Original Article

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

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ABSTRACT

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

Materials and Methods: Sixty freshly extracted mandibular incisors were randomly divided into four groups (n = 15 per group). After filling the root canals, root fillings were removed 2 mm apical to the cementoenamel junction, and a 2-mm-thick layer of zinc-phosphate cement base was applied. Group 1 served as the control. Intracoronal bleaching was performed with hydrogen peroxide (Opalacence Endo, Ultradent products Inc, South Jordan, Utah) in group 2, sodium perborate (Sultan Healthcare, Englewood, NJ) in group 3, and 37% carbamide peroxide (Whiteness Super Endo, Dentscare, ltda, Joinville, Brazil) in group 4. Orthodontic brackets were bonded with a light cure composite resin and cured with an LED light. After bonding, the SBS of the brackets was 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 1 (10.15 $\pm$ 1.15 MPa). The SBS was significantly lower in groups 2, 3, and 4 than in group 1 ($P < .001$). The lowest values for SBS were measured in group 3 (6.17 $\pm$ 0.85 MPa). SBS was significantly higher in group 4 than in group 3 ($P < .05$).

Conclusions: Intracoronal bleaching significantly affected the SBS of orthodontic brackets on human enamel. Bleaching with sodium perborate affects SBS more adversely than does bleaching with other agents. (*Angle Orthod.* 2012;82:942–946.)

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

INTRODUCTION

Discoloration of teeth is one of the biggest esthetic concerns of dental patients. Tooth discoloration may be classified as intrinsic, extrinsic, or a combination of both.[1] Intrinsic discoloration is caused by incorporation of chromatogenic material into dentin and enamel during odontogenesis or after eruption.[2] 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. Vital and nonvital 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 may decrease the shear bond strength (SBS) of orthodontic brackets.[3] Intracoronal bleaching is a conservative alternative to more invasive nonvital esthetic treatments such as crowning or the placement of veneers on discolored teeth.[2] Today, the most commonly used tooth-bleaching agents contain hydrogen peroxide as the active ingredient. Hydrogen peroxide may be applied directly or produced by a chemical reaction from sodium perborate or carbamide peroxide.[2] 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.[2]

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Various studies have evaluated the effect of extracoronal (vital) bleaching on the SBS of orthodontic brackets.[3–6] It has been demonstrated that 35% hydrogen peroxide solutions change enamel structure and composition.[7–9] Orthodontists are interested in determining whether any of these changes in the enamel surface also result in alteration of its adhesive characteristics to orthodontic bonding materials. Several authors found no adverse effect of bleaching on bond strengths of orthodontic brackets.[5,6,10] However, many others have reported a significant reduction in bond strength of brackets after bleaching.[3,11]

Several studies have evaluated the effect of extracoronal bleaching on the bond strength of orthodontic brackets; however, to the best of our knowledge, no studies have used sodium perborate or hydrogen peroxide, and only 2 studies[12,13] have used carbamide peroxide and subsequently investigated the effect of intracoronal bleaching on the bond strength values of metallic brackets.

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

MATERIALS AND METHODS

Sixty freshly extracted, noncarious, single-rooted mandibular incisors without any caries or 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 usage. Each tooth was individually embedded in auto polymerizing 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.

Standard endodontic access cavities were created with an International Organization of Standardization 12 round diamond bur (Diatech, Coltene Whaledent, Altststten, Switzerland) with a high-speed hand piece under water cooling. The root canal of each tooth was explored using a size-10 K-file (Mani Inc, Tochigi, Japan) until the apical foremen was reached and the tip of the file was seen. The step-back technique was used to prepare root canals to size 35 at a working length of 1 mm from the apex. Thorough irrigation of the instrumentation was performed using 2 mL of 2.5% sodium hypochloride after each file. After the final irrigation, root canals were dried with sterile paper points. The canals were filled with the epoxy resin–based root canal sealer AH Plus (Dentsply, De Trey, Konstanz, Germany) and gutta-percha (Diadent, Seoul, Korea) using a cold lateral condensation technique. After filling the root canals, the root fillings were removed 2 mm apical to the cementoenamel junction, and a 2-mm-thick layer of zinc-phosphate cement base (Adhesor, Spofa Dental, Markova, Czech Republic) was applied. All teeth were randomly assigned to four groups (n = 15 in each group) as follows:

