*Original Article*

# Effects of different bleaching methods on shear bond strengths of orthodontic brackets

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**ABSTRACT**

**Objective:** To evaluate the effects of different bleaching methods on the shear bond strength (SBS) of orthodontic brackets.

**Materials and Methods:** Forty-five freshly extracted premolars were randomly divided into three groups (n = 15 per group). In group I, bleaching was performed with the office bleaching method. In group II, bleaching was performed with the home bleaching method. Group III served as the control. Orthodontic brackets were bonded with a light cure composite resin and cured with an LED light. After bonding, the SBS of the brackets were tested with a Universal testing machine.

**Results:** Analysis of variance indicated a significant difference between groups ($P < .001$). The highest values for SBS were measured in group III (20.99 ± 2.32 MPa). The SBS was significantly lower in groups I and II than in group III ($P < .001$). The lowest values for SBS were measured in group II (6.42 ± 0.81 MPa). SBS was significantly higher in group I than in group II ($P < .001$).

**Conclusions:** Both of the bleaching methods significantly affected the SBS of orthodontic brackets on human enamel. Bleaching with the home bleaching method affected SBS more adversely than did bleaching with the office bleaching method. (*Angle Orthod.* 2013;83:686–690.)

**KEY WORDS:** Shear bond strength; Tooth bleaching agents; Orthodontic brackets; Dental bonding

## INTRODUCTION

Discoloration of teeth is one of the major esthetic concerns of dental patients.[1] With an increasing demand for adult orthodontics, orthodontists often encounter patients who are unsatisfied not only with the alignment but also with the color of their teeth.[1] Bleaching with various whitening agents in the office and in the home has now gained worldwide acceptance and has become popular among clinicians and patients as a method for lightening teeth. However, the changes in enamel structure and composition induced by these bleaching agents may decrease the shear bond strength (SBS) of orthodontic brackets.[2] Bleaching is a conservative alternative to more invasive esthetic treatments, such as crowning or the placement of veneers on discolored teeth.[3] Today, the most commonly used tooth bleaching agents contain hydrogen peroxide as the active ingredient.[1] Hydrogen peroxide may be applied directly or produced by a chemical reaction from sodium perborate or carbamide peroxide.[3] Hydrogen peroxide acts as a strong oxidizing agent through the formation of reactive oxygen molecules; these reactive molecules attack long-chained, dark-colored chromophore molecules and split them into smaller, less colored, and more diffusible molecules.[3]

Various studies[2,4–7] have evaluated the effects of bleaching on the SBS of orthodontic brackets with the office bleaching method. It has been demonstrated[8–10] that 35% hydrogen peroxide solutions change enamel structure and composition. Orthodontists are interested in determining whether any of these changes in the enamel surface also result in alteration of its adhesive characteristics with regard to orthodontic bonding materials. Several authors[5,6,11] found no adverse effect of bleaching on bond strengths of orthodontic brackets. However, many others[2,7,12] have reported a significant

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reduction in the bond strength of brackets after bleaching.

At-home bleaching is believed to be the most useful and effective bleaching method[13]; it was first described by Haywood and Heymann[14] in 1989 as nightguard dental bleaching. With this method, bleaching of all the teeth is undertaken over the course of 2 weeks, with bleaching occurring from 1 to 8 hours a day using a tray with a bleaching agent.[13,14]

Several studies have evaluated the effect of bleaching on the bond strength of orthodontic brackets with the office bleaching method; however, to the best of our knowledge, no studies have investigated the effects of home bleaching on the bond strength values of metallic brackets.

The aim of the present study was to determine the effects of different bleaching methods on the SBS and the adhesive remnant index (ARI) scores of metallic brackets. The null hypothesis to be tested was that there are no statistically significant differences in bond strength or failure site location between two bleaching methods.

