Key Engineering Materials
ISSN: 1662-9795, Vol. 751, pp 636-642
doi:10.4028/www.scientific.net/KEM.751.636

Submitted: 2016-12-20
Revised: 2017-05-01
Accepted: 2017-05-04
Online: 2017-08-23

Effect of Bleaching on Color Change of Stained Resin Composites

Ratcha Raksakmanut[1a*], Ampaporn Nithipratheep[1b*], Ornjira Weeriyanan[1], Panida Pittayaporn[1], Waivich Komonpale[1], Trong Techakunakorn[1], Nuttaporn Luanprueg[1] and Jakgree Promserane[1]

[1]Faculty of Dental Medicine, Rangsit University, Thailand

[a]ratcha.r@rsu.ac.th, [b]ampaporn.ni@rsu.ac.th

Keywords: Bleaching, Staining, Resin composite, Coffee, Wine.

Abstract. The aim of this study was to evaluate the effects of bleaching on color change of stained resin composites. Ninety disk-shaped specimens were prepared with 3 different composite materials (Estelite ∑ Quick, Premise, and Filtek Z350 XT). After stored in artificial saliva at 37°C for 24 hours in an incubator, the 30 specimens of each material were divided into 3 subgroups and immersed in either coffee, red wine, or artificial saliva (control) at 37°C. After 24 days, spectrophotometric measurement was performed. After the staining process, the bleaching agent (Opalescence, 10% carbamide peroxide) was applied to the surface of the specimens, 8 hours per day for 14 days. After the bleaching process, spectrophotometric measurement was performed. The color differences between specimens before and after bleaching were statistically significant ($\Delta E^*ab>3.3$) for all composites in the red wine staining. The highest-level color change after bleaching was observed for Filtek Z350 XT in red wine staining, while the least value was found in Estelite ∑ Quick in coffee staining. In summary, color changes of all red wine-stained composites after bleaching were noticeable and have higher level of color change than coffee-stained composites.

Introduction

Resin composite is one of the most popular esthetic restorative material in dental clinical practice for conservative and non-invasive treatment. Manufacturers have introduced different shades for restorative materials, capable of fulfilling all the requirements for environment light sensitivity, depth of cure, and especially, color match and stability. As an esthetic restorative material, resin composite should mimic the appearance of natural tooth, and this fact is directly related to the material's color match and color stability [1].

Although great improvements have been achieved during recent years, one of the major disadvantages of resin composites is the tendency to discolor after prolonged exposure to the environment in oral cavity [2-3]. This disadvantage is one of the main reasons for replacement of restoration [4]. Discoloration of resin composites may be caused by intrinsic and extrinsic factors. Intrinsic factors such as incomplete polymerization, initiators, fillers, and pigments can affect the color stability of resin composite [5-6]. Extrinsic factors such as absorption of stains from foods and drinks may also cause discoloration [7-8]. Red wine and coffee have the highest staining potential compared to the other drinks [9].

Bleaching has been suggested as an efficient and non-destructive treatment for discoloration of the teeth [10-12]. Some studies showed that the discoloration of resin composite can be partially removed by bleaching [13-14].

The aim of the study was to evaluate the effect of bleaching on color change of three resin composite brands with different types and amount of chemical components, stained by high-staining potential drinks.

Materials and Methods

Preparation of Specimens

Compositions of resin composites used in the study are shown in Table 1. The A3 shade color was selected for this study because it is a widely acceptable shade color. In each group, there were thirty disk-shaped specimens (90 specimens in total). There were 3 groups which were Estelite ∑ Quick, Premise, and Filtek Z350 XT (E, P, and Z respectively). The 15 ml polystyrene syringes were cut into 90 molds with a height of 1 mm and a diameter of 13 mm using a low-speed cutting machine. Each mold was placed on a glass slide, and each resin composite was filled up into each mold evenly. Another glass slide was pressed down onto each mold and excessive resin composite was removed using a dental explorer.

All specimens were polymerized by LED light curing system (Demi, Kerr) with light intensity of 1,100-1,330 mW/cm^2 for 40 seconds. The radiometer was used for light intensity calibration before the light curing process. The end of the light cure tip (13 mm diameter) was placed in contact to the glass slide in order to control the standardized distance between the tip and the filled-in resin composite in each mold. Glass slide has a thickness of 1 mm.

