability of three different adhesive systems was evaluated. According to the findings, it was determined that all of the tested fresh detox juices significantly decreased the color stability of all three adhesives. Therefore, the null hypothesis that fresh detox juices do not affect the color stability of adhesive systems has been rejected.

In previous studies, it is seen that the samples are kept in coloring solutions continuously. However, in this study, samples in the detox juice groups were soaked for ten minutes twice a day for 30 days [19, 20]. Other times it was kept in distilled water. In this way, an attempt has been made to simulate in vivo conditions as much as possible. However, the findings of this advanced study should be supported by in-vivo studies on the effect of detox waters on the color stability of adhesive systems.

Under clinical conditions, there are dental tissues under resin composite and adhesive layer. If clinical conditions were tried to be established in this study, the effects of color and color stability of the adhesive system on the final color of the resin composite discs could not be revealed [13]. Therefore, in this study, adhesive systems were applied to the bottom surfaces of composite discs, as in the study of Ritter et al. [14].

Considering the relationship between clinical significance and color change, there is no clear agreement in the literature on what extent of color change is visually detectable or acceptable. When the adhesive systems were evaluated and even in the early stages, they exhibited significant color changes in water so adhesives might be a possible factor that can affect the color stability of resin composite restorations. However, in previous studies, ΔE = 1-1.2 and ΔE = 2.7-3.7 were specified as perceptible and acceptable color difference threshold values [13]. Alabdulwahhab et al. stated that the color change range of 1.5 - 2.5 units can be recognized by an experienced clinician [15]. Considering these threshold values, it can be said that the fresh detox juices tested in this study caused a color change at a clinically acceptable level that could be detected by only experienced clinicians.

4. Conclusions

Within the limitations of this study, the following conclusions can be reached:

-regardless of color, all fresh detox juices adversely affected the color stability of all tested adhesive systems;

-the chemical structure of the adhesive does not affect the effect of the fresh detox juices on the color stability;

-since the color change values are at a level that only a specialist clinician can detect in the clinic, the potential of these color changes to cause problems in the clinic may be low.

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