

Shear Bond Strength of Orthodontic Brackets to Tooth Enamel After Treatment With Different Tooth Bleaching Methods

Elahe Vahid Dastjerdi,¹ Negar Khaloo,² Seyed Masoud Mojahedi,³ and Mohadese Azarsina^{2,*}

¹Department of Orthodontics, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran

²Department of Operative Dentistry, Dental School, International Branch of Shahid Beheshti University of Medical Sciences, Tehran, IR Iran

³Department of Laser and Surgery, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran

*Corresponding Author: Mohadese Azarsina, Department of Operative Dentistry, Dental School, International Branch of Shahid Beheshti University of Medical Sciences, Tehran, IR Iran. Tel: +98-9123859399, Fax: +98-2188695955, E-mail: azarsina2012@yahoo.com

Received 2014 May 24; Revised 2014 September 2; Accepted 2014 December 6.

Abstract

Background: Bleaching treatments decrease shear bond strength between orthodontic brackets and teeth; although definite results have not been reported in this regard.

Objectives: This study determined the effects of different bleaching protocols on the shear bond strength of orthodontic brackets to teeth.

Materials and Methods: This experimental study was performed in Iran. Forty-eight extracted human premolars were randomly assigned into four groups. In the control group, no bleaching treatment was performed. In groups 2 - 4, the bleaching procedures were performed using carbamide peroxide 45%, carbamide peroxide 20% and diode laser, respectively. Two weeks later, brackets were bonded to teeth and thermocycled. The shear bond strengths of the brackets to the teeth were measured. Data was analyzed by one-way ANOVA and Dunnett post-hoc test.

Results: Shear bond strength of the brackets to the teeth were 10.54 ± 1.51 , 6.37 ± 0.92 , 7.67 ± 1.01 and 7.49 ± 1.19 MPa, in groups 1-4, respectively. Significant differences were found between control group and all other groups ($P < 0.001$); and also between groups 2 and 3 ($P < 0.05$). No significant differences were found between the other groups.

Conclusions: The bleaching procedures using 20% carbamide peroxide and 45% carbamide peroxide and diode laser significantly decreased shear bond strength of brackets to the teeth. 45% carbamide peroxide had a more significant effect on bond strength compared to 20% carbamide peroxide. The difference in bond strength was not significant between laser group and either carbamide peroxide groups.

Keywords: Carbamide Peroxide, Hydrogen Peroxide, Shear Strength, Tooth Bleaching

1. Background

Esthetic demands have increased among patients, and they prefer to have well aligned and white teeth, showing their health and youth. Tooth bleaching and orthodontic therapy are common treatments that patients seek to have beautiful smiles. Various methods of bleaching have been introduced using different materials, such as hydrogen peroxide, carbamide peroxide and sodium perborate (1, 2). Techniques of bleaching have been improved to have whiter and brighter teeth in the shortest time possible, with the least risk to the health of the teeth, by addition of high intensity light, heat, potassium nitrate and fluoride, etc. (3, 4). Among lasers, diode laser has been suggested for tooth bleaching, which has the least potential to thermally damage vital teeth (2, 5). It is suggested that bleaching treatment can cause some structural changes in the tooth enamel (1).

Orthodontic therapy is often accompanied by esthetic problems such as white spot lesions and decalcification

of the teeth surfaces beneath brackets. Therefore, fluoride-releasing composite resins have gained popularity among orthodontists for bonding orthodontic brackets to teeth. These composites are believed to prevent caries under brackets (1).

In some cases, both bleaching and orthodontic treatment are performed in a short period of time, having effect on the outcome of each other. Some authors reported a decrease in shear bond strength of brackets to tooth enamel after bleaching (6, 7), while others suggested that bleaching has no detrimental effects on the bracket-enamel bond strength (8, 9).

2. Objectives

Due to paucity of data, the aim of the present study was to evaluate the effect of different bleaching methods on the shear bond strength of brackets to enamel bonded with a fluoride-releasing composite resin.