Table 1. Compositions of resin composites used in the study

Product	Type of resin monomer	Type of filler (particle size)	% of filler		Manufacturer
			by weight	by volume	
Estelite Σ Quick	Bis-GMA, TEGDMA	**Suprananofilled** silica-zirconia filler and composite filler [0.2 μm]	82%	71%	Tokuyama, Tokyu, Japan
Premise	Bis-EMA, UDMA, TEGDMA	**Nanohybrid** barium glass filler [0.4 μm], nanocharges of silicate [0.02 μm], prepolymerized filler [30 - 50 μm]	84%	69%	Kerr Corporation, Orange, CA, USA
Filtek Z350 XT	Bis-EMA(6), UDMA, PEGDMA	**Nanofilled** silica [0.02 μm] zirconia [0.004 - 0.011 μm], aggregated zirconia/silica cluster filler [0.6 - 10 μm]	78.5%	63.3%	3M ESPE, St.Paul, MN, USA

Data from manufacturers

Experimental procedure

All specimens were contained in the polystyrene mold. Transparent tape was used to cover up the bottom side of each mold so that the specimens were stained only on one side.

All specimens were stored and immersed in artificial saliva for 24 hours at 37°C in order to ensure the fully completed polymerization before the experiment. After the immersion, each group was further divided into 3 subgroups. Therefore, each subgroup had 10 samples (n=10). Samples of the first subgroup of each group were immersed in 50 ml of coffee (Birdy® Robusta). Samples of the second subgroup of each group were immersed in 50 ml of red wine (Penfolds® Bin 2). Samples of the third subgroup of each group were the controlled samples, and were immersed in 50 ml of artificial saliva. Each container was sealed by plastic wrap to prevent evaporation of the staining solution.

All specimens were immersed continuously in the staining solutions specified above for 24 days in an incubator at 37°C. We renewed the staining solutions in all containers on the 12th day of immersion. After 24 days, the specimens were taken out from their container for color measurement

by a spectrophotometer (Ultrascan XE, Hunter Lab, USA) using CIELab color space. The color measurement at this stage was identified as 'Stained group' ($L_1a_1b_1$).

To investigate the effectiveness of bleaching, all of the 90 specimens were removed from the polystyrene composite molds. Then, the specimens were put into new molds for holding specimens during the bleaching process. New polystyrene molds with a height of 1.5 mm and a diameter of 13.0 mm allow a 0.5x13.0 mm space for bleaching agent to fill in.

All of the 90 specimens were bleached using 10% carbamide peroxide (Opalescence® PF 10%, Ultradent, USA). We applied the bleaching agent onto each specimen with a thickness of 0.5 mm, 8 hours a day for 14 days. After each session of 8 hours a day, all of the specimens were rinsed by distilled water to clean off the bleaching agent, dried with paper towel, and kept in artificial saliva stored in an incubator at 37°C until the next session.

The spectrophotometer was used to perform color measurement of each specimen. The measurement at this stage was identified as 'Bleached Group' ($L_2a_2b_2$). The degree of color variation, ΔE^*, between specimens before and after bleaching in the 3-D L*a*b* color space was calculated using the below equation:

$$\Delta E^* = [(L_2^*-L_1^*)^2 +(a_2^*-a_1^*)^2 +(b_1^*-b_0^*)^2]^{½}$$

$\Delta E^*_{ab} > 3.3$ was considered as clinically noticeable difference in this study [15-16]. T-test was used to determine whether the degree of color variation (ΔE^*_{ab}) of each subgroup before and after bleaching is statistically greater than 3.3. Two-way analysis of variance (ANOVA) tests were used to analyze the data. Bonferroni's test was also used for comparisons of color variation (ΔE^*_{ab}) of each subgroup.

