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# Color change of some aesthetic dental materials: Effect of immersion solutions and finishing of their surfaces

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**KEYWORDS**

Color stability;
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Surface finishing

**Abstract** *Objectives:* The purpose of this research was to evaluate the color change of five aesthetic dental materials, before and after immersion in distilled water and blue food color solution for 7 and 21 days, and to study the effect of finishing the surfaces on any color change.

*Methods:* Disc shaped samples of five types of light curing composite (A2) ($n$ = 10 samples/composite) were prepared and all samples were light-cured with a Plasma Arc light cure unit for ten seconds. One side of each sample disc was finished and polished with a Super-Snap system all samples. After 24 h, color measurements of each sample were conducted using a digital spectrophotometer. Five sample discs from each composite group were immersed in 30 ml of food color solution for 7 and 21 days, while the remaining five sample discs were immersed in 30 ml of distilled water as a control. Color measurements were repeated for all samples at 7 and 21 days after immersion. The color changes were statistically analyzed using $t$-tests within the same group. A result was considered statistically significant at $\alpha = 0.05$.

*Results:* The color differences ($\Delta E$) ranged from 0.4 to 4.66 and statistically significant differences on the finished and unfinished surfaces were observed after immersion in the food color solution for 7 days. No significant differences were found in any group after immersion in the food color solution for 21 days. The Tetric EvoCeram and Arabesk groups showed less color differences after 7 and 21 days than other composites.

*Conclusion:* Finished composite surfaces showed less coloration than unfinished surfaces after 7 days, but all surfaces (finished and unfinished) were highly colored for all composite types after 21 days.



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## 1. Introduction

Composite resins are presently among the most popular aesthetic restorative materials in dental clinical practice. The use of these materials has been on the rise for the past several years and their popularity will only increase as manufacturers introduce stronger composite materials. The major disadvantage of resin composites is their color instability, which may be a major reason for the replacement of restorations (Inokoshi et al., 1996; Yannikakis et al., 1998).

Color is one of the most important attributes of aesthetic restorations. Matrix, filler composition, filler content, minor pigment addition, initiation components and filler coupling agents affect the color of aesthetic materials. The interactions of each of these components may have a role in the color stability of the material. The color stability is related to the dimension of the filler particles, depth of polymerization and coloring agents (Inokoshi et al., 1996; Yannikakis et al., 1998; Johnston and Reisbick, 1997; Ergücü et al., 2008). As resin matrix and filler compositions are different for different composites, they might interact differently with certain stains and this may be related to the chemical composition of the staining substance itself (Mc Kinney and Wu, 1985; Villata et al., 2006). Color change in resin restorations has been attributed to structural changes in the material due to aging, formation of colored degradation products, changes in surface morphology and extrinsic staining (Asmussen, 1983; Hachiya et al., 1984; Imazato et al., 1995). Intrinsic factors, such as changes in the filler, matrix or silane coating, or extrinsic factors, such as absorption of stains, incomplete polymerization, chemical reactivity, diet, oral hygiene and surface smoothness of the restoration, may cause discoloration of aesthetic materials (Patel et al., 2004; Türkün and Türkün, 2004; Satou et al., 1989). The intrinsic color of aesthetic materials may change when the materials are aged under various physical chemical conditions, such as ultraviolet exposure, thermal changes and humidity. For these reasons, discoloration of dental restorative materials has a multifactorial etiology (Iazzetti et al., 2000). Moreover, internal and external factors may both change the color of the aesthetic restorative material (Fruits et al., 1997).

The main purpose of finishing and polishing composite restorations is to create a restoration that is smooth, uniform, and easily cleaned. Roughness of restoration surfaces caused by wear and chemical degradation may also affect gloss and consequently increase extrinsic staining (Söderholm et al., 1984; Yu et al., 2009). The structure of the resin composite and characteristics of the particles have a direct impact on the surface smoothness and susceptibility to extrinsic staining (Deitschi et al., 1994; Van Groeningen et al., 1986).

Discoloration can be evaluated by visual or instrumental techniques. However, color evaluation by visual comparison may not be a reliable method due to inconsistencies inherent in color perception and specification between observers (Liberman et al., 1995; Johnston and Kao, 1989; Brook et al., 2007). Instrumental techniques for color measurement include colorimetry, spectrophotometry and digital image analysis, where spectrophotometry is the most reliable technique in dental material studies (Johnston and Kao, 1989; Brook et al., 2007).

