Dental Research Journal

Original Article

The effect of office bleaching on the color and bond strength of resin restorations

Homayoon Alaghehmand[1], Marzieh Rohaninasab[2], Ali Bijani[3]

[1]Dental Materials Research Center, Department of Esthetic and Restorative Dentistry, Babol University of Medical Science, [3]Social Determinant of Health Research Center, Babol University of Medical Science, Babol, [2]Department of Esthetic and Restorative Dentistry, Dental School of Tehran University of Medical Science, International Campus, Tehran, Iran

ABSTRACT

Background: Bleaching may affect the bond strength of existing composite fillings and may weaken it. Hence, the aim of this study was to find the best method of in-office bleaching with the least effect on microshear bond strength (MSBS) of existing composite resin fillings to tooth structure.

Materials and Methods: In this *in vitro* study, Class V cavities were prepared on buccal surface of 50 extracted third human sound molars. The cavities in 25 teeth had enamel axial walls, Group E, which were divided into five subgroups of E1 through E5 and in 25 teeth had dentin axial walls, Group D, which were divided into five subgroups of D1 through D5. Cavities were treated with Single Bond 2 adhesive system and restored with composite resin (Z250). The corresponding subgroups received similar bleaching methods and materials; 1 – not bleached, 2 – hydrogen peroxide (HP) 25%, 3 – HP + ultraviolet light, 4 – HP + light-emitting diode-curing device, and 5 – HP + diode laser. Teeth colors were monitored before and after bleaching, and MSBS test and failure modes were examined. Results were analyzed with one-way ANOVA and Kruskal–Wallis tests. $P < 0.05$ was considered significant.

Results: One-way ANOVA did not show differences in MSBS of enamel subgroups but showed significant differences in dentin subgroups ($P < 0.00$). Adhesive fracture in all of the subgroups was the most frequent mode of failure. Kruskal–Wallis test showed that laser was the most effective instrument to change ΔE.

Conclusion: Diode laser was the best method for tooth bleaching because lowering the shear bond strength between composite resin and enamel was minimum and also had the most ΔE in tooth bleaching.

Key Words: Color, hydrogen peroxide, laser, tooth bleaching

Received: September 2017
Accepted: June 2018

Address for correspondence:
Dr. Marzieh Rohaninasab, Department of Esthetic and Restorative Dentistry, Dental School of Tehran University of Medical Science, International Campus, Tehran, Iran.
E-mail: mrohaninasab@yahoo.com

INTRODUCTION

Many factors affect human smile design such as form, position, and color of teeth. In a study,[1] tooth related factors were found to be more important than orthodontic problems. This shows that the appearances of teeth are more significant than the position of teeth. Bleaching is the most conservative tooth whitening method. Vital bleaching techniques include in-office technique, referred to as power bleaching, and at home bleaching. These techniques may be used separately or combined.[2]

Access this article online

Website: www.drj.ir
www.drjjournal.net
www.ncbi.nlm.nih.gov/pmc/journals/1480

How to cite this article: Alaghehmand H, Rohaninasab M, Bijani A. The effect of office bleaching on the color and bond strength of resin restorations. Dent Res J 2019;16:47-52.

Oxygenating agents such as hydrogen peroxide (HP) are used in tooth bleaching to diffuse into enamel and dentin.[3] Some studies have demonstrated that the sodium fluoride in bleaching agents improves enamel remineralization through increasing the inorganic crystals containing fluoride. Using different desensitizing agents by the patients either combined with whitening agent or separately before or after bleaching may affect bonding of resin to tooth structure.[4]

High concentration of HP used in office bleaching materials is accelerated by light or heat.[5] Light sources such as light-emitting diode (LED) light-curing units, lasers, and ultraviolet (UV) light (ZOOM! Advanced) accelerate bleaching process with different mechanisms. In a study, Wetter *et al*. showed that diode laser causes less tooth and gingival sensitivity than HP alone does.[6] Today, LED is very popular among dentists because it is available in almost all dental offices, but its affection on microshear bond strength (MSBS) of composite resin to dentin and enamel is not clear yet. ZOOM! Advanced power system (Discus Dental, USA) has a different effect on HP other than lasers. This system accelerates tooth bleaching with UV waves, and in this way, it improves bleaching agents' effectiveness and consequently decreases the chairside time.[7]