Result

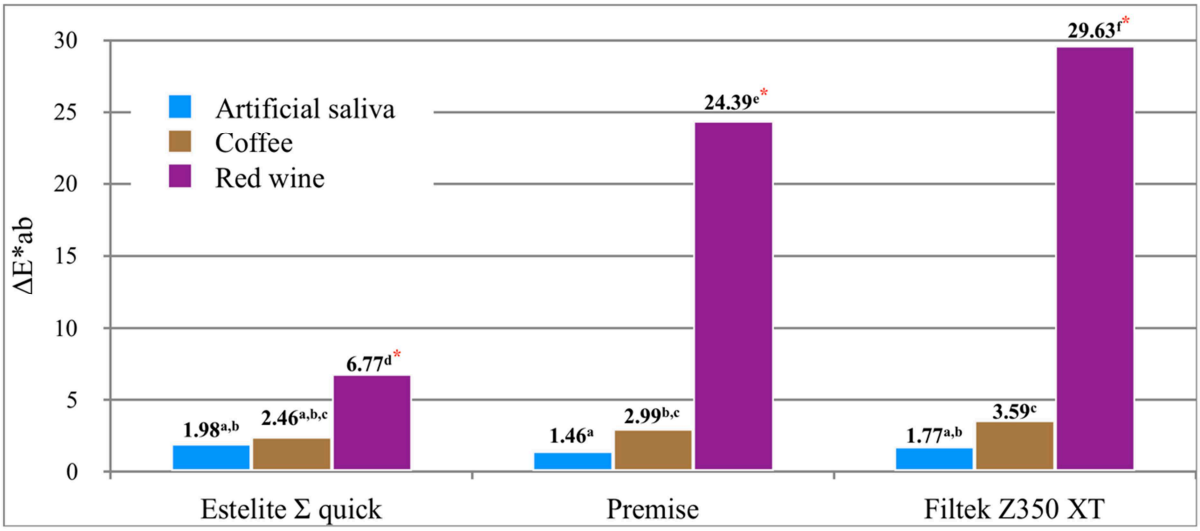
We can observe that color difference of stained resin composites before and after bleaching were noticeable for all resin composites immersed in red wine.

All specimens which were immersed in red wine and subsequently bleached had the value of ΔE^*_{ab} significantly higher than 3.3 (table 2). Even though we can also observe that specimens of Z350XT resin composite immersed in coffee and subsequently bleached had the value of ΔE^*_{ab} higher than 3.3, it is not statistically significant at 95% confidence level. The other subgroups had the observed value of ΔE^*_{ab} lower than 3.3. In other words, we can observe that the bleaching agent is clinically effective for only specimens which were immersed in red wine.

The effectiveness of bleaching on color changes of stained resin composite in each subgroup was compared using Bonferroni's test, the results are shown in figure 1. It can be observed from the statistics results that the values of ΔE^*_{ab} are statistically different at 95% confidence level among resin composite brands for specimens which were immersed in red wine and subsequently bleached.

Table 2. Result of paired t-test of ΔE compared to 3.3

Groups	Test value = 3.3				
	N	Mean	Standard Deviation	t	Sig 2 tailed
Es	10	1.98	.72087	-5.786	.000
Ec	10	2.46	.58515	-4.523	.001
Ew	10	6.77*	1.33121	8.245	.000*
Ps	10	1.46	.67924	-8.562	.000
Pc	10	2.99	.67180	-1.440	.184
Pw	10	24.39*	1.78292	37.412	.000*
Zs	10	1.77	.86682	-5.593	.000
Zc	10	3.59	.52223	1.750	.114
Zw	10	29.63*	1.18230	70.417	.000*



[a]2-way analysis of variance (ANOVA) and Bonferroni's test (ɑ=0.05). Means identified with the same lowercase letters indicate statistically similar averages.

*ΔE must be > 3.3 and significant (two-tailed) *p* values must be < .05, otherwise the color change is not significant.

Figure 1.Comparisons of ΔE among each subgroup.

Discussion

The resin composites are eventually discolored throughout their life span. In this study, to mimic the restoration in the oral cavity that usually all surfaces were not exposed to the environment, a transparent tape was used to cover the bottom side of the mold during the staining process. So, the specimens were exposed only one side to the staining solutions.

According to one of the coffee manufacturers, the average consumption time for one cup of coffee is 15 minutes and the average consumption quantity is 3.2 cups per day among coffee drinkers. Therefore, a 24-hour storage time simulates about one month of coffee consumption [17].

Hence, 24 days of immersion corresponds to 2 years of staining in oral cavity. However, the consumption rate of 3.2 cups per day is relatively high and should represent the heavy drinkers for coffee. This consumption rate might not be applied to all people.