The objectives of this study were to evaluate the color change of five commercially-available composites marketed in Syria for the restoration of teeth after immersion in distilled water and blue food color solutions for 7 and 21 days, and to study the effect of finishing composite surfaces on color changes.

## 2. Materials and methods

Five types of composite restorative materials (shade A2) were used in the present study. Detailed descriptions of the materials are presented in Table 1. For color measurements, a specially constructed mold was fabricated for each specimen to eliminate any contact with the materials. The specimens were packed against a celluloid strip to minimize the oxygen inhibition layer (Finger and Jorgensen, 1979) and to obtain the smoothest possible surface (Deitschi et al., 1994; Yap et al., 1997; Stoddard and Johnson, 1999). Ten discs of each composite material (4 mm thickness, 9 mm diameter) were prepared by filling a plastic ring mold with uncured resin-composite covered on both sides with Mylar strips (universal strips of acetate foil, Italy). Each mold was then compressed between two glass slides to remove excess material and obtain a flat surface. The surfaces of all samples were polymerized for 10 s on each side with a plasma Arc light cure Unit (Plasma STAR MONITEX SP-2000 light cure system, 2250 ± 5 mW/cm$^2$ power density, Taiwan). The cured specimens were removed from the mold, and the top surfaces were polished with a super-snap-Rainbow technique Kit (Shofu Inc., Kyoto, Japan). The bottom surfaces were left unfinished. The disc thicknesses were measured using digital caliper (Electronic Digital Caliper – 150 mm 6” Digital Caliper Vernier Gauge Micrometer). All procedures were carried out by the same operator at room temperature (23 °C). All sample discs were immersed in distilled water for 24 h and then the color values were recorded using a digital spectrophotometer (Vita Easyshade, Compact, Vita, Zahnfabrik, Bad Sackingen, Germany). Color measurements were performed by positioning the specimens on a white background to prevent

**Table 1** The used restorative dental materials.

| Group | Product name | Manufacturer | Composition type | Lot number | Filler size | Filler (wt%) |
|---|---|---|---|---|---|---|
| 1 | Tetric EvoCeram | Ivoclar Vivadent Liechtenstein | Resin-based dental restorative material | M47698 | 550 nm | 75–76% |
| 2 | Arabesk | Voco GmbH Germany | Microhybrid resin based dental restorative | 1005237 | 0.05 μm 0.5–2 μm | 76.5% |
| 3 | Charisma | Heraeus Germany | Universal micro glass composite | 010329 | 0.02–2 μm 0.02–0.07 μm | 77% |
| 4 | Beautifil II | Shofu Inc. Japan | Fluoride releasing dental restorative material | 030978 | 0.01–4 μm 0.8 μm | 83.3% |
| 5 | Estelite ∑Quick | Tokuyama Dental Japan | Submicron filled composite resin | E459 | 0.1–0.3 μm | 82% |

potential absorption effects. Three measurements were taken with the active point of the spectrophotometer in the center of each specimen. The instrument automatically averaged the three readings and this average reading was subsequently used for data analysis. After initial color measurements, five sample discs from each composite group were immersed in 30 ml of blue food coloring solution for 7 and 21 days, while the remaining five sample discs were left in 30 ml of distilled water as a control. Blue food color was chosen based on a previous study (Sarkis, 2010) that concluded that blue and green colors stain composites more than other colors.

Before each series of measurements, the spectrophotometer was calibrated according to the manufacturer recommendations using the supplied white calibration standard. The color measurements were done before immersion and after 7 and 21 days immersion. Each specimen was dried using blotting paper before color measurement. The color difference ($\Delta E$) was calculated for each sample using the following equation: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]$ ½, where "L" namely white-black, "a" red-green, "b" yellow-blue. The color change data were statistically analyzed using paired $t$-tests within the same composite group and unpaired $t$-tests between composite groups. For all statistical tests, a result was considered statistically significant at $\alpha = 0.05$. All statistical calculations were carried out by Microsoft Excel (version 7).

## 3. Results

Table 2 shows the mean color changes ($\Delta E$) and standard deviations (SD) for the five composite groups after immersion in distilled water for 24 h. All mean color change values were below 0.575. These data were used as baseline values to measure the color change of samples after immersion in blue food color solutions for 7 and 21 days.

