Original Article

J Babol Univ Med Sci
Vol 18, Issu 9; Sep 2016. P:14-19

Comparing Color Change Value of Three Types of Composite Resins in Distilled Water during the First 24 Hours after Exposure to Light

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J Babol Univ Med Sci; 18(9); Sep 2016; PP: 14-19

Received: Apr 25th 2016, Revised: Jun 1st 2016, Accepted: Jul 27th 2016.

ABSTRACT

BACKGROUND AND OBJECTIVE: Color change of composite resin restorations is one the most common causes for replacing these restorations, which might occur due to internal and external factors. This research was carried out to study and compare color change value of three types of composite resins in distilled water during the first 24 hours after exposure to light.

METHODS: In this laboratory research, 120 samples were prepared from three types of composites (Z350, Z250 and Heliomolar) and were divided into 3 groups of 40. Samples with 2 mm thickness and 7 mm diameter were prepared. After assessing the initial color by spectrophotometer, samples were exposed to distilled water for 1, 6, 12 and 24 hours, respectively. Then, the final color was assessed by EasyShade device and the color change value (ΔE) was calculated for all samples. Moreover, $\Delta E<3.3$ was clinically acceptable.

FINDINGS: In 12h group, Heliomolar composite showed lowest color change value compared with two other composites (Z350=1.385, Z250=1.179 and Heliomolar=0.854) ($p<0.05$), while no significant difference was observed in other groups. Furthermore, lowest color change value in each composite was observed 1 hour after curing (Z350=0.352, Z250=0.641 and Heliomolar=0.298) and color change value increased 24 hours after curing (Z350=1.888, Z250=1.903 and Heliomolar=1.929).

CONCLUSION: Results of the study revealed that color change value of all three composites in distilled water was less than 3.3 after 24 hours and it was clinically acceptable.

KEY WORDS: *Composite resin, Color change, Spectrophotometer, Distilled water.*

Please cite this article as follows:

Afkhami S, Abolghasemzade F, Esmaeili B, Khafri S. Comparing Color Change Value of Three Types of Composite Resins in Distilled Water during the First 24 Hours after Exposure to Light. J Babol Univ Med Sci. 2016;18(9):14-19.

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[DOR: 20.1001.1.15614107.1395.18.9.2.2]

[DOI: 10.22088/jbums.18.9.14]

Introduction

Dental composite resins are types of synthetic resins which are commonly used in dentistry as restorative material and their use has increased due to development of composites and improvement of their physical and chemical properties in recent years (1). Color stability is one of the key factors that determine the acceptability of tooth colored restoratives (2). Color change of composite restoratives is a reason to replace them which worries patients and dentists while wasting a lot of time and money. As time goes by, the color of resin restorative materials changes under the influence of different foods (3), which might occur due to internal and external factors. Internal factors include incomplete polymerization of composite resin or long-term exposure to water, whereas external factors include exposure to coffee, tea, nicotine-rich foods, alcoholic drinks and etc.

Moreover, the effect of these chromatic materials on composite resins depends on the internal characteristics of composite such as chemical composition (4). Composite resins are categorized based on their size, composition and type of filler as well as physical and mechanical properties (5). Three groups of composites widely used today include microfill composites, microhybrid composites and nanocomposites. Although recent improvements in producing composite resins such as increased filler content, reduced diameter of filler particles and increased hydrophobic properties might increase the resistance of these materials to color change, color stability of composites is still a major problem (6). The relationship between color stability of composites and conversion rate is a proven relationship. Therefore, incomplete polymerization decreases the mechanical properties of composites and increases the color change value of composites. It has been reported that about 70% of polymerization occurs in the first 10 to 15 minutes after curing (7).

However, the polymerization process continues for hours and the maximum polymerization occurs after the first 24 hours (3, 4). Time is a key factor in color change of composites. In several studies, color change of composites in distilled water has been observed after 24 hours (3, 5 and 6) but color change during the first 24 hours after curing cannot be recognized. Color change of dental materials can be assessed by visual or instrumental techniques. However, color evaluation by visual comparison may not be a reliable method. There are various systems for this task including: colorimetry, spectrophotometry and digital image analysis, among which spectrophotometry is the most reliable technique in dentistry studies (8). VITA Easyshade is a spectrophotometry device which was used our study. According to a report by Kim Pusateri et al., accuracy and reliability of VITA Easyshade in measuring color is more than 90% (9).

Easyshade reports the color of samples based on CIE L*a*b* color system. CIE L*a*b* color system is the most common international method used for dental purposes. This system identifies colors with three factors of L, a and b; L indicates transparency value, a indicates green-red value and b indicates yellow-blue value (10, 11). Hence, color change of resin composites was assessed and compared at various moments during the first 24 hours after curing.

Methods

This experimental study was carries out using 120 composite samples in lab environment. Composite samples were of three types: microhybrid (3M ESPE Filtek Z250, USA), nanofill (3M ESPE Filtek Z350, USA) and microfill (Heliomolar, Ivoclar/Vivadent, Liechtenstein) in A3 shade (table 1).

