



Effect of Home Bleaching on the Color Matching of Composite Resin Restorations

Saeedeh Asdaghi¹, Mehdi Daneshpooy², Mahdi Rahbar², Fatemeh Dabaghi-Tabriz², Ayla Bahramian³,
Mahdi Esmaielzadeh²

¹Department of Operative and Esthetic Dentistry, Faculty of Dentistry, Zanjan University of Medical Sciences, Zanjan, Iran.

²Department of Operative and Esthetic Dentistry, Dental and Periodontal Research Center, Faculty of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran.

³Department of Oral and Maxillofacial Medicine, Faculty of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran.

Author to whom correspondence should be addressed: Mahdi Rahbar, Department of Operative and Esthetic Dentistry, Dentistry Faculty, Tabriz University of Medical Sciences, Tabriz, Iran. Phone: +98 914 154 3176. E-mail: mahdirhbr@gmail.com.

Academic Editors: Alessandro Leite Cavalcanti and Wilton Wilney Nascimento Padilha

Received: 20 May 2018 / Accepted: 09 August 2018 / Published: 15 August 2018

Abstract

Objective: To investigate the effect of home bleaching on color matching between the dental restoration and the adjacent tooth structure after the staining process. **Material and Methods:** Ten intact maxillary central incisors were used. After preparation (semi-mesial restoration of the specimens), the specimens were immersed in a colored solution for 14 days and then were washed and the bleaching process was there after performed. A spectrophotometer apparatus was used to determine the color of the specimens in the part of the tooth filled with restorative material three times, including before the staining process, fourteen days after the staining process and immediately after the bleaching process. Paired t-test was employed to compare the color of the intact tooth and the dental restoration before and after the staining and bleaching processes. The level of significance was set at 5%. **Results:** Pre-bleaching E color of the teeth was 68.1, which increased to 78.8% after bleaching, and this increase was also statistically significant ($p < 0.001$). Pre and Post-bleaching E color of composite restorations was 65% and 77.6%, respectively. This increase was also statistically significant ($p < 0.001$). Post-bleaching E color of the tooth and composite material was 78.8% and 77.6%, respectively. This difference was not statistically significant ($p = 0.342$). **Conclusion:** The staining and bleaching processes had a significant effect on the discoloration of the dental restoration and the tooth; however, the application of bleaching on the teeth and composite improved the tooth composite color-match.

Keywords: Tooth Bleaching; Tooth Discoloration; Composite Resins; Aging.

Introduction

Today, dental beauty has become one of the primary demands of patients, and tooth-colored restorative materials, especially composites, are considered an important component in this field [1]. The intrinsic characteristics and properties of restorative materials should not only be consistent with the patient's expectations in terms of function and longevity; the aspect of beauty and color-match should also be taken into consideration [2].

The color mismatch between the restored tooth and other teeth can cause economic challenges (cost of replacing the restorative materials), patient dissatisfaction and possibly undesirable reputational consequences for the dentist [3]. It was reported that the potential for achieving excellent color-matching restorations has improved recently, however, color-match is still one of the most challenging tasks in clinical dentistry [4].

Although several factors with different intensities are efficacious in the discoloration of aesthetic restorative materials, lower pH, food color and bleaching are among the most essential factors involved in this process [5]. In the past, teeth with ugly appearance underwent more invasive therapies, such as prosthetic treatments, but nowadays, easier, cheaper and more efficient methods such as bleaching, which are widely accepted, have been proposed and have made bleaching a popular dental treatment technique in recent decades [5,6].

In fact, the role of bleaching is to brighten the tooth color by using chemicals to oxidize the organic pigments [7]. Different concentrations of substances such as hydrogen peroxide, carbamide peroxide and sodium perborate are used in the bleaching technique to brighten the vital and non-vital teeth. Vital bleaching is carried out using home (using tribleaching at home) and office techniques (using bleaching materials at the office) [7].

The bleaching materials can affect the organic and inorganic structure of the composites, and it is thought that the oxidizing capacity of the bleaching agents can impair the polymer fittings of the composite structure and may lead to the vulnerability of composite to chemical change and discoloration [7,8]. Some authors examined the effect of staining and bleaching on the discoloration of composites, including three micro-hybrid composites and five nanohybrid within composites for twenty minutes, fourteen days and one day being kept in tea and after bleaching in terms of discoloration rates showed that all micro and nanohybrid composites had the same discoloration rate in tea, and these discolorations were removed after bleaching [9].

