Original Article

Bleaching and Desensitizer Application Effects on Shear Bond Strengths of Orthodontic Brackets

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ABSTRACT

Objective: To evaluate the effects of bleaching and desensitizer application on shear bond strengths of orthodontic brackets.

Materials and Methods: Forty-eight extracted human premolar teeth were randomly assigned to 4 groups of 12 each. The first group of teeth was bleached with a 35% hydrogen peroxide office bleaching agent. The second group was bleached the same as the first group and UltraEZ desensitizer was applied. No bleaching procedures were applied on the third and fourth groups. UltraEZ desensitizer alone was applied to teeth in the third group. The fourth group served as control. Orthodontic brackets were bonded with a LC (light cure) composite resin and cured with a halogen light. After bonding, the shear bond strengths of the brackets were tested with a Universal testing machine.

Results: The results showed that bleaching, bleaching plus desensitizer, and desensitizer procedures significantly reduced the bonding strengths of the orthodontic brackets ($P < .05$, $P < .001$, and $P < .01$, respectively). No statistically significant difference was found between bleaching, bleaching plus desensitizer, and desensitizer groups ($P > .05$).

Conclusions: Because bleaching and desensitizer application significantly affected shear bond strengths of orthodontic brackets on human enamel, they should be delayed until the completion of orthodontic treatment.

KEY WORDS: Bleaching; Desensitizer; Hydrogen peroxide; Potassium nitrate; Shear bond strength; Carbamide peroxide

INTRODUCTION

Discoloration of teeth is a great esthetic problem. Its etiologic factors are varied and complex but are usually classified as being either intrinsic, extrinsic, or internalized in nature.[1] Today, in-office or home vital bleaching with various whitening agents has gained acceptance among dentists and patients as a simple, safe, effective, and predictable method to lighten teeth.[2]

Two of the most commonly used agents are hydrogen peroxide and carbamide peroxide solutions. It has been demonstrated that 35% hydrogen peroxide solutions change enamel structure and composition.[3–5] Clinicians and researchers are obviously interested in determining whether any of the changes in the enamel surface also result in alteration of its adhesive characteristics to orthodontic bonding materials. Several authors have dealt with this subject and found no adverse effect of bleaching on bond strengths of orthodontic brackets.[6–8] However, Miles et al[9] reported a significant reduction in bond strength of ceramic brackets after 72 hours of bleaching. More recent studies have shown that bleaching immediately before bonding reduced tensile and shear bond strengths of composite resin to enamel.[10,11] Therefore, further research is needed to clarify these conflicting results.

It has been documented that patients undergoing the procedure may experience tooth sensitivity as a side effect.[12,13] Patients might benefit from a regimen of a desensitizing agent to decrease or prevent sensitivity during or after bleaching.[13–17] The effect of de-

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sensitizers on the bond strength of adhesives to dentin is well documented.[18–21] However, to our knowledge, the effect of desensitizer agents on shear bond strength of orthodontic adhesives to human enamel has been investigated in only two recent studies.[22,23] However, composite specimens were used instead of brackets to test bond strength. Therefore, the aim of this in vitro study was to evaluate the effects of bleaching and desensitizer application on shear bond strengths of orthodontic brackets.

MATERIALS AND METHODS

Forty-eight noncarious freshly extracted human permanent premolar teeth without any caries or visible defects were stored in 0.1% thymol solution at room temperature. Each tooth was individually embedded in auto-polymerizing acrylic resin (Meliodent, Herause Kulzer, Hanau, Germany). The specimens were kept in distilled water except during the bleaching, bonding, and testing procedures. All teeth were randomly assigned to 4 groups of 12 each.

Group I. Teeth were bleached with 35% hydrogen peroxide (Opalescence Xtra, Ultradent Products Inc, South Jordan, Utah), exposed to a fast halogen curing light (1000 mW/cm^2) (Blue Swan, Dentanet, Istanbul, Turkey) for 20 seconds, and left standing for 15 minutes. The gel that had been applied to the tooth was washed away and a fresh gel was reapplied, light-activated, left standing for another 15 minutes, and washed away. Before bonding, the teeth were stored in distilled water for 2 days at room temperature.

Group II. Teeth were bleached in the same manner as for group I, except that after bleaching and before bonding, UltraEZ (Ultradent Products Inc) desensitizer gel was placed in the buccal surfaces of the teeth and left on overnight at room temperature. All teeth were rinsed with water before bonding.

Group III. Only UltraEZ desensitizer gel was applied, in the same manner as for group II.

Group IV. Control group. Neither bleaching nor desensitizer was applied.