3. Materials and Methods

This experimental in-vitro study was performed on 48 intact extracted human premolar teeth. For selecting the sample size, we used the Power and Sample size (PS) vs. 2.1.31 software (Vanderbilt University). The level of significance was set at 0.05 and the power of study was at least 80 %. All teeth were polished with prophylaxis paste and rubber cup for 10 seconds and then rinsed and dried. They were randomly assigned into four groups as follows:

Group 1 (control group): Teeth (n = 12) were kept in artificial saliva (Hypozalix, Biocodex, France) at 37°C before the study. Artificial saliva was refreshed daily. For bonding the brackets, the teeth were etched with 37% phosphoric acid (Dentsply, York, PA, USA) for 30 seconds. After that, teeth were rinsed for 20 seconds and then dried with stream of air for 20 seconds to appear opaque and frosty. Lingual metallic brackets (Gemini bracket, 3M Unitek, Monrovia, California, USA) with 3.3 mm diameter and mesh base were bonded to the etched enamel with a fluoride-releasing composite resin (Biofix, Biodinamica, Brazil). The brackets were fixed on the tooth surface with light finger pressure and the excess material was removed with a scaler and light-cured for 40 seconds with an LED light-curing unit at 800 mW/cm² (Demi LED Light Curing System, Kerr Corp, Orange, CA, USA) from a 5 mm distance.

Group 2: In this group (n = 12), 45% carbamide peroxide gel (Opalescence; Ultradent Products, South Jordan, Utah, USA) was placed on the buccal surfaces of the teeth at 1mm thickness for 30 minutes at 37°C and 100% humidity. After removing the bleaching gel, the teeth were rinsed and dried, and kept in artificial saliva for two weeks. Afterwards, all the steps similar to group 1 were performed on the samples.

Group 3: In this group, the teeth (n = 12) were bleached with 20% carbamide peroxide gel (Opalescence; Ultradent Products, South Jordan, Utah, USA) daily for two weeks. The bleaching gel was placed on the buccal surfaces of the teeth four hours a day. During the 2-week procedure (the remaining 20 hours daily) and 2 weeks after the termination of the procedure, the teeth were kept in artificial saliva at 37°C. All the steps similar to group 1 were performed on teeth.

Group 4: In this group (n = 12), bleaching was performed with 40% aqueous hydrogen peroxide gel (Opalescence; Ultradent Products, South Jordan, Utah 84095, USA), which was activated with diode laser (Doctor Smile, Lambdaspa, 36040 Brendola, Italy) at 810 nm wavelength (power: 2.5 W). Laser irradiation was performed for 60 seconds on each sample with 1mm distance from the tooth surface in a continuous, noncontact mode. After bleaching, the teeth were kept in artificial saliva for two weeks, and then the steps similar to group 1 were performed on the teeth.

After bonding the brackets, all the samples were stored in an incubator with 37°C temperature for 24 hours; and

then thermo-cycled (DORSA, Tehran, Iran) for 500 cycles between 5°C and 55°C with dwell time of 30 seconds.

For shear bond strength testing, each sample was mounted in the universal testing machine (SANTAM, Tehran, Iran) and a shear force was applied parallel to the height of contour of the teeth to the interface of tooth-bracket in an occluso-gingival direction, with a 1-kN load cell at the crosshead speed of 0.5 mm/min. The maximum load in which the brackets were debonded was recorded and by calculating the load in the unit surface area of each sample, shear bond strength was reported in Mega Pascal (MPa).

All the samples were tested for shear bond strength by a single observer. Data was statistically analyzed by one-way ANOVA and Dunnett multiple comparison tests using SPSS 18.0 (SPSS Inc., Chicago, IL, USA).

4. Results

The means and standard deviations (SD) of the bond strength data are reported in Table 1. The results of this study showed that the bleached teeth in test groups (groups 2 - 4) had significantly lower shear bond strength values compared with the control group ($P < 0.001$).