According to previous studies, the use of 30-35% hydrogen peroxide or 20-35% carbamide peroxide had no effect on the surface structure and discoloration of the composites. However, the use of concentrations higher than the specified values induced significant changes in the color of the composites [10,11].

After reviewing valid references and databases, it was concluded that even though there have been some studies on the effect of bleaching on micro leakages at restoration edges and their hardness, as well as previous studies on their discolorations due to bleaching [12,13], there has been no study on the color-match between composite restorations and natural adjacent teeth after

bleaching. Therefore, the current study is the first to investigate this issue and answer the following questions: Is it essential to replace existing restorations at visible surfaces due to the color mismatch between dental restoration and adjacent teeth after bleaching treatment or not? Do bleaching materials have any negative effects on the color quality of these restorations?

Material and Methods

Sampling

To determine the sample size, the power & sample size software and results of a previous similar study were used [9]. Considering $\alpha = 0.05$, power = 90% and a pre and post- bleaching color difference of 0.6 [9], and a pre and post-bleaching SD of 0.34, 0.28, 8; specimens were used to measure the research variable; however, 10 specimens were later included in order to boost the study precision rate. A total of 10 intact maxillary incisors (with A2 color) were used.

Data Collection

The teeth color was determined using a spectrophotometer (Olympus Corp., Tokyo, Japan). The composite used included a nanohybrid Gradia Direct X composite (A2 color) (GC Dental Products Corp., Kasugai, Japan) while the bleaching material included 10% carbamide peroxide (Opalescence® Whitening Material, Ultradent Products, Inc., Utah, USA).

The restoration procedure was performed as follows: a class V cavity of 2 x 4 mm diameter was created in the cervical buccal side of the tooth. Tooth shaving was later performed on the semi-mesial of the tooth from the middle line and in the hypothetical range (Figure 1). The shaved tooth was etched using 37% phosphoric acid for 20 seconds (Etch-Rite, Pulpdent Corp., Watertown, MA, USA). After being washed and dried, these teeth were prepared for the next procedure according to the manufacturer's instructions. At this stage, bonding (G-aenial Bond, GC Dental Products Corp., Kasugai, Japan) was applied to the etched enamel and dentin teeth surfaces using a micro-brush, and spread using an air spray for two seconds; finally, a 30 seconds curing was performed.

After completing the binding agent exposure process, the Gradia Direct X nanohybrid composite (CG America Inc., Alsip, IL, USA) was placed in a 2 mm thick layer in the created cavity and exposed to a power of 1000 mw/cm² using Litex 680A Curing Light (Dentamerica Inc., California, USA). The layers were added using this technique until the cavity restoration was completed. Finally, the teeth were polished and treated in a similar manner. Specimens were treated using (Sof-Lex, 3M ESPE Dental Products, St. Paul, MN, USA) systems with medium, soft and very soft disks, and a handpiece at speeds ranging from 7000-8000 rpm. Disks were used once and all specimens were treated in one direction. At this stage, the color of the composite treated sections of the specimens were also determined in three regions (L, a, b) and the average of the three points was later recorded. After completion of the treatment steps, specimens were placed in an incubator containing distilled water (37°C) for 24 hours.

Staining Process

The staining solution was prepared as follows: two tea bags were placed in 500 ml of distilled boiling water for ten minutes. The specimens were immersed in the colored solutions for 20 minutes per day for 14 consecutive days (every 24 hours), so that the clinical matching is achieved [9]. After completion of the above process, the specimens were washed and placed in distilled water. It should be noted that the solutions were replaced daily and placed in covered vials to forestall evaporation of the desired solution.

Bleaching Process

Specimens were removed from the container containing the distilled water and dried for 5 seconds. The bleaching process was performed on specimens according to the manufacturer's instructions for fourteen days (8 hours each day). The bleaching material with thickness of about 1 mm were placed on the surface of the specimens. After each bleaching procedure, the bleaching material was removed from the specimens by water spraying for one minute; the specimens were then kept in an incubator containing distilled water at 37°C [13].

Measuring the Color

The specimens' color in both the dental restoration and the intact parts of the tooth was determined in three time intervals, including before the staining process, after fourteen days of staining, and immediately after the bleaching process, using a spectrophotometer (Olympus Corp., Tokyo, Japan) and indicators (L, a, b) on a white background. The points at which color determination was achieved are shown in Figure 1, and the average of the three points was recorded as the final color in each section. It should be noted that the spectrophotometer apparatus was adjusted according to the manufacturer's instructions. The color of each specimen was determined four times at each point and its average was subsequently recorded. Color evaluation was carried out using CIE L* a* b* system. In this system, L* refers to the brightness level, a* indicates a red color in positive values and a green color in negative values, b* refers to yellow color in positive values and blue color in negative values [9].