## MATERIALS AND METHODS

Forty-five freshly extracted, noncarious, premolar teeth without visible defects were used in this study. After extraction, any residual tissue attached to the root surface was removed mechanically. The teeth were washed under running tap water and stored in distilled water until use. Each tooth was individually embedded in autopolymerizing acrylic resin (Meliodent, Heraus Kulzer, Hanau, Germany). The facial surfaces of the teeth were cleaned with a mixture of water and pumice. The teeth were rinsed thoroughly with water and dried with compressed air.

All teeth were randomly assigned to one of three groups (n = 15 in each group) as follows: (1) Group I: Teeth were bleached with an office bleaching method (Illuminé Office, Dentsply, Konstanz, Germany), according to the manufacturer's instructions. Bleaching agent (15% hydrogen peroxide) was utilized for 1 hour a day for 3 days. (2) Group II: Teeth were bleached with a home bleaching method (Illuminé Home, Dentsply), according to the manufacturer's instructions. Bleaching agent (10% carbamide peroxide [releasing hydrogen peroxide in a concentration of about 3.6%]) was utilized 8 hours a day for 3 weeks. (3) Group III: No bleaching procedure was applied. This group served as the control.

All bleaching procedures were conducted in a humid atmosphere at 37°C. The bleaching agents were applied on the dried enamel surfaces. The teeth were immersed in artificial saliva between bleaching applications. After bleaching and before retransferring to saliva, the bleaching material was carefully removed with a soft toothbrush under tap water.

The teeth were immersed in artificial saliva and allowed to stand for 4 weeks before bracket bonding. Before bonding, the facial surfaces of the teeth were cleaned with a mixture of water and pumice. The teeth were rinsed thoroughly with water and dried with oil- and moisture-free compressed air. Each tooth was etched with 37% phosphoric acid gel for 30 seconds. Next, all teeth were rinsed with a water/spray combination for 30 seconds and dried until a characteristic frosty white etched area was observed.

Ormco Mini 2000 (Ormco Corp, Glendora, Calif) premolar metallic brackets with 9.63 $mm^2$ surface area were used. Light Bond (Reliance Orthodontic Products Inc, Itasca, Ill) was used as an orthodontic adhesive. With a microbrush, a thin uniform layer of sealant was applied on the etched enamel and cured for 20 seconds. A thin coat of sealant was also painted on the metal bracket base and cured for 10 seconds before the paste was applied. A syringe tip was used to apply the paste to the bracket base. Then the bracket was positioned on the tooth and pressed lightly in the desired position. Excess adhesive was removed with a sharp scaler, and the adhesive was cured with a LED light curing unit (Ortholux TM, 3M Unitek, Monrovia, Calif) for 20 seconds.

Each specimen was loaded into a Universal testing machine (Instron Universal test machine, Elista, Istanbul, Turkey), with the long axis of the specimen kept perpendicular to the direction of the applied force. The standard knife edge was positioned in the occlusogingival direction and in contact with the bonded specimen. Bond strength was determined in the shear mode at a crosshead speed of 0.5 mm/min until fracture occurred. The values of failure loads (N) were recorded and converted into Megapascals (MPa) by dividing the failure load (N) by the surface area of the bracket base (9.63 $mm^2$).

After debonding, all teeth and brackets in the test groups were examined under 10× magnifications. Any adhesive remaining after debonding was assessed and scored according to the modified ARI.[15] The scoring criteria of the index are as follows:

1. The entire composite, with an impression of the bracket base, remained on the tooth.
2. More than 90% of the composite remained on the tooth.
3. More than 10% but less than 90% of the composite remained on the tooth.
4. Less than 10% of the composite remained on the tooth.
5. No composite remained on the tooth.

