Effect of Composite Color and Thickness on Correction of Tooth Discoloration

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Abstract

Objective: Selection of an appropriate shade of composite is critical in achieving an esthetic restoration. Different systems are used to assess and describe color parameters. This study aimed to assess the effect of color and thickness of Filtek Supreme (FS) and Premise (P) composite resins on correction of tooth discoloration.

Methods: In this *in vitro* experimental study, 10 anterior teeth with Vita A2 color shade were selected. Composite specimens were fabricated in 0.5 and 0.75 mm thicknesses of FS and P composites. Intact teeth, prepared teeth, prepared teeth with enamel and dentin composite discs on their buccal surfaces, stained teeth and stained teeth with composite discs were photographed using a digital camera under standard conditions and color change (ΔE) at different phases was calculated.

Results: The L*, a* and b* color parameters in prepared and unstained teeth were not significantly different from those of intact teeth. In stained teeth, the L* parameter only in prepared and stained teeth with 0.75mm P composite was not significantly different from the L* parameter in intact teeth. Significant differences were seen in other stained teeth. The a* and b* parameters only in prepared and stained teeth with 0.5 mm FS composite were significantly different from those in intact teeth. By increasing the thickness of composite, the color change in comparison with intact teeth decreased in both groups.

Conclusion: The results showed that the effect of type of composite, its thickness and their interaction on the color change was significant when using FS and P composites in 0.5 and 0.75mm thicknesses in comparison to intact teeth and the lowest color difference with intact teeth was achieved using 0.75mm thickness of P composite (enamel and dentin).

Key words: Color change, Composite resin, Dental restoration, Discolored teeth, Thickness.

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Introduction:

Esthetics is among the main reasons behind many dental restorations. The color match of composite restorations with natural teeth must be good enough not to be noticed by the ordinary people. Shade selection of composites plays a critical role in achieving an esthetically excellent restoration (1). Color detection may be done by subjective visual judgment using a color shade guide or measurement of color parameters via colorimetry, spectrometry or use of digital images (2). In visual technique using a color shade guide, some differences were found between some composites and shade guide color samples (3-5). Visual judgment is commonly used in dental clinical setting to detect small differences in color (6, 7). In this method, to achieve more reliable results, the effect of some confounders such as light source, metamerism, experience, age, tiredness and color blindness may be controlled for. Kim and Um (1996) reported that most shade guide systems cannot accurately determine the color shade of composites since they are made of acrylic resins (8).

Another method to visually determine the color of composites is to compare the tooth color with the color of restorative material. In this method, a small amount of composite resin is placed on the tooth surface and polymerized and the color match of the tooth and polymerized composite is evaluated (8, 9). This method is particularly efficient when the background color has a direct effect on the final color of composite resin since this method allows for direct contact of composite with the background tooth structure. Light curing is necessary in this method since polymerization changes the restorative materials (9, 10). The drawback of this technique is the time required for polymerization of tooth-colored restorative materials (8). However, if the color and translucency of composites are not changed during polymerization, this step will not be necessary and time will be saved.

Different color systems have been used to describe color parameters among which, Munsell and CIE are the most commonly used systems. The Munsell system uses hue, value and chroma while in more recent CIE systems like CIE L* (a*b*), three parameters of a, b and L are used for color description. Color change in this system is calculated using ΔE. It has the advantage of comparing the change in color three-dimensionally (2). The current *in vitro* study sought to assess the effect of color and thickness of FS and P composites on correction of tooth discoloration.

Methods:

This laboratory experimental study used 10 anterior teeth stored in distilled water to prevent dehydration. The inclusion criterion was tooth color matching with Vita shade guide.

Filtek Supreme (3m ESPE, St. Paul, MN, USA) and Premise (SDS, Kerr, Orange, CA, USA) composite resins in two types of enamel and dentin composites were used in this study.