There may be composite resin restorations in the teeth subject to bleaching. Little is known about the effect of in-office bleaching on bond strength of composite resin restorations to tooth structure. In a study,[8] the effect of bleaching on the bond strength of restoration to tooth was evaluated and found that it depends on the type of adhesive system and restoration material. However, another studies showed that bleaching cannot damage bond interface.[2,5]

One of the most reliable methods to determine tooth color is spectrophotometery. This method shows color of teeth in CIELAB system. The three last letters in the CIELAB refer to the three opponent process dimensions: A* for red-green contrast; b* for yellow-blue contrast; and L* for luminosity dimension or whiteness, and it is proportional to the power of the light reflected from the object's surface.[9]

Hence, the aim of this study is *in vitro* evaluation of the effect of different light sources on the MSBS of a composite resin to enamel and dentin and also on teeth color in office bleaching. The null hypothesis is whether new methods of bleaching could be more reliable to use on composite restorations.

MATERIALS AND METHODS

Specimen preparation

In this *in vitro* study, approved by the Human Research Ethics Board of Babol University of Medical Sciences, Babol, Iran, 50 extracted noncarious human third molars were collected and stored in 0.2% thymol solution at 4°C for no longer than 3 months. Teeth were cleaned and randomly divided into two groups of E and D equally. Class V cavities were prepared with the dimensions of 4 mm × 4 mm × 1 mm (length × width × depth) in Group E to have enamel axial walls and 4 mm × 4 mm × 2 mm in Group D to have dentinal axial walls. Cavities were prepared 2 mm cervical to the buccal cusp tip.

Bonding procedure

Cavities were etched by applying 35% phosphoric acid (3M ESPE, St. Paul, MN, USA) [Table 1] for 30 s on enamel and 15 s on dentin and then were rinsed. Enamel surfaces were gently air-dried, and dentinal surfaces were dried with cotton pellet.

Table 1: List of materials tested in this study

Material name	Ingredient	Filler	Filler percentage by weight	Manufacture
Scotchbond™ universal etchant 35%	Phosphoric acid, polyethylene glycol, aluminum oxide, water	Synthetic amorphous silica	5-10	3M-ESPE
Adper™ single bond 2	BISGMA, HEMA, copolymer of acrylic and itaconic acids, glycerol 1,3-dimethacrylate, UDMA, diphenyliodonium hexafluorophosphate, EDMAB, ethyl alcohol, water	Silane-treated silica (nanofiller)	10-20	3M-ESPE
Filtek™ Z250	BISEMA6, UDMA, BISGMA, TEGDMA, aluminum oxide, EDMAB, benzotriazole	Silane-treated ceramic	75-85	3M-ESPE
Zoom 25% H2O2	Poloxamer 407, hydrogen peroxide, glycerin, propylene glycol, potassium hydroxide, potassium nitrate, *Mentha piperita*, eugenol, ferrous gluconate, water	-	-	Discus Dental

BISGMA: Bisphenol A diglycidyl ether dimethacrylate; HEMA: 2-hydroxyethylmethacrylate; UDMA: Diurethane dimethacrylate; EDMAB: Ethyl 4-dimethylaminobenzoate; BISEMA6: Bisphenol A polyethylene glycol diether dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate

Cavities were then treated with Single Bond 2 (3M ESPE, St. Paul, MN, USA) [Table 1] adhesive system, gently air-dried, and cured with UltraLume 2 (Ultradent Products, Inc., South Jordan) LED-curing unit (400 mw/cm^2) for 20 s. Composite resin (Filtek Z250, A2) (3M ESPE, St. Paul, MN, USA) [Table 1] was placed incrementally with 1 mm in thickness for any increment and cured for 40 s. Finishing and polishing were done with Sof-Lex finishing and polishing disc system (3M ESPE, St. Paul, MN, USA) from coarse to superfine in 30 s. Teeth were stored in 24°C incubator in water until perfuming the bleaching procedure.