Figure 1. A schematic figure of the class V cavity of the tooth, showing the colored part of the restored part of the tooth and the non-colored intact part of the adjacent tooth. The color determination are shown in points 1-3, which are placed in the middle of the tooth at 0.5, 1 and 1-5 mm distances, respectively.

Statistical Analysis

Data analysis was performed using descriptive statistical methods (mean \pm SD) in the SPSS software (SPSS Inc., Chicago, IL, USA), version 16. The normal distribution of specimens was evaluated using Kolmogorov Smirnov test. Paired t-test was also used to compare the color of the intact tooth and the composite treated part used before and after bleaching. In this study, $p < 0.05$ was considered as the statistically significant level.

Results

Table 1 shows the mean and standard deviation of E color of composites and teeth before staining, after staining and after bleaching. It was later observed that bleaching reduced this difference.

Table 1. Mean and standard deviation of E Δ color mismatch between dental restorations and intact tooth.

Stage	Tooth Color	Composite Resin Restoration Color
Before Staining	3.3 \pm 70.4	3.1 \pm 71.1
After Staining	7.2 \pm 68.1	3 \pm 65
After Bleaching	4.6 \pm 78.8	2.3 \pm 77.6

According to Table 2, E color of the tooth was 70.4 before staining, but decreased to 68.1 after staining, and this decrease was not statistically significant ($p = 0.209$). In addition, E color of the tooth was 68.1 before the bleaching, but increased to 78.8 after bleaching, and this increase was statistically significant ($p < 0.001$). Regarding, the color of composite restorations before and after staining, E color of the tooth was 71.1 before staining, but decreased to 65% after staining, and this decrease was statistically significant ($p < 0.001$).

According to Table 2, E color of composite restorations was 65% before bleaching, but increased to 77.6 after bleaching, and this increase was statistically significant ($p < 0.001$). Post-bleaching E color of the adjacent tooth and dental restoration was 78.8 and 77.6, respectively, which is slightly different from each other, but this difference was not statistically significant ($p = 0.342$).

Table 2. Comparison of tooth and composite color in different stages.

Variables	Stage	Mean	p-value
Tooth Color	Before Staining	70.4	0.209
	After Staining	68.1	
Tooth Color	Before Bleaching	68.1	<0.001
	After Bleaching	78.8	
Color of Composite Resin Restorations	Before Staining	71.1	<0.001
	After Staining	65.0	
Color of Composite Resin Restorations	Before Bleaching	65.0	<0.001
	After Bleaching	77.6	
Tooth Color	After Bleaching	78.8	0.342
Color of Composite Resin Restorations	After Bleaching	77.6	

Paired-t-test.

Discussion

Considering the increasing importance of dental beauty today, more patients are demanding for teeth whitening techniques, such as bleaching. The home bleaching technique was also designed by Klusmier in 1960 using 10% carbamide peroxide. Many studies have focused on the effect of bleaching on composite resins properties. The results of some of these studies show that the composite resins that undergo bleaching easily absorb color due to changes in their surfaces after bleaching.

In addition, it was observed that bleaching can remove the outer surface color of the composite and, that unlike the tooth enamel, composite restorations do not undergo discoloration after bleaching [14]. In the present study, to evaluate the effect of bleaching on the color-match between dental restoration and adjacent tooth, the staining and the bleaching processes were performed on the specimens. After each process, the specimens were washed and placed in distilled water. Various studies have identified the following as the methods involved in the staining process: boiling, thermocycling, storage in citric acid, sodium chloride and distilled water [9].

In this study, the specimens were immersed in colored solution obtained from tea 20 minutes per day (every 24 hours) for 14 consecutive days to simulate the clinical solution [9]. Then, the specimens were placed in distilled water after each process since it is possible to simulate hydrolytic degradation and hydrolysis as well as oxidation reactions that can occur in the oral environment if the specimens are placed in a humid environment [15].

Color measurement is a phenomenon that differs among different individuals at different times. Various factors such as exposure, translucency and opacity conditions as well as light diffusion and the human eye can affect color evaluation [16,17]. To determine the subjective errors in this study, the color determination and evaluation was performed using the spectrophotometer apparatus, which is currently the most accurate tool for discoloration measurement [18]. It is a more objective method than the eye method (in 93.3% of cases), with an accuracy rate higher than current techniques (33% higher) [19].