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. Then, 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) bicuspid metal brackets with 9.63 mm^2 surface area were used. Light Bond (Reliance Orthodontic Products Inc, Itasca, Ill) was used as 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. Using a syringe tip, the paste was applied 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 Heliolux DLX (Vivadent ETS, Schaan, Liechtenstein) (75W) for 40 seconds (20 seconds on the mesial and 20 seconds on the distal surface of the brackets).

Each specimen was loaded into universal testing machine (Lloyd, Fareham, Hants, England) using Nexjen software (Nexjen Systems, Charlotte, NC) for testing, with the long axis of the specimen being perpendicular to the direction of the applied force. The standard knife edge was positioned in the occluso-gingival direction and to make 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× magnification. Any adhesive remained after debonding was assessed and scored according to the modified adhesive remnant index (ARI).[24] The scoring criteria of the index are as follows:

1 = All of the 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 composite remained on the tooth.
5 = No composite remained on the tooth.

Statistical Analysis

Descriptive statistics, including the mean, standard deviation, standard error, and minimum and maximum values, were calculated for each of the groups tested. One-way analysis of variance (ANOVA) and Tukey multiple comparison tests were used to compare shear bond strengths of the groups. The chi-square test was used to determine significant differences in the ARI scores among groups. Significance for all statistical tests was predetermined at $P < .05$. All statistics were performed with SPSS version 13.0.0 (SPSS Inc, Chicago, Ill).

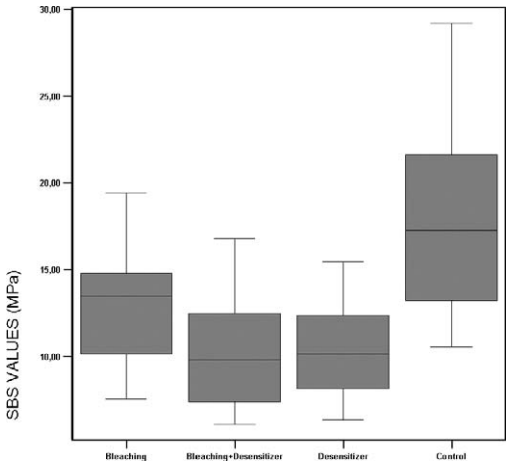

Figure 1. Shear bond strengths (MPa) of the groups. Results presented as boxplots. Horizontal line in middle of each boxplot shows median value; horizontal lines in box give 25% and 75% quartiles; lines outside box give 5th and 95th percentiles.

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

Group I (Bleaching)		Group II (Bleaching + Desensitizer)		Group III (Desensitizer)		Group IV (Control)		Significance
Mean	SD	Mean	SD	Mean	SD	Mean	SD	
13.10	3.60	10.14	3.31	10.87	3.86	17.76	5.83	0.000***

Post Hoc Tests					
I–II	I–III	I–IV	II–III	II–IV	III–IV
ns	ns	*	ns	***	**

[a] ns indicates nonsignificant; *$P < .05$; **$P < .01$; ***$P < .001$.

RESULTS

The descriptive statistics on the shear bond strength (MPa) for the groups are presented as boxplots in Figure 1. All groups displayed clinically acceptable mean bond strengths (over 8 MPa). Analysis of variance indicated a significant difference between groups ($P < .001$) (Table 1). The highest values of shear bond strengths were measured in group IV (control). The shear bond strengths in groups I, II, and III were significantly lower than those of group IV ($P < .05$, $P < .001$, and $P < .01$, respectively). No significant difference was found between groups I, II, and III ($P > .05$).

Frequency distribution of the ARI scores is presented in Table 2. Chi-square comparison revealed no significant difference between groups. There was a greater frequency of ARI scores of 1 and 2 in all groups, which indicated that failures were mainly in the adhesive-bracket interface.

DISCUSSION

After an increasing demand for adult orthodontics, orthodontists often face patients who are not satisfied only with well-aligned, but also want white teeth. In-office or home vital bleaching with various whitening agents has now gained worldwide acceptance among clinicians and patients for lightening teeth. However, changes in enamel structure and composition induced by these bleaching agents are still controversial. Moreover, orthodontists also wonder whether enamel bleaching adversely influences the bond strengths of brackets bonded to the enamel. Bishara et al[6,8] evaluated the effect of enamel bleaching on the bonding strength of orthodontic brackets and stated that the use of 10% carbamide peroxide did not result in significant changes in the shear bond strength of orthodontic brackets. Uysal et al[7] suggested that office bleaching with 35% hydrogen peroxide did not adversely affect the bond strengths of brackets bonded immediately after bleaching or for 30 days after bleaching.