Bleaching procedure

The teeth in Groups E and D were divided equally into five subgroups of E1 and D1 through E5 and D5, respectively. Subgroups E1 and D1, as the control subgroups, received no bleaching treatment.

Subgroups E2 and D2 were bleached with 25% HP (chairside whitening gel, Discus Dental, USA) [Figure 1a]. Double syringe and self-mixing tip delivery devices, designed for this system, were used to mix the two components in the right proportion and preparing an activated 25% HP. The

Figure 1: (a) Twenty-five percent hydrogen peroxide, (b) Ultraviolet-emitted unit (Zoom! Advanced power), and (c) diode laser (Dr. Smile). (d) Light-emitting diode-curing device (UltraLume 2).

devices were washed and refilled with fresh bleaching materials every 15 min for 1 h. In all other groups in addition to applying bleaching material in the same way as subgroups 2, the teeth were irradiated with UV-emitted unit (Zoom! Advanced power, Discus Dental, USA) [Figure 1b] for 60 min, in Subgroups E3 and D3.And with UltraLume2 LED curing unit [Figure 1d] for 5 * 30 s with 15 min intervals (400 mw/cm2) in E4 and D4 subgroups Also in E5 and D5 subgroups, irradiation with diode laser (Dr. Smile, Italy, 815 nm) [Figure 1c] for 5 *10s with 15 min intervals. In all the subgroups, the manufacturer's instructions were followed.

The teeth were then mounted and positioned in a nonstop cutting instrument (delta precision sectioning machine, Mashhad, Iran) to have four slices from each tooth. The dimensions of each slice were approximately 1 mm × 1 mm which were measured with a micrometer (Mitutoyo micrometer code 103–137 graduation 0.01 mm, Illinois, USA). Hence, in each group, we had 20 slices that were mounted in self-cured acryl and were fixed in a grasp of a microtensile testing device (Microtensile tester machine, COMPACT GAUGE 200N, Bisco. Inc.) and tested for shear bonding strength at a crosshead speed of 0.5 mm/min until failure with wire loop technique (it is a technique that a wire loop was placed at the interface between composite and enamel or dentin for exertion of shear force). The maximum force in Newton scale was recorded at failure and divided by the surface area to determine the MSBS in MPa.

Failure mode assessment

Following the microshear test, each fragment of the ruptured stick was examined using a stereoscopic microscope (Nikon SMZ-800, USA) with ×40 magnificence, as the initial assessment of the failure mode. Fracture types were as follows:

- Adhesive fracture: Failure in adhesive, fracture at the interface
- Cohesive fracture: Dental substrate failure or restorative material failure
- Mixed fracture: Dental substrate and resin material fracture (adhesive or resin composite).

Color assessment

Before and 1 week after bleaching, VITA easy shade (Vident, Brea, Calif) was used to evaluate the color of buccal surface of teeth. The instrument's tip was positioned on the same place in both of the times with a special jig (made by Duralay acryl [Dental Mfg Co., Illinois, USA]) for all the teeth. Δa, Δb, and ΔL were measured, and ΔE formula was used to assess the color changes:

$$\Delta E\ (L^*\ a^*\ b^*) = ([\Delta L^*]^2 + [\Delta a^*]^2 + [\Delta b^*]^2)^{1/2}$$

Statistical analysis

The MSBS and ΔE results were analyzed with Kolmogorov–Smirnov test to evaluate the normal distribution of data. One-way ANOVA and Tukey's *post hoc* tests were used to analyze data with normal distribution. $P < 0.05$ was considered significant.