40 disc-shaped samples with 2 mm thickness and 7 mm diameter were prepared from each composite using a plastic mold. In order to prevent air retention and to have flat surface, composite samples were pressed from two sides by a 1 mm glass coverslip after being placed in the mold. In addition, samples were light cured for 20 seconds by VALO LED curing light (ultradent, USA) with 1000 mW/cm2 intensity according to manufacturer instructions. After coming out of the generator, samples were exposed to light for another 20 seconds from the other side. The surface of samples was finished and polished by 600, 800 and 1200 grit silicon carbide paper.

The initial color was assessed by Easyshade spectrophotometer (VITA Zahnfabrik, Germany) on a standard white background. This device calculated and recorded L* (Values indicator), a* and b* (Chroma indicator) indices for all samples based on CIE Lab system. Afterwards, samples of each composite were divided into 4 subgroups of 10. Color determination was done for each group before placing them in distilled water. Samples of the first, second, third and forth group were exposed to distilled water for 1, 6, 12 and 24 hours, respectively. After washing and drying, the color of samples was assessed by Easyshade

[DOR: 20.1001.1.15614107.1395.18.9.2.2]
[DOI: 10.22088/jbums.18.9.14]

device. Then, color change value was calculated by this formula: $\Delta E=\sqrt{(\Delta a)^2+(\Delta b)^2+(\Delta l)^2}$. Moreover, $\Delta E<3.3$ was clinically acceptable. The collected data were analyzed using SPSS 22 software, one-way analysis of variance (ANOVA) and Tukey's test and $p<0.05$ was considered significant.

Results

After exposure to distilled water, color change value of Z350 composite was different at various time intervals and increased over time. This value increased from 0.352 after 1 hour to 1.888, 24 hours after curing (p=0.00). Color acceptance value of 6h group (0.756) increased compared with 1h group (0.352) but it was not statistically significant. Color change value of Z250 composite was also different after exposure to distilled water at various time intervals ($p<0.05$) and increased over time. However, color change value in 6h group (0.875) was not significantly different from 1h group (0.641). Moreover, difference in color change value of this composite after 6 hours (0.875) and 12 hours (1.179) after curing was not statistically significant. Color change of Heliomolar composite was also different after exposure to distilled water at various time intervals ($p<0.05$) and increased over time. Color change value increased from 0.298 after 1 hour to 1.929 after 24 hours (p=0.00). However, color change value in 12h group (0.854) was not significantly different from 6h group (0.701).

A comparison between composites at various time intervals demonstrated that color change value of Z250 composite after 1 hour (0.641) and after 6 hours (0.875) was higher than Z350 and Heliomolar composites but this difference was not statistically significant (Fig 1). In 12h group, Heliomolar composite (0.854) revealed less color change compared with Z350 composite (1.385) (p=0.00) and Z250 composite (1.179) (p=0.04), which was statistically significant. In 24h group, color change value of Z350, Z250 and Heliomolar composites was 1.888, 1.903 and 1.929, respectively, while lowest value belonged to Z350 composite. However, this difference was not statistically significant (table 2).

Table 1. Specifications of composites under study in 3A color

Ingredients	Manufacturer	Product no.	Type of composite
Bis-GMA,Bis-EMA,UDMA, TEGDMA, Zirconia/silica (particle size:20-75 nm)	3M ESPE	701063	Z350
Bis-GMA,Bis-EMA,UDMA, TEGDMA, Zirconia/silica (particle size:0.01-3.5 μm)	3M ESPE	593673	Z250
Bis-GMA,UDMA,DDMA/colloidal silica,copolymer (particle size:0.04-0.2 μm)	Ivoclar vivadent	42313	Heliomolar

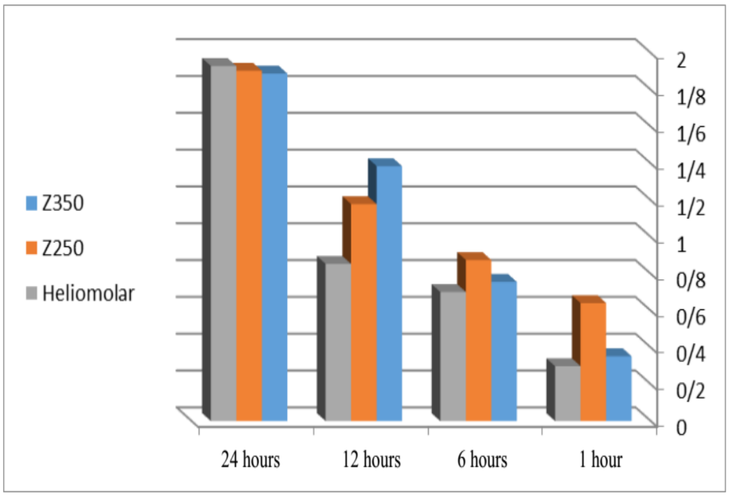

Figure 1 Comparing color change of different composites after exposure to distilled water at various time intervals