For specimen fabrication, plastic rings with 0.5 and 0.75mm depths were placed on glass slabs. The respective composite was applied into the rings. Another glass slab was placed on top of them and a 5kg weight was placed over the glass slab for 3 minutes to obtain a uniform thickness of composite (Figure 1).

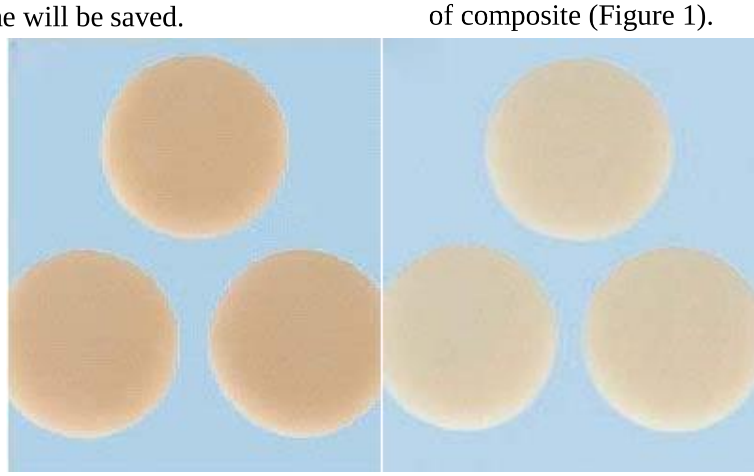

Figure 1- Discs fabricated of FS and P enamel and dentin composites

All specimens were light cured for 40 seconds (VSI, AriaLux, Iran) with an intensity of 400 mW/cm^2. The output of the unit was checked each time the device was used using a radiometer.

The specimens were subjected to the following steps:

Step 1. Color of intact teeth stored in distilled water was compared with A2 Vita shade.

Step 2. The buccal surfaces of the teeth were ground using abrasive discs for better adaptation of composite discs on the surface.

Step 3. A2 shade enamel and dentin composite discs of each type were placed on the buccal surfaces of the teeth. Enamel and dentin discs of FS and P composites with 0.5 mm thickness were placed together (enamel on top of dentin) to reach a thickness of 1 mm. The same was done for 0.75 mm discs to reach a thickness of 1.5mm. Glycerin gel was applied in-between composite discs. By doing so, the layering technique was simulated.

Step 4. The teeth were prepared as in step 2 and stained using the Sulieman method (11). Two grams of black tea (Golestan, Iran) were boiled in 100cc of distilled water for 5 minutes. The specimens were immersed in this solution for one week. The solution was refreshed daily. After completion of one-week period, the specimens were rinsed under running water and immersed in distilled water. The index for staining of teeth was the L* parameter, which was considered to be in the range of $65 \leq L \leq 85$ (11).

Step 5. Composite discs were placed on the buccal surfaces of stained teeth as described in step 3.

Step 6. Digital photographs were obtained of A2 Vita shade guide.

Specimens in different groups were photographed using a digital camera (Canon Power Shot G12, Canon Inc., Japan) with a macro lens under standard conditions. Specimens were fixed against a dark background at 25 cm distance from the camera and positioned right in the middle of camera visor; 18% gray card (White Balance, USA) was placed in the corner for matching (Figure 2) since even with maximum standardization, difference in photographs is inevitable. The gray card reflects 18% of the light. Gray card is a neutral target with equal amounts of red, blue and green colors. Since the gray card has certain amounts of color values, by calculating the color values in the image and their comparison with the main color values, color mismatch in the entire image can be corrected. Photographs were taken in a dark room. Two lamps (6500 K°, OSRAM, Germany) lit the specimen surface at the two sides with a 45° angle. The camera was adjusted at A position, with 1:1 magnification, no flash light and ASA100.