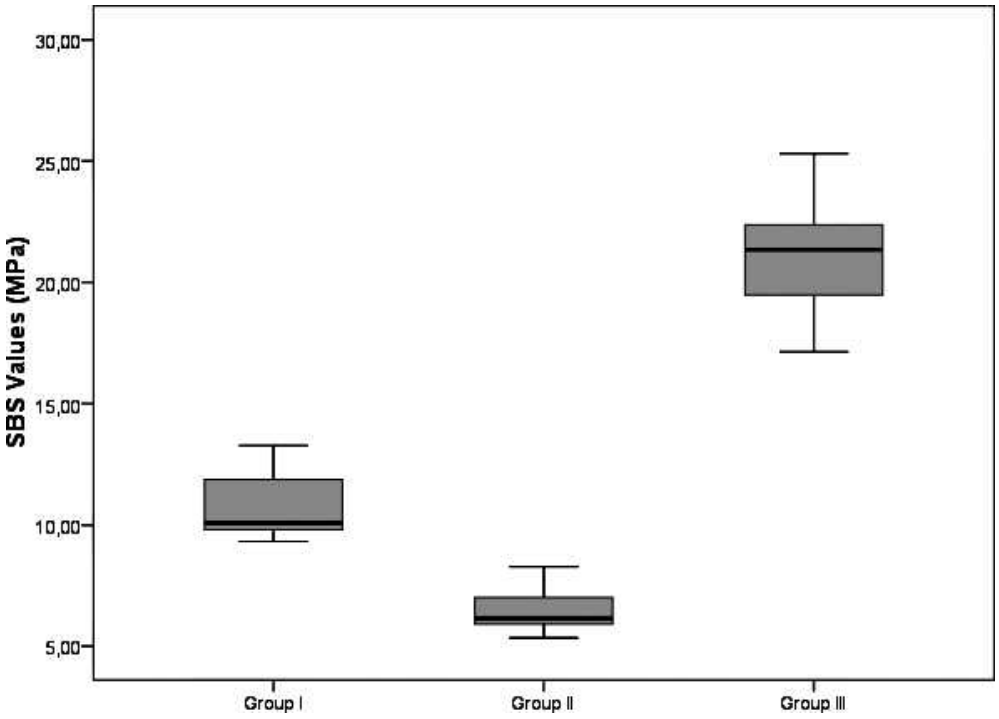


**Figure 1.** Shear bond strengths (MPa) of the groups. Results are presented as box plots. The horizontal line in the middle of each box plot shows the median value; horizontal lines in the box provide 25% and 75% quartiles; lines outside the box provide 5th and 95th percentages.

### Statistical Analysis

Descriptive statistics, including the mean, standard deviation, standard error, and minimum and maximum values, were calculated for each of the groups tested. The Kolmogorov-Smirnov test was used to determine whether the sample was normally distributed. The values indicated that the data were normally distributed ($P > .05$). Therefore, parametric tests were used. One-way analysis of variance (ANOVA) and Tukey multiple comparison tests were used to compare SBS among the groups. The chi-square test was used to determine significant differences in ARI scores among groups. Significance for all statistical tests was predetermined at $P < .05$. All statistics were performed with SPSS version 17.0 (SPSS Inc, Chicago, Ill).

## RESULTS

Descriptive statistics for the SBS (MPa) of all groups are presented as box plots in Figure 1. ANOVA indicated a significant difference between groups ($P < .001$) (Table 1). The highest values for SBS were measured in group III (20.99 $\pm$ 2.32 MPa). The SBS was significantly lower in groups I and II than in group III ($P < .001$). The lowest values for SBS were measured in group II (6.42 $\pm$ 0.81 MPa). SBS was significantly higher in group I than in group II ($P < .001$).

The frequency distribution of the ARI scores is presented in Table 2. Chi-square comparison revealed no significant differences between the groups. There was a greater frequency of ARI scores of 2, 3, and 4 in all groups, which indicated that failures showed cohesive characteristics.