RESULTS

Table 2 displays the means and standard deviations of MSBSs of composite resin to enamel and dentin. One-way ANOVA for enamel MSBSs did not show significant difference between the groups. The same analysis showed a significant difference in MSBSs of composite resin to dentin ($P < 0.00$). In these groups, MSBS values decreased, but there were no significant differences between them. Table 3 shows the modes of failure in enamel and dentin subgroups. Adhesive fracture in all of the groups was the most frequent failure mode.

Table 4 shows the mean and standard deviation values of ΔE. Kruskal–Wallis test showed that ΔE significantly increases with diode laser, UV, and LED accelerators ($P < 0.034$). Laser was the most effective instrument to change ΔE, followed by UV and LED, respectively.

Table 2: Mean and standard deviation of microshear bond strength of composite resin to enamel and dentin in Mpa (*n*=20)

Subgroups	Enamel groups	Dentin groups
1	17.37±7.14[a]	8.59±2.02[a]
2	14.13±5.81[a]	5±2.64[b]
3	14.7±4.88[a]	3.11±2.01[b]
4	13.08±6.61[a]	4±2.93[b]
5	17.57±4.95[a]	4.09±3.05[b]

Groups with the same superscript are not statistically different (*P*>0.05)

Table 3: Failure mode in enamel and dentin subgroups

Subgroups	Enamel group (*n*=20)			Dentin group (*n*=20)		
	Ad	Co	Mi	Ad	Co	Mi
1	10 (50)	9 (45)	1 (5)	16 (80)	4 (20)	-
2	13 (65)	7 (35)	-	18 (90)	2 (10)	-
3	14 (70)	6 (30)	-	19 (95)	1 (5)	-
4	15 (75)	5 (25)	-	20 (100)	-	-
5	11 (55)	8 (40)	1 (5)	17 (85)	3 (15)	-

Inside of parentheses are failure mode percentages. Ad: Adhesive fracture; Co: Cohesive fracture; Mi: Mixed fracture

Table 4: Mean value and standard deviation of ΔE

Subgroups	Mean±SD
1	0.41±0.28[a]
2	3.12±0.77[b]
3	5.35±1.74[c]
4	5±1.08[c]
5	6.16±1.64[c]

Subgroups with the same superscript are not statistically different (*P*>0.05). SD: Standard deviation

DISCUSSION

In this study, Tukey's test showed that MSBS of composite resin to enamel did not decrease significantly after bleaching but decreased significantly to dentin. Other studies also showed similar results in dentin with different concentrations of carbamide peroxide and HP.[8,10] About 25% HP forms different amounts of oxygen radicals depending on temperature, light, PH, co-catalysts, and other conditions. Hydroxyl free radical (HO_2^-) that is formed from H_2O_2 is extremely reactive and has great oxidative power. It may break up large stain macromolecules into smaller molecules and by diffusion expel them to the surface.[11] It is also thought to be attached to stain molecules in the inorganic structure as well as matrix proteins.[12] The free radicals eventually combine to form oxygen molecules and water. Some aspect of this chemical process may accelerate the hydrolytic degradation of composite resins.[13] Hence, bleaching agents might have some effects on bond degradation of composite resin if it could penetrate to tooth structure. Some studies show that bond strength would not decrease after bleaching.[2,5] On the other hand, many studies suggest that some composite resins may be more susceptible to alteration, so various adhesive systems and composite resins show varying results.[14,15] Cavalli *et al*., 2005, evaluated the effect of bleaching on the composite resin restorations bonded with self- or total-etch adhesive systems. The results showed that bond strength of composite resin to enamel would decrease if it was bonded with self-etch CLEARFIL SE bond. However, total-etch adhesive system (Single Bond 2) had stronger initial bond and bleaching would not decrease it so much. Furthermore, bleaching agents at higher concentrations can cause more changes than lower ones.[14] Far and Ruse, 2003, found that fracture strength of composite resin to dentin would decrease after bleaching with carbamide peroxide at higher concentrations than 15% and re-bonding of restorations was necessary after bleaching procedures.[16] Stocks *et al*., 1992, stated that HP has negative effects on shear bond strength of resin to enamel.[15] Ulukapi *et al*., 2003, and Turkun *et al*., 2004, suggested that nonvital bleaching with 10% carbamide peroxide can increase microleakage score.[17,18] Moosavi *et al*., 2009, also found postoperative bleaching with carbamide peroxide increased microleakage in dentinal margins.[10] Klukowska *et al*., 2008, explored the effects of different concentrations of HP and carbamide peroxide agents on the enamel margin microleakage of composite restorations.[19] In their study as well as in White's research,[20] bleaching agents could not increase the microleakage scores of Filtek Z250 bonded with scotch bond. This controversy is maybe because of different study design and using older generations of adhesive systems.