The finding of the current study revealed that E color of composite restorations significantly decreased after staining, which may be due to the fact that resin composite is composed of mineral fillers in organic matrix and also prone to degradation and discoloration in different environments. In fact, the simplest reaction can occur at the composite contact surface environment, beyond which the material penetrates the composite; and the composite thereafter undergoes discoloration. There is a direct relationship between the amount of composite polymerization and cross-linking rate; and the efficacy rate of solutions in them. In addition, the chemical composition of matrix and filler as well as silane play a major role in the degradation of composites in different environments [20].

Also, the evaluation results showed that bleaching induced a significant change in E tooth color compared to the pre-bleaching phase, and the same result was observed for the E discoloration of composite restorations. However, the important inference is that the difference between the mean E discoloration of the tooth and composite restoration decreased after bleaching. The difference was

not statistically significant; in fact, bleaching increased the color-match between the intact tooth and the tooth that underwent restoration process. It can be concluded that bleaching could be a suitable treatment for increasing the color-match between natural teeth and composite restorations in the clinic.

A previous study showed that the type of beverage (type of color environments) had a significant effect on the staining of the composites; however, there was no significant difference between micro-hybrid and nanohybrid composites in terms of their staining rate [21]. In addition, the post-staining discoloration of the composites significantly increased [9]. This is in consonance with the findings of this study. It was demonstrated that a number of nanocomposites appear to be significantly brighter in color after bleaching, while some do not show significant discoloration. The present study also showed that the nanohybrid composite used was significantly lighter than the pre-bleaching phase (after staining) [9].

In a previous study on the spectrophotometric and visual evaluation of dental bleaching at various concentrations of carbamide peroxide, also observed that bleaching causes a dental discoloration such that the higher the concentration of the bleaching materials, the higher the changes in the amount of luminosity and color of the teeth [22] and this is consistent with the results of the current study.

Although it was shown the effects of bleaching on color stability and several other composite parameters [13], the results of the present study revealed that the composite color (after staining) was significantly different and increased, before and after the bleaching; that is, the bleaching caused the composite color to change. The reason for this difference is that the teeth color was measured 15 days after bleaching in the above study while the measurement was done immediately after bleaching in the present study. It was shown that prophylaxis would minimize the degree of discoloration in the office and increases the durability of restoration beauty [2]. After measuring the color of the composite restorations before and after staining, it was concluded that the mean E color of composite decreased significantly, and that periodic office prophylaxis can be an appropriate technique for preserving the initial color of composite restorative materials over time.

Conclusion

Bleaching induced a significant change and improvement in the color of the tooth and composite material in such way that the color-match between the tooth and the composite will be acceptable after bleaching.

References

1. Daneshpooy M, Pournaghiaza F, Rahbar M, Sobhi E. Frequency of Post-Operative Sensitivity in Class II Composite Restorations in Iranian Patients. *Pesq Bras Odontoped Clin Integr* 2018; 18(1):e4114. doi: 10.4034/PBOCI.2018.181.62.
2. Samra AP, Ribeiro DG, Borges CP, Kossatz S. Influence of professional prophylaxis on reducing discoloration of different aesthetic restorative materials. *J Dent* 2012; 40:e71-e76. doi: 10.1016/j.jdent.2012.06.003.