The mean $\Delta E$ values of the five different composite groups without surface finishing after immersion for 7 and 21 days in food color solutions are shown in Fig. 1. The largest color change occurred in the Beautifill II, while the Tetric EvoCeram demonstrated the smallest color change over the same time period. $\Delta E$ ranged from 0.96 (Tetric Evo Ceram after 7 days immersion) to 4.9 (Beautifill II after 21 days immersion). Large color changes occurred with Beautifill II and Charisma, while smaller color changes were observed for Tetric Evo Ceram and Arabesk.

Fig. 2 shows the mean $\Delta E$ values of color change of the five composite groups with surface finishing after 7 and 21 days of immersion in food color solutions. Large color changes occurred in the Beautifill II, while smaller color changes were observed for the Arabesk. $\Delta E$ ranged from 0.4 (Arabesk after 7 days immersion) to 3.86 (Beautifill II after 21 days immersion). Large color changes occurred with Beautifill II, while smaller color changes were observed for Arabesk.

$\Delta E$ were less than 3.2 for all groups (finished and unfinished surfaces) after 7 days of immersion in the color food solution. Larger color changes occurred in groups without finished

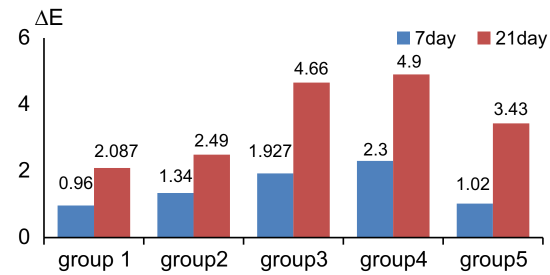


**Figure 1** Mean values of color change ($\Delta E$) of all groups (without surface finishing) after immersion in blue food color solution on 7th day and 21st days.

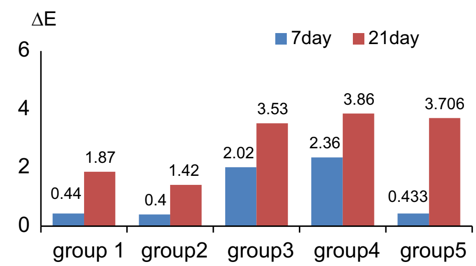


**Figure 2** Mean values of color change ($\Delta E$) of all groups (with finished surface) after immersion in food color solution on 7th day and 21st days.

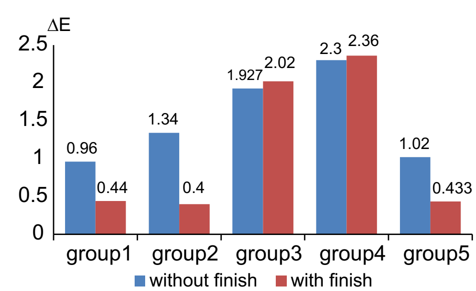


**Figure 3** Mean values of color change ($\Delta E$) of all groups after immersion in food color solution on the 7th day.

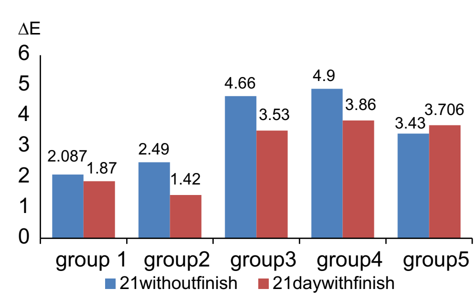


**Figure 4** Mean values of color change ($\Delta E$) of all groups after immersion in food color solution on the 21st day.