Dunnett's multiple comparison tests indicated significant differences in shear bond strength between control and laser groups ($P < 0.001$), control and 20% CP groups ($P < 0.001$), control and 45% CP groups ($P < 0.001$) and 20% CP and 45% CP groups ($P < 0.05$). Significant differences were not observed between CP 20% and laser groups ($P = 0.98$), and also between CP 45% and laser groups ($P = 0.1$).

Table 1. Mean and SD of Shear Bond Strength in the Studied Groups

| Group | Mean (MPa) ± SD | Min | Max |
|---------|-----------------|------|-------|
| Control | 10.54 ± 1.51 | 7.06 | 12.28 |
| CP 45% | 6.37 ± 0.92 | 5.06 | 8.53 |
| CP 20% | 7.67 ± 1.01 | 5.76 | 9.66 |
| Laser | 7.49 ± 1.19 | 6.48 | 10.44 |

5. Discussion

All the bleaching methods evaluated in this study significantly reduced the shear bond strength of the brackets to tooth enamel. The shear bond strength was lower in the group in which the teeth were bleached with 45% CP compared to the 20% CP group. Thus, increase in concentration of CP was related to decrease in shear bond strength of the brackets to enamel. This result is in accordance with the reports of Patusco et al. who suggested a significant reduction in bond strength to enamel after bleaching with 35% hydrogen peroxide in comparison with 10% CP.⁶ However, Bishara et al. reported that bond strength is not dependent on the reverse effects of the type of bleaching agent (10).

Nano-leakage in the enamel-resin interface is reported as isolated silver granules and bubbles in bleached teeth (11). A reduction in the amount of calcium ion, micro-hardness and change in the organic composition of the enamel are factors contributing to reduced shear bond strength of resin to bleached enamel (12, 13). Bleaching with CP is reported to cause some morphologic changes on enamel surface (14); although it is not confirmed in other studies (15).

Titely et al. reported obvious differences between resin-bleached enamel interface and resin-unbleached enamel interface. In bleached samples, extensive areas of enamel was denuded of resin and in the areas that resin existed, the resin tags were segmented with undefined borders. These tags had a shallower penetration into the enamel surface compared to the tags in unbleached enamel (7). Titely et al. also reported the existence of bubbles and granules in the SEM observations of the bleached enamel-resin interface (16). SEM observations also indicated a reverse association between the amount of bubbles in the bond areas and bond strength values. These bubbles are believed to be oxygen molecules from the oxidation of peroxide agents trapped in the subsurface layer of enamel (7).

CP releases oxygen free radicals which are responsible for breaking the complex molecules into smaller ones and this way whitening the tooth color (17). Existence of these molecules in the surface and subsurface layers of enamel is a deterrent for polymerization of resin components and therefore a strong bond between resin and tooth structure (17). As suggested in literature (10, 18-20), we bonded the brackets two weeks after termination of the bleaching process to minimize the effect of free radicals on bond strength of resin to enamel. Oztaş et al. reported a recovery in bond strength values after two weeks delay for bonding process after the bleaching treatment (20). However, a two-week lag between bleaching and bonding process did not cause the recovery of shear bond strength to a level similar to the control group in the present study.

The advantage of the present study was comparison of routine bleaching protocols, including at-home, in-office and laser bleaching for their effects on shear bond strength of resin to tooth enamel and seek for the method with the least detrimental effect on the bond strength of brackets to teeth.

In the present study, similar effects on bond strength were observed after bleaching with laser, and other techniques of bleaching. This indicates that laser did not have adverse thermal effects on the tooth structure, as a result, no further decrease in bond strength due to thermal destruction of the tooth structure. Although, it did not have any benefit over other techniques of bleaching in restoring the shear bond strength of resin to tooth surface. In the study of Kinoshita et al, KTP laser in combination with a bleaching material was very effective in lightening the color of a damaged and discolored tooth, while using

this laser for more than 750 seconds could damage the tooth enamel structure (21).