The comparisons of color change among groups with $\Delta E^*_{ab}>3.3$ revealed that there were noticeable differences in all resin composites in the red wine-stained groups. The color detection of resin composite was usually done by visual inspection under conventional illumination. However, this method greatly depended on the experience and skills of the examiner. Using ΔE^*_{ab} in CIELab system as a measuring method is more suitable because this method is a non-biased measurement that can calculate quantitative differences in color measurement. $\Delta E^*_{ab}>3.3$ could be perceived as noticeable color change and can be detected by naked eye [15-16].

Staining susceptibility of resin composites is directly related to their degree of water sorption, related to the hydrophilic/hydrophobic nature of the matrix resin. If resin composites can absorb water, it is also more likely to absorb water-soluble pigments, resulting in discoloration after staining in various solutions [16,18].

Bleaching of the teeth can be done by peroxide bleaching agents. These peroxides penetrate the dental structures and oxygenate the dye substances (chromophores) absorbed in both enamel and dentin. The free radicals, originated from the oxidation of the peroxides, attack unsaturated double bonds of the chromophores, and the natural white tooth color is restored [19-20]. The dental enamel structure is composed of ~96% highly dense inorganic crystal of hydroxyapatite [21]. Nevertheless, the enamel structure does not impose a physical barrier for the penetration of the free radicals in bleaching mechanism which can diffuse through the whole enamel and dentin thickness and even into the pulp [22]. According to this reason, it is possible that these free radicals could penetrate through the resin composite structure used in this study, which have 63.3-71 vol% of inorganic components (Filtek Z350XT, Premise, Estelite Σ quick - information from each manufacturer).

In red wine-stained subgroups, the most color change could be observed for Filtek Z350XT, followed by Premise and Estelite Σ quick, respectively. This might be related to the amount of inorganic components in the composites. The more inorganic part the material have, the less color change could occur.

Comparing between staining solutions, all resin composites in red wine-stained subgroups had significantly greater color change than coffee-stained subgroups after bleaching. This might be due to the difference in type of pigments between red wine and coffee. Color of red wine is mainly resulted from anthocyanins and tannins [23]. Color of coffee is directly related to caramelization of the sucrose in coffee beans during roasting process [24]. The different chemical and physical structure of the pigments might affect the susceptibility with the free radicals in bleaching process, resulting in different bleaching potentials.

From the result of this study, bleaching of stained resin composite restorations might be a possible treatment option. Especially for patients who want a conservative and non-destructive treatment for discolored restoration without any other defects. However, the effects of bleaching agent on physical properties of materials are issues that the dentists should concern since the contact with bleaching agents can cause superficial degradation of resin composites, affecting roughness, hardness, and gloss [25]. Moreover, it might be possible that resin composite restorations would stain more easily after bleaching because mechanically rough surfaces tended to retain surface stains more than smoother surfaces [26-27]. The comparison between advantages and disadvantages of the bleaching treatment should be discussed with the patient for the most suitable treatment for each individual.

Conclusion

Within the limitations of this in vitro study, color changes of all red wine-stained composites after bleaching were noticeable and significantly more than the coffee-stained groups. In term of resin composite brands, the highest color change when bleaching was observed in Filtek Z350XT followed by Premise and Estelite Σ quick.