**Table 2** Mean values of color change ($\Delta E$) of all groups after immersion of specimens in distilled water for 24 h.

| Specimens | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 |
|---|---|---|---|---|---|
| Without surface finishing means (±SD) | 0.51 ± 0.226 | 0.5 ± 0.2 | 0.437 ± 0.228 | 0.45 ± 0.25 | 0.4 ± 0.206 |
| With surface finishing means (±SD) | 0.45 ± 0.193 | 0.45 ± 0.218 | 0.25 ± 0.194 | 0.575 ± 0.238 | 0.425 ± 0.294 |

surfaces, while groups with finished surfaces had smaller color changes after both 7 and 21 days immersion (Figs. 3 and 4). After 21 days, $\Delta E$ were less than 3.2 for Tetric Evo Ceram and Arabesk for both finished and unfinished surfaces while $\Delta E$ were more than 3.2 for Estelite $\sum$Quick, Charisma, and Beautifill II for both finished and unfinished surfaces. Comparison of the mean $\Delta E$ values after 7 days immersion with $\Delta E$ values after 21 days immersion, confirmed increases in $\Delta E$ over the time period for all groups. The results showed significant differences for samples with and without finishing after immersion in food color solutions for 7 days for the same composite type. No significant differences were observed between all groups after immersion in food color solution for 21 days.

## 4. Discussion

Several studies have reported discoloration of dental composites by colored solutions (Um and Ruyters, 1991; Türkün and Türkün, 2004; Sarkis, 2010). It has been found that the failure or success of any restoration depends on the color match and color stability of the aesthetic materials. The extent of discoloration has been shown to depend on the material, test method, curing time, curing device and aging conditions (Buchalla et al., 2002; Janda et al., 2005, 2007). In this study, five resin-composite restorative materials (shade A2) were selected to investigate color change. The selected shade was a universal color for all materials according to Uchida et al. (1998). Shade A2 is a light composite shade and therefore is susceptible to greater color changes.

Equal irradiance of all material was applied using a plasma Arc light cure unit, regardless of instructions from the manufacturers.

Smoother resin composites are more comfortable for the patient (Jones et al., 2004) and increased surface roughness leads to staining in vitro studies (Yu et al., 2009). For these reasons, the samples were finished and polished using a handpiece and soflex disks.

According to the study of Ferracane and Condon (1990), specimens were immersed in distilled water for 24 h after curing in order to elute unreacted components from the composite and allow for post irradiation and post-setting polymerization to occur (Yap et al., 1997; Stoddard and Johnson, 1999; Ferracane and Condon, 1990; Gürdal et al., 2002).

In this study, Vita Easyshade was used because it has both reliability and accuracy values greater than 90% according to the study by Kim et al. (2009).

In the present study, $\Delta E$ values greater than or equal to 3.3 were considered clinically perceptible, based on previous reports (Brook et al., 2007). $\Delta E$ values less than 1 were regarded as not detectable by the human eye. Color differences of $3.3 > \Delta E > 1$ may be detectable by a skilled operator but were considered clinically acceptable. On the other hand, values of $\Delta E > 3.3$ would be detectable by non-skilled persons and were therefore considered clinically unacceptable (Miyagawa et al., 1981; Um and Ruyters, 1991).

Color differences were imperceptible and clinically acceptable when composite resins were immersed in distilled water for 24 h. This observation confirms that water sorption by itself did not alter the composite color in agreement with Burrow and Makinson (1991).

In the current study, the greatest color change was observed for Beautifill II after 7 and 21 days of immersion in blue food color solution. Beautifill II releases fluoride and as a water soluble component that leaches out after immersion in an aqueous solution. This might have effect on the color stability according to Iazzetti et al. (2000) during the 7 day period.

Although $\Delta E$ was less than 3.3 for all surfaces with and without finishing and for composite types, there were significant differences between finished and unfinished surfaces for each composite type after 7 days of immersion. In contrast, there were no significant differences between finished and unfinished surfaces for each composite type after 21 days immersion.

$\Delta E$ were more than 3.2 for Estelite $\sum$Quick, Charisma, Beautifill II on finished and unfinished surfaces, while $\Delta E$ for Tetric Evo Ceram and Arabesk on finished and unfinished surfaces were less than those for the other composites.

## 5. Conclusions

This study has shown that the finished surfaces of the composites tested showed less coloration than unfinished surfaces after 7 days immersion, while finished and unfinished surfaces were both highly colored for all composites after 21 days immersion. Therefore, we conclude that under our study conditions, the color stability of all materials was affected. In particular, the color changes were within the clinically acceptable range after 7 days but not after 21 days for all groups. Finishing of the composite surface affected the color stability after 7 days, but not after 21 days. For these reasons, the dental restorative materials tested here are not color stable.

## Ethical Statement

There is no ethical issue regarding this study.

## Conflict of interest

No conflict of interest declared.

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