3. Negahdari R, Pournasrollah A, Rahbar M, Bohlouli S, Pakdel SM. Comparison of shade match compatibility between vitapan classical and 3D master shade guide systems by dental students in Tabriz Faculty of Dentistry. *Adv Biosci Clin Med* 2016; 4(1):4-10. doi: 10.7575/aiaa.abcmmed.16.04.01.02.
4. Lee YK, Yu B, Lee SH, Cho MS, Lee CY, Lim HN. Shade compatibility of esthetic restorative materials - A review. *Dent Mater* 2010; 26(12):1119-26. doi: 10.1016/j.dental.2010.08.004.
5. Yu H, Li Q, Cheng H, Wang Y. The effects of temperature and bleaching gels on the properties of tooth-colored restorative materials. *J Prosthet Dent* 2011; 105(2):100-7. doi: 10.1016/S0022-3913(11)60007-3.
6. Mohammadi N, Mowlaie S, Savadi-Oskoei S, Ebrahimi ME, Rikhtegaran S, Rahbar M, Pirzadeh T. Effect of 15% carbamide peroxide on the surface roughness and adhesion of *Streptococcus mutans* to microhybrid composite resin and giomer. *World J Dent* 2017; 8(4):288-95. doi: 10.5005/jp-journals-10015-1452.
7. Lima DANL, De Alexandre RS, Martins ACM, Aguiar FHB, Ambrosano G, Bovi M, et al. Effect of curing lights and bleaching agents on physical properties of a hybrid composite resin. *J Esthet Rest Dent* 2008; 20(4):266-73. doi: 10.1111/j.1708-8240.2008.00190.x.
8. Summitt JB, Robbins J, Hilton T, Schwartz R, Santos J. *Fundamentals of Operative Dentistry: A Contemporary Approach*. Chicago: Quintessence Pub., 2013; Chapter 16, pp. 414-440.
9. Poggio C, Beltrami R, Scribante A, Colombo M, Chiesa M. Surface discoloration of composite resins: Effects of staining and bleaching. *Dent Res J* 2012; 9(5):567-73.
10. Bowels WH, Lancaster LS, Wagner MJ. Reflectance and texture changes in bleached composite resin surfaces. *J Esthet Rest Dent* 1996; 8(5):229-33. doi: 10.1111/j.1708-8240.1996.tb00897.x.
11. Langsten RE, Dunn WJ, Hartup GR, Murchison DF. Higher-concentration carbamide peroxide effects on surface roughness of composites. *J Esthet Rest Dent* 2002; 14(2):92-6. doi: 10.1111/j.1708-8240.2002.tb00157.x.
12. Hannig C, Duong S, Becker K, Brunner E, Kahler E, Attin T. Effect of bleaching on subsurface micro-hardness of composite and a polyacid modified composite. *Dent Mater* 2007; 23(2):198-203. doi: 10.1016/j.dental.2006.01.008.
13. Rattacaso RM, da Fonseca Roberti Garcia L, Aguilar FG, Consani S, Pires-de-Souza FCP. Bleaching agent action on color stability, surface roughness and microhardness of composites submitted to accelerated artificial aging. *Eur J Dent* 2011; 5(2):143-9.
14. El-Murr J, Ruel D, St-Georges AJ. Effects of external bleaching on restorative materials: A review. *J Can Dent Assoc* 2011; 77:b59.
15. Khatri A, Nandlal B. Comparative evaluation of shear bond strength of conventional composite resin and nanocomposite resin to sandblasted primary anterior stainless steel crown. *J Indian Soc Pedod Prev Dent* 2007; 25(2):82-5. doi: 10.4103/0970-4388.33453.
16. Mundim FM, Garcia LF, Cruvinel DR, Lima FA, Bachmann L, Pires-de-Souza FC. Color stability, opacity and degree of conversion of pre-heated composites. *J Dent* 2011; 39(Suppl 1):e25-9. doi: 10.1016/j.jdent.2010.12.001.
17. Yousef M, Abo El Naga A. Color stability of different restoratives after exposure to coloring agents. *J Am Sci* 2012; 8(2):20-6.
18. Hubbezoglu I, Akaoğlu B, Dogan A, Keskin S, Bolayir G, Özçelik S, Dogan OM. Effect of bleaching on color change and refractive index of dental composite resins. *Dent Mater J* 2008; 27(1):105-16. doi: 10.4012/dmj.27.105.
19. Karakaya İ, Cengiz E. Effect of 2 bleaching agents with a content of high concentrated hydrogen peroxide on stained 2 CAD/CAM blocks and a nanohybrid composite resin: An AFM evaluation. *Biomed Res Int* 2017; 2017:6347145. doi: 10.1155/2017/6347145.
20. Schneider LF, Pfeifer CS, Consani S, Prahl SA, Ferracane JL. Influence of photoinitiator type on the rate of polymerization, degree of conversion, hardness and yellowing of dental resin composites. *Dent Mater* 2008; 24(9):1169-77. doi: 10.1016/j.dental.2008.01.007.
21. Mazaheri R, Malekipour MR, Seddighi H, Sekhavati H. Effect of common drinks on the color stability of microhybrid and nanohybrid composites in children. *J Mash Dent Sch* 2013; 37(2):163-76.
22. Braun A, Jepsen S, Krause F. Spectrophotometric and visual evaluation of vital tooth bleaching employing different carbamide peroxide concentrations. *Dent Mater* 2007; 23(2):165-9. doi: 10.1016/j.dental.2006.01.017.