- Group 1: The access cavity was rinsed with distilled water and dried, and the final composite restoration was applied.
- Group 2: Intracoronal bleaching was performed with 35% hydrogen peroxide (Opalescence Endo, Ultradent Products Inc). The bleaching agent was placed into the cavity, and the cavity was closed by a temporary filling material (Cavit, AG, D-82229, 3M ESPE, Seefeld, Germany). This procedure was repeated a further two times (once every four days). After 12 days, the temporary filling material was removed, the access cavity was rinsed with distilled water, and the final composite restoration was applied.
- Group 3: Intracoronal bleaching was performed with sodium perborate (Sultan Healthcare, Englewood, NJ). The bleaching procedure used was the same as that for group 2.
- Group 4: Intracoronal bleaching was performed with 37% carbamide peroxide (Whiteness Super Endo, Dentscare). The bleaching procedure used was the same as that for group 2.

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) mandibular incisor metallic 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. 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

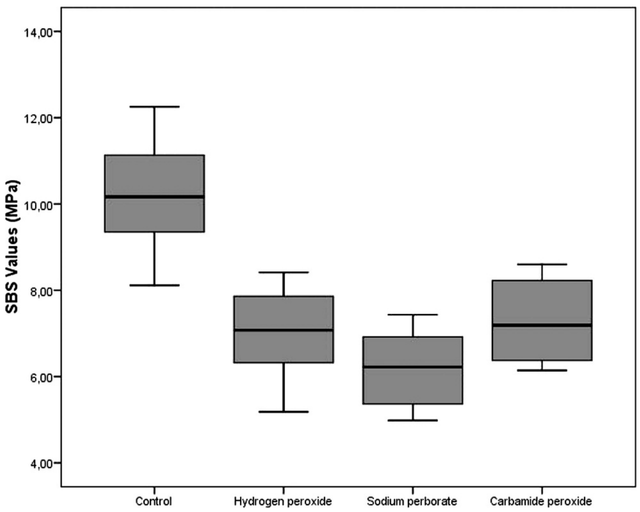

Figure 1. Shear bond strengths (MPa) of the groups. Results presented as boxplots. The horizontal line in the middle of each boxplot shows the median value, the horizontal line in the box gives 25% and 75% quartiles, and lines outside the box give 5th and 95th percentiles.

desired position. Excess adhesive was removed with a sharp scaler, and the adhesive was cured with an 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× magnification. Any adhesive remaining after debonding was assessed and scored according to the modified ARI.[14] 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 the 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 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 18.0 (SPSS Inc, Chicago, Ill).

RESULTS

Descriptive statistics for the SBS (MPa) of all groups are presented as boxplots in Figure 1. ANOVA indicated a significant difference between groups ($P < .001$; Table 1). The highest values for SBS were measured in group 1 (control). The SBS values in groups 2, 3, and 4 were significantly lower than those in group 1 ($P < .001$). The lowest values for SBS were measured in group 3 (sodium perborate). The SBS in group 4 was significantly higher than that in group 3 ($P < .05$). No significant difference was found between groups 2 and 3 or between groups 2 and 4 ($P < .05$).