[DOI: 10.22088/jbums.18.9.14]
[DOR: 20.1001.1.15614107.1395.18.9.2.2]

Table 2. Comparing color change value of three types of composite at various time intervals

Composite / Time Intervals	Z350	Z250	Heliomolar	P-value
1 hour	0.352 ± 0.24^{a}	0.641 ± 0.49^{a}	0.298 ± 0.22^{a}	0.075
6 hours	0.756 ± 0.81^{ab}	0.875 ± 0.39^{ab}	0.701 ± 0.25^{b}	0.769
12 hours	1.385 ± 0.36^{c}	1.179 ± 0.19^{bc}	0.854 ± 0.27^{bd}	0.001
24 hours	1.888 ± 0.39^{ce}	1.903 ± 0.35^{e}	1.929 ± 0.48^{e}	0.975
P-value	<0.001	<0.001	<0.001	

Dissimilar letters indicate significant difference between groups at p<0.05 level

Discussion

In this study, color change value of three types of composite resins was assessed at various time intervals during the first 24 hours after curing. According to the results of this study, distilled water changes the color of composites and its value increases over time. However, it is clinically acceptable ($\Delta E<3.3$). Color change of dental materials can be assessed by visual or instrumental techniques.

However, color evaluation by visual comparison may not be a reliable method. There are various systems for this task including: colorimetry, spectrophotometry and digital image analysis, among which spectrophotometry is the most reliable technique in dentistry studies (8). VITA Easyshade is a spectrophotometry device used in the present study. According to a report by Kim Pusateri et al., accuracy and reliability of VITA Easyshade in measuring color is more than 90% (9). Easyshade reports the color of samples based on CIE L*a*b* color system. CIE L*a*b* color system is the most common international method used for dental purposes. This system identifies colors with three factors of L, a and b; L indicates transparency value, a indicates green-red value and b indicates yellow-blue value (10, 11).

After exposure to distilled water, color change value of samples in all groups was lower than 3.3, which was clinically acceptable. It seems that color acceptance value of composites is more influenced by physicochemical properties of resin matrix such as water absorption rate and hydrophilic property than surface properties of materials or value and size of filler particles. It is reported that hydrophilic materials show a higher rate of water absorption and therefore reveal more color change compared with hydrophobic materials. Color change of composites may depend on water absorption rate of resin matrix (3). Water absorption is basically caused by direct absorption of resin matrix of material and glass fillers cannot induce water absorption, though playing a role in water absorption by the surface of material. Water absorption rate depends on resin content of material and rigidity of resin/filler surface (12).

Due to water absorption, composite resins may be subject to plasticization of resin portion or silane hydrolysis and thus microscopic cracks over time. These cracks and gaps at the junction of filler and matrix allow penetration of chromatic materials and thus color change of composites (12, 3). Water absorption rate of composites depends on the value and type of resin as well as quality of the connection between filler and resin. Therefore, it seems that UDMA resin is more resistant to color than Bis-GMA resin and adding TEGDMA to resin compounds increases their color acceptance (3).

No similar study was carried out to investigate the effect of distilled water on color change of composites during the first 24 hours after curing. E-Silva et al., in a study on the effect of different drinks on color change of nanocomposites, have demonstrated that color change value of these composites, 1, 2, 4, 8 and 12 weeks after exposure to distilled water was clinically acceptable (5). In addition, results of the present study are in accord with results achieved by Salahalddin et al. and Bagheri et al. (13, 14).

These studies demonstrated that distilled water alone cannot induce clinically unacceptable color change. On the other hand, study of Malekipour et al. revealed unacceptable color change in composites, 24 hours after exposure to distilled water, which was attributed to increased water absorption and extrusion of distilled water from composite (12).

Difference between results of their study and the present study may be due to difference in type of composite and its chemical composition. It was also reported that composites with larger filler particles are more prone to water-induced color change and reveal

[DOR: 20.1001.1.15614107.1395.18.9.2.2]
[DOI: 10.22088/jbums.18.9.14]

higher color change value than composites with small filler particles (15). Presumably, longer exposure to water increases the cumulative effect of water on properties of composite, which explains why color acceptance of composites increases during the first 24 hours after curing. Since in this study and similar ones, color change of composites was only measured as they were exposed to distilled water, it is suggested that the effect of saliva, thermal changes and color solutions on composites be assessed. In this study, color change value of all three composites was lower than 3.3 after exposures to distilled water, which was clinically acceptable.

Acknowledgments

Hereby, we express our deepest sense of gratitude and indebtedness to Research & Technology Deputy of Babol University of Medical Sciences for his financial support.

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[DOR: 20.1001.1.15614107.1395.18.9.2.2]

[DOI: 10.22088/jbums.18.9.14]