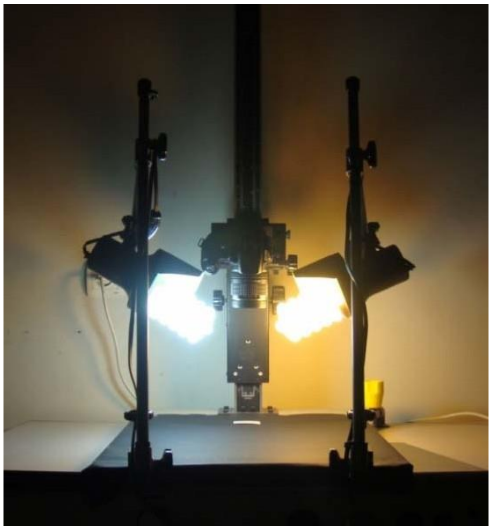

Figure 2-The camera and photographing under standard conditions

After photographing, the images were transferred to a computer and evaluated using Adobe Photoshop 9.0 software. This is a standard software program for image editing, visualization and color measurement. To obtain comparable images in terms of brightness, this parameter was adjusted on medium (L=54).

For the conversion of Lab values to CIE Lab in Adobe Photoshop software, it should be noted that the range of these values is different in the two systems. The spectrum of change of b, a and L parameters in Adobe Photoshop 9.0 ranges from zero to 255. But, in the CIE L*a*b* color system, L* ranges from zero to 100 and a* and b* range from -120 to +120. Thus, to convert values to CIE system, the following formula was used (12):

$$L\times = L \times \frac{100}{255}$$

$$a\times = (a - 128) \times \frac{240}{255}$$

$$b\times = (b - 128) \times \frac{240}{255}$$

ΔE was calculated using the equation below:

$$\Delta E = \sqrt{(\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2}$$

To compare Lab parameters and ΔE, repeated measures ANOVA and for pair wise comparisons, Bonferroni method were used. Type one error (α) was considered as 0.05.

Results:

A total of 10 teeth were evaluated in different steps. L*, a* and b* parameters in different teeth were evaluated using descriptive statistics (Table 1).

Table 1- Descriptive statistics for color parameters

	Mean (SD) of L*	Mean (SD) of a*	Mean (SD) of b*	Mean (SD) of ΔE
Intact tooth	96.15 (1.34)	-0.74 (0.09)	9.94 (1.83)	-
Prepared tooth	95.2 (1.66)	-0.68 (0.12)	9.42 (1.67)	2.08 (0.58)
Prepared tooth+ FS (0.5mm)	94.37 (1.32)	-0.78 (0.14)	8.97 (1.62)	1.71 (0.66)
Prepared tooth+ FS (0.75mm)	94.99 (1.28)	-0.58 (0.59)	9.62 (1.45)	1.29 (0.54)
Prepared tooth+ p (0.5mm)	94.57 (1.49)	-0.61 (0.71)	9.35 (1.93)	1.6 (0.57)
Prepared tooth+ p (0.75mm)	95.59 (0.79)	1.06 (3.29)	10.47 (1.96)	1.17 (0.49)
Prepared and stained tooth	74.72 (3.41)[a]	29.31 (3.27)[b]	36.98 (4.69)[c]	43.88 (6.62)
Prepared and stained tooth+ FS (0.5mm)	86.46 (3.54)[a]	5.31 (6.39)[b]	17.03 (4.97)[c]	27.05 (5.88)[d]
Prepared and stained tooth+ FS (0.75mm)	91.34 (2.43)[a]	2.74 (2.51)	13.27 (1.35)	4.92 (1.27)
Prepared and stained tooth+ p (0.5mm)	90.55 (3.05)[a]	2.89 (3.95)	13.38 (2.48)	16.31 (1.42)[d]
Prepared and stained tooth+ p (0.75mm)	94.3 (1.82)	2.34 (1.66)	11.99 (1.58)	3.01 (1.24)
A2 Vita shade guide	97.12 (0)	-0.49 (0.69)	8.97 (0)	-

*Superscripts indicate statistically significant difference.