The minimum acceptable bond strength values of brackets to teeth are suggested to be 6-8 MPa, and the maximum bond strength to prevent enamel fracture is reported as 14 Mpa (17, 22). Although in the present study, the shear bond strength of brackets to teeth was significantly reduced with all the bleaching methods, the bond strength in all the groups was in clinically acceptable range.

Other studies with more similar conditions to oral environment and evaluating various concentrations and combinations of the bleaching agents, and also various bonding agents are suggested to be performed to obtain more precise results. Within the limitations of the present study, it is concluded that bleaching teeth with CP 20%, CP 45% and diode laser could significantly reduce the shear bond strength of brackets to teeth bonded with fluoride-releasing composite resin. 45% carbamide peroxide had a more significant effect on bond strength compared to 20% carbamide peroxide. The difference in bond strength value was not significant between laser group and either carbamide peroxide groups.

Acknowledgments

The authors would like to thank Dr. Siamak Sabour for his assistance in statistical analysis.

Footnote

Authors' Contributions: Study concept and design: Elahe Vahid Dastjerdi, Mohadese Azarsina, Seyed Masoud Mojahedi; Acquisition of data: Negar Khaloo, Mohadese Azarsina, Seyed Masoud Mojahedi; Analysis and interpretation of data: Elahe Vahid Dastjerdi, Negar Khaloo, Seyed Masoud Mojahedi, Mohadese Azarsina; Drafting of the manuscript: Mohadese Azarsina, Negar Khaloo; Critical revision of the manuscript for important intellectual content: Mohadese Azarsina; Statistical analysis: Negar Khaloo; Study supervision: Elahe Vahid Dastjerdi, Mohadese Azarsin.

References

1. Akin M, Aksakalli S, Basciftci FA, Demir A. The effect of tooth bleaching on the shear bond strength of orthodontic brackets using self-etching primer systems. *Eur J Dent.* 2013;7(1):55-60. [PubMed: 23408777]
2. Buchalla W, Attin T. External bleaching therapy with activation by heat, light or laser—a systematic review. *Dent Mater.* 2007;23(5):586-96. doi:10.1016/j.dental.2006.03.018. [PubMed: 16820199]
3. Kugel G, Perry RD, Hoang E, Scherer W. Effective tooth bleaching in 5 days: using a combined in-office and at-home bleaching system. *Compend Contin Educ Dent.* 1997;18(4):378. [PubMed: 9452545]
4. Tavares M, Stultz J, Newman M, Smith V, Kent R, Carpino E, et al. Light augments tooth whitening with peroxide. *J Am Dent Assoc.* 2003;134(2):167-75. [PubMed: 12636120]
5. Dostalova T, Jelinkova H, Housova D, Sulc J, Nemeč M, Miyagi M, et al. Diode laser-activated bleaching. *Braz Dent J.* 2004;15 Spec No: S13-8. [PubMed: 15690765]
6. Patusco VC, Montenegro G, Lenza MA, Alves de Carvalho A. Bond