References

[1] A.D. Puckett, J.G. Fitchie, P.C. Kirk, J Gamblin. Direct composite restorative materials. Dent Clin North Am. 51 (2007) 659-75.
[2] H.J. Kroeze, A.J. Plasschaert, M.A. Van 't Hof, G.J. Truin. Prevalence and need for replacement of amalgam and composite restorations in Dutch adults. J Dent Res. 69 (1990) 1270-4.
[3] N.H. Wilson, F.J. Burke, I.A. Mjor. Reasons for placement and replacement of restorations of direct restorative materials by a selected group of practitioners in the United Kingdom. Quintessence Int. 28 (1997) 245-8.
[4] I.A. Mjör, J.E. Moorhead, J.E. Dahl. Reasons for replacement of restorations in permanent teeth in general dental practice. Int Dent J. 50 (2000) 361-6.
[5] M. Eldiwany, K.H. Friedl, J.M. Powers. Color stability of light-cured and post-cured composites. Am J Dent. 8 (1995) 179-81.
[6] A.F. Reis, M. Giannini, J.R. Lovadino, G.M. Ambrosano. Effects of various finishing systems on the surface roughness and staining susceptibility of packable composite resins. Dent Mater. 19 (2003) 12-8.
[7] C.M. Um, I.E. Ruyter. Staining of resin-based veneering materials with coffee and tea. Quintessence Int. 22 (1991) 377-86.
[8] N. Abu-Bakr, L. Han, A. Okamoto, M. Iwaku. Color stability of compomer after immersion in various media. J Esthet Dent. 12 (2000) 258-63.
[9] S. Ardu, V. Braut, D. Gutenberg, I Krejci, D. Dietschi, A.J. Feiler. A long-term laboratory test on staining susceptibility of esthetic composite resin materials. Quintessence Int. 41 (2010) 695-702.
[10] V.B. Haywood, H.O. Heymann. Nightguard vital bleaching. Quintessence Int. 20 (1989) 173-6.
[11] V.B. Haywood. History, safety, and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching technique. Quintessence Int. 23 (1992) 471-88.
[12] V.B. Haywood. Considerations and variations of dentist-prescribed, home-applied vital tooth-bleaching techniques. Compend Suppl (1994) S616-21.
[13] L.S. Türkün, M. Türkün. Effect of bleaching and repolishing procedures on coffee and tea stain removal from three anterior composite veneering materials. J Esthet Restor Dent. 16 (2004) 290-302.
[14] P. Villalta, H. Lu, Z. Okte, F. Garcia-Godoy, J.M. Powers. Effects of staining and bleaching on color change of dental composite resins. J Prosthet Dent. 95 (2006) 137-42.
[15] I.E. Ruyter, K. Nilner, B. Möller. Color stability of dental composite resin materials for crown and bridge veneers. Dent Mater. 3 (1987) 246-51.
[16] C.H.M Um, I.E. Ruyter. Staining of resin-based veneering materials with coffee and tea. Quintessence Int. 22 (1991) 377-86.
[17] E. Ertas, A.U. Guler, A.C. Yucel, H. Koprulu, E. Guler. Color stability of resin composites after immersion in different drinks. Dent Mater J. 25 (2006) 371-6.
[18] W.H. Douglas, R.G. Craig. Resistance to extrinsic stains by hydrophobic composite resin systems. J Dent Res 61 (1982) 41-3.
[19] R.L Cooley, K.M. Burger. Effect of carbide peroxide on composite resins. Quintessence Int. 22 (1991) 817-21.
[20] S.J. Bailey, E.J. Swift Jr. Effect of home bleaching products on composite resins. Quintessence Int. 23 (1992) 489-94.

[21] Y.R. Zhang, W. Du, X.D. Zhou, H.Y. Yu. Review of research on the mechanical properties of the human tooth. Int J Oral Sci. 6 (2014) 61-9.
[22] A. Joiner. The bleaching of teeth: review of the literature. J Dent 34 (2006) 412-9.
[23] A.C. Muñoz-Espada, K.V. Wood, B. Bordelon, B.A. Watkins. Anthochyanin quantification and radical scavenging capacity of Concord, Norton, and Marechal Foch grapes and wines. J Agric Food Chem. 52 (2004) 6779-86.
[24] H-D. Belitz, W. Grosch, P. Schieberle. Food Chemistry: Springer Verlag; (2009).
[25] T.H. Gouveia, C. Jdo. Publio, G.M. Ambrosano. Effect of at-home bleaching with different thickeners and going on physical properties of a nanocomposite. Our J Dent 10 (2016) 82-91.
[26] R.R. Moraes, J.L. Marimon, L.F. Schneider, L. CorrerSobrinho, G.B. Camacho, M. Bueno. Carbamide peroxide bleaching agents: Effects on surface roughness of enamel, composite and porcelain. Cli Oral Investing 10 (2006) 23-8.
[27] D. Tuncer, E. Karaman, E. Firat. Does the temperaturee of beverages affect the surface roughness, hardness, and color stability of a composite resin? Our J Dent 7 (2013) 165-71.