## DISCUSSION

Various studies have investigated different bleaching agents and the various concentrations of these agents used for bleaching with regard to the SBS of orthodontic brackets. Most authors[2,4,8,12,16] concluded that bleaching adversely affects the SBS of orthodontic brackets when the bonding procedure is performed immediately or delayed by up to 1 month. Bishara et al.[6,11] and Uysal et al.[5] contradicted the studies that reported adverse effects of bleaching agents on SBS of brackets. They suggested that bleaching with 10% carbamide peroxide or 35% hydrogen peroxide did not adversely affect SBS of brackets. SBS values were

**Table 1.** The Results of the Analysis of Variance Comparing the Shear Bond Strengths of the Groups[a]

| Test Groups | n | Mean | SD | Minimum | Maximum | *P*-Value |
|---|---|---|---|---|---|---|
| Group I A | 15 | 10.77 | 1.36 | 9.32 | 13.27 | .000 |
| Group II B | 15 | 6.42 | 0.81 | 5.35 | 8.27 | |
| Group III C | 15 | 20.99 | 2.32 | 17.13 | 25.31 | |

[a] Significance: The same small capital letters indicate homogeneous subsets. SD indicates standard deviation.

**Table 2.** Frequency Distribution of the Adhesive Remnant Index (ARI) Scores and the Chi-Square Comparison of the Groups

| | ARI Scores (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| Groups | 1 | 2 | 3 | 4 | 5 | n | *P*-Value |
| Group I | 0 (0) | 5 (33.3) | 6 (40) | 3 (20) | 1 (6.7) | 15 | .389 |
| Group II | 1 (6.7) | 3 (20) | 6 (40) | 4 (26.7) | 1 (6.7) | 15 | |
| Group III | 0 (0) | 1 (6.7) | 4 (26.7) | 8 (53.3) | 2 (13.3) | 15 | |

significantly lower in all of the study groups than in the control group in the current study. Reduction in SBS after bleaching may be due to enamel surface morphology with varying degrees of surface roughness and structural changes by loss of prismatic formation,[8] alterations in the organic substance, the loss of calcium and decreases in microhardness,[17] or the residual oxygen from the bleaching agent, which interferes with resin infiltration into the bleached enamel or inhibits resin polymerization.[18]

Home bleaching is one of the most preferred bleaching methods because of its simplicity, low cost, and safety (as a result of the use of low concentrations of peroxide used).[19] Ten percent carbamide peroxide is the commonly used material with this method.[19] In the current study, bleaching with the home bleaching method affected the SBS of the orthodontic brackets more adversely than did bleaching with the office bleaching method. Since there is no study evaluating the effect of home bleaching on SBS of orthodontic brackets, we could not compare the results of our study. Although the peroxide concentration of the bleaching material used in office bleaching is about four times greater than the peroxide concentration of the bleaching material used in home bleaching, home bleaching more adversely affected the SBS of orthodontic brackets. This finding can be explained by the longer application periods associated with the home bleaching method because alterations in the organic substance and the loss of calcium could be increased in time. It can be concluded that duration of application of the bleaching material is important, and if bleaching is mandatory, office bleaching should be used as the bleaching method.

Some authors[12,18] reported that the residual oxygen produced by the bleaching agents inhibited resin polymerization and interfered with resin attachment. Most authors recommend delaying bonding of the brackets after bleaching for 2 to 4 weeks. To eliminate the detrimental effects of residual oxygen from the bleaching agent, in our study, we delayed bonding of the brackets for 4 weeks and stored the specimens in artificial saliva.

ARI scores are used to define the site of bond failure among the enamel, adhesive, and bracket base. Bond failures within the adhesive or at the bracket-adhesive interface are preferred because they decrease shear force stress at the enamel surface and increase the probability of maintaining an undamaged enamel surface.[15] In this study, the results of ARI score comparisons indicated no significant differences among the four groups. The results indicated that bleaching did not have a detrimental effect on the failure site during debonding. The failures mainly showed cohesive characteristics in all groups, as is preferred.

## CONCLUSIONS

- Bleaching significantly affects the SBS of orthodontic brackets on human enamel.
- Bleaching with the home bleaching method affects SBS more adversely than does bleaching with the office bleaching method.
- Bleaching procedures should be delayed until the completion of orthodontic treatment.
- If bleaching is mandatory, office bleaching should be used as the bleaching method.

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