In this study, the lowest MSBS to dentin after bleaching was belonged to UV group. It can be related to special treatment plan of this device. The latest version of Zoom! Advanced power uses White Speed LED bleaching lamp (LED) in the range of 350–400 nm (violet light). An important aspect of the new White Speed unit is that it emits some UV light too. After application of HP, Zoom! Advanced power (UV wave) irradiates for 60 min, but with LED and laser, the duration of irradiation is 30 and 15 s, respectively. The negative effects of UV irradiation on the bond interface between composite resin and tooth structure may be time sensitive. On the other hand, we should know that if bleaching agent could penetrate into tooth structure, it may affect bond strength.

The most frequent mode of fracture in enamel and dentin groups was adhesive fracture, but it was less frequent in enamel groups [Table 3], and it is consistent with the lowered bond strength, due to bleaching, in enamel groups compared to dentin groups [Table 2]. More frequent cohesive failure or mixed fracture represents the higher strength of bond compared to the strength of substrates.

Different light sources can accelerate bleaching process. In this study, diode laser was the most effective light in tooth color change followed by UV and LED, respectively. Several other investigations also showed this result. In a study that compared the effect of plasma arc and diode laser on tooth whitening and tooth sensitivity, the authors mentioned that while both devices improved the effectiveness of bleaching agents, diode laser lowered tooth sensitivity more significantly that was more acceptable for the patients.[21] Luk *et al*. 2004 studied the effect of different laser devices on bleaching.[22] They found that light sources accelerated only the special bleaching agent's reaction and also pulp temperature must be monitored during the process. CO2 laser increases pulp temperature and can damage it, but diode laser increases temperature under the deleterious limit (5.5°C).

Zoom! Advanced power system also had positive effects on whitening the teeth. Gallagher *et al*., 2002, and Toko *et al*., 2005, in their studies found that this system is better than halogen and xenon lamps and Opalescence Xtra boost kit for teeth bleaching.[23,24]

CONCLUSION

Then, under limitations of this study, the followings may be concluded:

1. All light sources in this study could accelerate bleaching process and cause brighter teeth and using them is suggested
2. Diode laser was the best unit for tooth bleaching because it had the lowest effect on shear bond strength between composite resin and enamel and had the highest ΔE in tooth color change
3. More investigations utilizing other bonding systems and composite resins and also other bleaching materials with other kinds of light sources are recommended.

Acknowledgment

We would like to thank Babol Dental Material Research Center and Research Council of Babol University of Medical Sciences.

Financial support and sponsorship

Research Council of Babol University of Medical Sciences.

Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Sulieman MA. An overview of tooth-bleaching techniques: Chemistry, safety and efficacy. Periodontol 2000 2008;48:148-69.
2. Roberson T, Heymann H, Swift EJ Jr. Sturdevant's Art and