- strength of metallic brackets after dental bleaching. *Angle Orthod.* 2009;**79**(1):122-6. doi: 10.2319/072507-345.1. [PubMed: 19123701]
7. Titley KC, Torneck CD, Smith DC, Chernecky R, Adibfar A. Scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel. *J Endodont.* 1991;**17**(2):72-5. doi: 10.1016/s0099-2399(06)81611-0.
 8. Bishara SE, Sulieman A, Olson M. Effect of enamel bleaching on the bonding strength of orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 1993;**104**(5):444-7. doi: 10.1016/0889-5406(93)70070-5. [PubMed: 8237896]
 9. Uysal T, Basciftci FA, Üşümez S, Sari Z, Buyukerkmen A. Can previously bleached teeth be bonded safely? *Am J Orthod Dentofacial Orthop.* 2003;**123**(6):628-32. doi: 10.1016/s0889-5406(03)00151-3. [PubMed: 12806341]
 10. Bishara SE, Oonsombat C, Soliman MM, Ajlouni R, Laffoon JF. The effect of tooth bleaching on the shear bond strength of orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 2005;**128**(6):755-60. doi: 10.1016/j.ajodo.2004.07.044. [PubMed: 16360917]
 11. Lai SC, Tay FR, Cheung GS, Mak YF, Carvalho RM, Wei SH, et al. Reversal of compromised bonding in bleached enamel. *J Dent Res.* 2002;**81**(7):477-81. [PubMed: 12161460]
 12. Firoozmand LM, Brandao JV, Fialho MP. Influence of microhybrid resin and etching times on bleached enamel for the bonding of ceramic brackets. *Braz Oral Res.* 2013;**27**(2):142-8. [PubMed: 23538425]
 13. Uysal T, Ustdal A, Nur M, Catalbas B. Bond strength of ceramic brackets bonded to enamel with amorphous calcium phosphate-containing orthodontic composite. *Eur J Orthod.* 2010;**32**(3):281-4. doi: 10.1093/ejo/cjp115. [PubMed: 20080960]
 14. Turkun M, Kaya AD. Effect of 10% sodium ascorbate on the shear bond strength of composite resin to bleached bovine enamel. *J Oral Rehabil.* 2004;**31**(12):1184-91. doi: 10.1111/j.1365-2842.2004.01369.x. [PubMed: 15544654]
 15. Leonard RJ, Eagle JC, Garland GE, Matthews KP, Rudd AL, Phillips C. Nightguard vital bleaching and its effect on enamel surface morphology. *J Esthet Restor Dent.* 2001;**13**(2):132-9. [PubMed: 11499448]
 16. Titley KC, Torneck CD, Ruse ND. The effect of carbamide-peroxide gel on the shear bond strength of a microfil resin to bovine enamel. *J Dent Res.* 1992;**71**(1):20-4. [PubMed: 1740551]
 17. Kunjappan S, Kumaar V, Khalid SA, Paul J, Prithiviraj. The effect of bleaching of teeth on the bond strength of brackets: An in vitro study. *J Pharm Bioallied Sci.* 2013;**5**(Suppl 1):S17-20. doi: 10.4103/0975-7406.113285. [PubMed: 23946568]
 18. Souza-Gabriel AE, Vitussi LO, Milani C, Alfredo E, Messias DC, Silva-Sousa YT. Effect of bleaching protocols with 38% hydrogen peroxide and post-bleaching times on dentin bond strength. *Braz Dent J.* 2011;**22**(4):317-21. [PubMed: 21861032]
 19. Homewood C, Tyas M, Woods M. Bonding to previously bleached teeth. *Aust Orthod J.* 2001;**17**(1):27-34. [PubMed: 11506167]
 20. Oztas E, Bagdelen G, Kilicoglu H, Ulukapi H, Aydin I. The effect of enamel bleaching on the shear bond strengths of metal and ceramic brackets. *Eur J Orthod.* 2012;**34**(2):232-7. doi: 10.1093/ejo/cjq193. [PubMed: 21262931]
 21. Kinoshita J, Jafarzadeh H, Manabe A, Nozawa M, Uchida T, Abbott PV. Effects of KTP Laser Bleaching on Traumatized Tooth Enamel. *Trauma Mon.* 2014;**19**(2):e18168. doi: 10.5812/traumamon.18168. [PubMed: 25032154]
 22. Loretto SC, Braz R, Lyra AM, Lopes LM. Influence of photopolymerization light source on enamel shear bond strength after bleaching. *Braz Dent J.* 2004;**15**(2):133-7. doi: 10.1590/S0103-64402004000200009. [PubMed: 15776196]