Comparison of L* color parameter in different groups with repeated measures ANOVA revealed significant differences ($p<0.001$). To detect groups with a significant difference in L* parameter, Bonferroni test was applied. The results of this test regarding L* color parameter revealed that the differences between intact teeth with prepared and stained teeth, prepared and stained teeth+ FS composite with 0.5mm thickness (enamel and dentin), prepared and stained teeth + 0.75mm FS composite (enamel and dentin) and prepared and stained teeth + P composite with 0.5mm thickness (enamel and dentin) were significant ($p<0.001$ for all). In other comparisons, no significant difference was found.

Comparison of a* color parameter revealed significant differences between the intact teeth and other groups ($p<0.001$). Pair wise comparison of this parameter revealed that the difference between intact teeth and prepared and stained teeth and also prepared and stained teeth with 0.5mm FS composite (enamel and dentin) was significant ($p<0.001$); no other significant differences were noted.

Comparison of b* color parameter revealed significant differences between intact teeth and other groups ($p<0.001$). The difference between intact teeth and prepared and stained teeth and also prepared and stained teeth with 0.5mm FS composite (enamel and dentin) was significant ($p<0.001$) and no other significant differences were found.

Comparison of ΔE of intact teeth with that of teeth in different groups revealed a significant difference between intact teeth and prepared and stained teeth with 0.5mm of FS and P composites ($p<0.001$).

Discussion:

This study aimed to assess the effect of color and thickness of P and FS composites on correction of discolored teeth using digital photography. This method is suitable due to its easy use and the ability to standardize all factors that can affect the results. Also, this method does not have the difficulty and high cost of spectrophotometry.

Another positive point in this study was using image-editing software that matches all images with similar lighting conditions. The difference between this software and spectrophotometry is that in the software, the respective color parameters are determined in a specific frame; while in spectrophotometry, only the parameters of specific points are determined. Digital camera has been used in many studies for evaluation of color parameters (13-17).

In this study, the teeth were visually evaluated and compared with Vita shade guide. Next, the intact teeth and A2 Vita shade guide were digitally photographed. The difference in ΔE between the two was not significant. Dietschi, *et al*. (2006) used visual inspection and showed that the mean L*, a* and b* parameters were not significantly different in teeth in Vita groups A and B. For selection of teeth in Vita groups, visual observation was the main factor and L*, a* and b* parameters played no role in selection of Vita groups (18).

Tea has been used for external staining of teeth in many studies and its reproducibility has been confirmed by spectrophotometry (11, 19). Also, tea as a chromogen is capable of causing internal discoloration in teeth similar to what occurs in the oral cavity. Following the use of tea, significant changes occurred in L*,a* and b* parameters. Changes in L* parameter indicate darkening of teeth and changes in a* and b* indicate color progression towards red and yellow, respectively. It appears that these changes occur due to polyphenolic chromogens present in tea including thearubigins and theoflavins yielding red and yellow colors (20).

Comparison of L* color parameter revealed that the differences between intact teeth and prepared and stained teeth, prepared and stained teeth+ FS composite with 0.5mm thickness (enamel and dentin), prepared and stained teeth + 0.75mm FS composite (enamel and dentin) and prepared and stained teeth + P composite with 0.5mm thickness (enamel and dentin) were significant ($p<0.001$ for all). In other comparisons, no significant difference was found. It means that the L* parameter in other groups was close to that of intact teeth and P composite with 0.75mm thickness (enamel and dentin) was capable of correcting the L* parameter in discolored teeth. For a* and b* color parameters, significant differences were found in comparison of intact teeth with prepared and stained teeth and prepared and stained teeth with 0.5mm of FS composite (enamel and dentin). No other significant differences were noted. It means that a* and b* parameters in other groups were close to those of intact teeth and FS composite with 0.75mm thickness (enamel and dentin) and P composite with 0.5 and 0.75 mm thicknesses (enamel and dentin) were capable of correcting the a* and b* parameters of discolored teeth.