Science of Operative Dentistry. 5th ed. Philadelphia: Mosby; 2006. p. 641-3.
3. Joiner A. The bleaching of teeth: A review of the literature. J Dent 2006;34:412-9.
4. Alaghehmand H, Esmaeili B, Sheibani SA. Effect of fluoride-free and fluoridated carbamide peroxide gels on the hardness and surface roughness of aesthetic restorative materials. Indian J Dent Res 2013;24:478-83.
5. Summitt JB, Robbins J, William H, Thomas J, Schwartz RS. Fundamentals of Operative Dentistry: A Contemporary Approach. 3rd ed. Illinois: Quintessence Publishing; 2006. p. 437-61.
6. Wetter NU, Walverde D, Kato IT, Eduardo Cde P. Bleaching efficacy of whitening agents activated by xenon lamp and 960-nm diode radiation. Photomed Laser Surg 2004;22:489-93.
7. Yazici AR, Khanbodaghi A, Kugel G. Effects of an in-office bleaching system (ZOOM) on pulp chamber temperature *in vitro*. J Contemp Dent Pract 2007;8:19-26.
8. Yu H, Zhang CY, Cheng SL, Cheng H. Effects of bleaching agents on dental restorative materials: A review of the literature and recommendation to dental practitioners and researchers. J of Dental Sciences 2015;10(4):345-51.
9. Long J. The New Munsell Student Color Set. 2nd ed. Richmond: Virginia Common Wealth University; 2001.
10. Moosavi H, Ghavamnasiri M, Manari V. Effect of postoperative bleaching on marginal leakage of resin composite and resin-modified glass ionomer restorations at different delayed periods of exposure to carbamide peroxide. J Contemp Dent Pract 2009;10:E009-16.
11. Feinman RA, Madray G, Yarborough D. Chemical, optical, and physiologic mechanisms of bleaching products: A review. Pract Periodontics Aesthet Dent 1991;3:32-6.
12. Fasanaro TS. Bleaching teeth: History, chemicals, and methods used for common tooth discolorations. J Esthet Dent 1992;4:71-8.
13. Söderholm KJ, Zigan M, Ragan M, Fischlschweiger W, Bergman M. Hydrolytic degradation of dental composites. J Dent Res 1984;63:1248-54.
14. Cavalli V, de Carvalho RM, Giannini M. Influence of carbamide peroxide-based bleaching agents on the bond strength of resin-enamel/dentin interfaces. Braz Oral Res 2005;19:23-9.
15. Stokes AN, Hood JA, Dhariwal D, Patel K. Effect of peroxide bleaches on resin-enamel bonds. Quintessence Int 1992;23:769-71.
16. Far C, Ruse ND. Effect of bleaching on fracture toughness of composite-dentin bonds. J Adhes Dent 2003;5:175-82.
17. Ulukapi H, Benderli Y, Ulukapi I. Effect of pre- and postoperative bleaching on marginal leakage of amalgam and composite restorations. Quintessence Int 2003;34:505-8.
18. Türkün M, Türkün LS. Effect of nonvital bleaching with 10% carbamide peroxide on sealing ability of resin composite restorations. Int Endod J 2004;37:52-60.
19. Klukowska MA, White DJ, Gibb RD, Garcia-Godoy F, Garcia-Godoy C, Duschner H. The effects of high concentration tooth whitening bleaches on microleakage of class V composite restorations. J Clin Dent 2008;19:14-7.
20. White DJ, Duschner H, Pioch T. Effect of bleaching treatments on microleakage of class I restorations. J Clin Dent 2008;19:33-6.
21. Gurgan S, Cakir FY, Yazici E. Different light-activated in-office bleaching systems: A clinical evaluation. Lasers Med Sci 2010;25:817-22.
22. Luk K, Tam L, Hubert M. Effect of light energy on peroxide tooth bleaching. J Am Dent Assoc 2004;135:194-201.
23. Gallagher A, Maggio B, Bowman J, Borden L, Mason S, Felix H, *et al*. Clinical study to compare two in-office (chairside) whitening systems. J Clin Dent 2002;13:219-24.
24. Toko T, Tamaoka K, Hoshino M, Hisamitsu H. Effect of Different Light Source on Office Bleach. The IADR/AADR/CADR 83rd General Session; March, 2005. p. 9-12. Available from: https://www.iadr.abstractarchives.com/abstract/2005Balt-61883/>effect-of-different-light-source-on-offi ce-bleach.