Table 2. Frequency Distribution of the Adhesive Remnant Index (ARI) Scores[a]

Test Group	ARI Score 1	2	3	4	5	n
Bleaching	4	5	2	0	1	12
Bleaching + Desensitizer	4	5	2	1	0	12
Desensitizer	5	2	4	1	0	12
Control	4	4	2	1	1	12

[a] Chi-square comparison revealed no significant differences between groups.

However, Miles et al[9] contradicted the studies that reported no adverse affects of bleaching agents on bond strengths of brackets. Their results indicated that recently bleached teeth with 10% carbamide peroxide had significantly reduced bond strength values when compared with controls. They suggested discontinuing tooth whitening product usage at least 1 week before the bonding of orthodontic attachments. In agreement with Miles et al,[9] lower shear bond strengths in bleaching groups were obtained in the present study.

This decrease in bond strength may be related to any of the changes in enamel surface and/or composition.[3,4] The reaction between peroxide and the organic materials on the surface or subsurface of enamel can result in morphologic alterations.[25] Josey et al[5] investigated the effect of vital bleaching technique on enamel surface morphology and the bonding of composite resin to enamel. Light microscopy investigation suggested that the bleaching process resulted in a loss of mineral from enamel that was evident 24 hours after bleaching and was sustained following 12 weeks of storage in artificial saliva. Scanning electron microscopy showed a definite change in the surface texture of the bleached enamel surface. Acid etching of the bleached enamel surface produced loss of pris-

matic form and the enamel appeared overetched. Moreover, loss of calcium, decrease in microhardness, and alterations in the organic substance have been associated with reduced bond strengths.[25,26] On the other hand, Chen et al,[27] Haywood et al,[28] and Scherer et al[29] concluded that carbamide peroxide solutions did not cause any significant change in enamel surface structure or result in enamel etching.

Some authors suggested that residual bleaching agents affected the bonding process and were responsible for decreased bond strengths.[4,9] They recommended pumicing before bonding to reduce any residual hydrogen peroxide. They also suggested that bleaching should be ceased 1 week before orthodontic bonding to ensure adequate bond strengths.[9–11] Several authors also recommended delaying bonding after bleaching, with delay periods varying from 24 hours to 4 weeks.[7,30–32] In addition, Lai et al[33,34] and Bulut et al[10,11] recommended treating the bleached enamel surface with 10% sodium ascorbate, an antioxidant agent, to reverse the reduced bond strengths obtained immediately after bleaching. On the other hand, Sung et al[35] recommended use of alcohol-based dental bonding agents to reduce or eliminate the detrimental effects of residual oxygen to the composite bonding process. All their results are promising and worth further investigations. Residual bleaching agents might be a factor, but not the only one. We suggest that any changes in composition and surface of enamel with or without residual bleaching agents might be responsible for inadequate bond strengths.

Tooth sensitivity is a common side effect associated with tooth bleaching.[13] Authors recommended use of desensitizers or 10% carbamide peroxide bleaching gels containing potassium nitrate and fluoride to reduce tooth sensitivity.[15–17] In our study, UltraEz (Ultradent Products Inc) (3% potassium nitrate and 0.11% fluoride ion) was used as a desensitizer agent. The desensitizing effect of potassium nitrate is believed to result from the sensory nerves' being prevented from repolarizing after initial depolarization. Increased levels of potassium nitrate may maintain the depolarized state of the sensory nerves, decreasing the perception of pain.[16,36] Sequential application of these agents resulted in instant occlusion of dentin tubules and immediate relief from hypersensitivity. However, covering the surface with this gel and remnants may possibly affect bonding of adhesives. Malkoc et al[22] reported remarkably decreased bond strength of orthodontic adhesives used to attach the bracket to the etched enamel surface after application of Gluma Desensitizer™. They related this reduction with the result of the glutaraldehyde content blocking the enamel tags. Holzmeier et al[23] explained the reduction in shear bond strength values (in conjunction with the addition of glutaraldehyde) as a decrease in etching capacity. Reduced shear bond strength values in the bleaching plus desensitizer group and the desensitizer group supported this hypothesis.

The oral cavity is a complex environment, with variations in temperature, stresses, humidity, acidity, and plaque.[37] Although it is impossible to reproduce a laboratory condition that fully represents the oral environment, storage conditions and variations in temperature must at least be similar. Thermocycling of the specimens was recommended for quality testing of adhesive materials.[38] It was the weakness of this study that no thermocycling was performed. Further studies on this subject may better correlate with clinical conditions.

CONCLUSIONS

a. Bleaching and desensitizer application significantly affected shear bond strengths of orthodontic brackets on human enamel.
b. Bleaching and desensitizer procedures should be delayed until the completion of orthodontic treatment.

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