Vichi, *et al*. in 2007 stated that increased thickness of composite layers decreased the translucency of the final restoration (21). This result is in accord with our finding. In our study, staining of teeth significantly changed the color parameters. By increasing the thickness of composite over the stained area, opacity increased and these parameters returned to their baseline values. Other studies have stated that thickness of a restoration can affect its appearance. When thickness of a composite restoration increases on a white sheet, the value and hue decrease. The most significant change due to increased thickness of composite is its increased opacity (22).

The results of the current study showed that in all cases, the difference in ΔE of intact teeth and that of all other groups was statistically significant. Ruyter, *et al*. in 1987 showed that in the clinical setting, human eye can perceive $\Delta E \geq 3.3$ (23). Thus, $\Delta E < 3.3$ would be suitable for color matching of composites. In our study, the ΔE of intact teeth with prepared teeth and prepared teeth with FS and P composites in 0.5 and 0.75mm thicknesses was less than 3.3 and thus, not detectable with the naked eye. In prepared and stained teeth with P composite in 0.75mm thickness, ΔE was less than the value detectable with the naked eye.

Our results showed that although significant differences were detected in ΔE of intact teeth and that of other groups, the mean change in color of teeth with FS composite with 0.5 mm thickness was significantly higher than that of P composite with 0.5 mm thickness (27.05 versus 16.31). The mean ΔE when using 0.75mm thickness of FS composite was higher than that of 0.75mm thickness of P composite compared to intact teeth (4.92 versus 3.01); however, this difference was not as much as that in 0.5 mm thicknesses of the two composites and not significant. This difference may be due to the different composition of the two composites. The color of layered tooth-colored restorative materials depends on all their constituents and each of the constituents affects the color of the final restoration (24).

Accordingly, many of the composite constituents such as the initiator, activator, inhibitor, stains and resin matrix are susceptible and subject to color change (25, 26). FS composite contains a combination of zirconia and silica fillers measuring 20nm in size and the particle sizes range from 5-20 nm. Also, Premise composite has tri-modal fillers that enhance the efficacy of this composite. It contains barium filler particles 0.4 micron in size with a weight percentage of 84% mixed with nanoparticles. This increases the polish ability and glossiness of this composite. Addition of pre-polymerized filler particles (PPF) has improved the physical characteristics of hybrid composites. Kawaguchi, *et al*. (1994) reported that some hybrid composite resins, due to the incorporation of components of different sizes, have low transmission coefficient, which affects the color of composite (27). Also, Campbell, *et al*. in 1986 showed that in polymethyl methacrylate composite resins, light scattering in quartz fillers decreases by an increase in filler size (28). Clearly, use of matrix components and filler type, filler volume, initiators and coupling agents can all affect the color and translucency of composite resins (29). Other possible factors playing a role in this regard include chemical degradation, oxidation of unreacted carbon double bonds, accumulation of stains, dehydration, microleakage, inadequate bond and surface roughness (30). Thus, the difference in color of P and FS composites may be due to the above-mentioned factors.

The results of this study showed that by increasing the thickness from 0.5 to 0.75 mm in FS and P composites, the difference in color of specimens with intact teeth decreased from 27.05 (in comparison of intact teeth and stained teeth with 0.5mm thickness of FS composite) to 4.92 (in comparison of intact teeth and stained teeth with 0.75mm thickness of FS composite). In teeth with P composite, this value decreased from 16.31 (in comparison of intact teeth and stained teeth with 0.5mm thickness of P composite) to 3.01 (in comparison of intact teeth and stained teeth with 0.75mm thickness of P composite). The results of Arikawa, *et al*. in

1999 also indicated an increase in color difference of specimens by decreasing their thickness (31).

Conclusion:

The current study results showed that the effect of type of composite, its thickness and their interaction on the color change was significant when using FS and P composites in 0.5 and 0.75 mm thicknesses in comparison to intact teeth.

The lowest color difference with intact teeth was achieved in restoration with P composite at 0.75mm thickness (enamel and dentin). By increasing the thickness, the color difference with intact teeth decreased in both groups.

Conflict of Interest: "None Declared"

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