The frequency distribution of the ARI scores is presented in Table 2. Chi-square comparison revealed no significant difference 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 extracoronal bleaching with regard to

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

Test Group	Significance	Mean	Min	Max	SD	SE	5% PCT	25% Q	Median	75% Q	95% PCT
Group 1	a	10.15	8.12	12.25	1.15	0.30	9.50	9.33	10.17	11.2	10.80
Group 2	b,c	7.05	5.18	8.41	0.96	0.25	6.51	6.26	7.07	7.9	7.58
Group 3	b	6.17	4.98	7.43	0.85	0.22	5.70	5.35	6.22	7.04	6.65
Group 4	c	7.28	6.14	8.60	0.95	0.25	6.76	6.35	7.19	8.34	7.81

[a] Significance: The same letters indicate homogeneous subsets. SD indicates standard deviation; SE, standard error; PCT, percentile; Q, quartile.

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

	ARI Scores						
	1	2	3	4	5	ıı	Test
Group I	1	5	5	2	2	15	NS
Group II	0	7	4	3	1	15	NS
Group III	1	8	4	1	1	15	NS
Group IV	0	8	2	4	1	15	NS

NS, non-significant.

the SBS of orthodontic brackets. Most authors conclude that bleaching adversely affects the SBS of orthodontic brackets when the bonding procedure is performed immediately or delayed by up to 1 month.[3,4,9,11,15] Bishara et al.[6,10] 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.

Although numerous studies have investigated extracoronal bleaching, we have found only two studies that investigated the effect of intracoronal bleaching treatment on the SBS of metallic brackets bonded with orthodontic composites to enamel.[12,13] In both of these studies, Uysal et al.[12,13] reported that intracoronal bleaching with 16% carbamide peroxide adversely affected the SBS of brackets bonded immediately after bleaching or 30 days after bleaching. They suggested that lower SBS could be due to changes in enamel structure resulting from increased porosity or reduction of the microhardness of dentin and enamel by the loss of calcium. In agreement with Uysal et al.,[12,13] lower SBS in all bleaching groups was observed in the present study.

SBS after the application of various intracoronal bleaching agents has been compared by several authors. Amaral et al.[16] evaluated the in vitro effects of sodium perborate, carbamide peroxide, and hydrogen peroxide intracoronal bleaching on enamel and dentin bond strength; they concluded that all of the intracoronal bleaching techniques tested reduced the bond strength of dentin. The lowest bond strengths to dentin were observed in groups that received intracoronal bleaching with sodium perborate. The authors stated that this could be due to the pH of sodium perborate. Consistent with this finding, the sodium perborate group also showed the weakest SBS in the current study. On the other hand, Rotstein et al.[17] found that intracoronal bleaching with hydrogen peroxide reduced the level of calcium in tooth enamel, while bleaching with sodium perborate did not affect calcium levels. Shinohara et al.[18] compared the effects of perborate and carbamide peroxide intracoronal bleaching on enamel and dentin bond strength; they found a statistically significant decrease in the bond strength of composite resin for enamel and dentin after nonvital bleaching with both agents. However, they found no statistically significant differences between these bleaching agents. This discrepancy with the present report may be due to differences in study design.

Some authors[11,19] have suggested that residual oxygen produced from bleaching agents inhibits resin polymerization and interferes with resin attachment. Most authors recommend delaying bonding of the brackets after bleaching for 2 to 4 weeks. To eliminate the 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. However, Uysal et al.[12] suggested that during intracoronal bleaching, sealing the pulp chamber and the access cavity where the bleaching gel is placed before immersion in artificial saliva might retard the elimination of residual peroxide from the tooth structure. Consistent with this suggested explanation, in the present study, SBS values were significantly lower in all of the study groups than in the control group.

ARI scores are used to define the site of bond failure between 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.[14] In this study, the results of ARI score comparisons indicated no significant differences among the four groups. The failures mostly showed cohesive characteristics in all groups, as preferred.

Most authors have concluded that bleaching adversely affects the SBS of orthodontic brackets.[3,4,9,11,15] In agreement with these studies, SBS values were significantly lower in all of the study groups than in the control group in the current study. Therefore, bleaching procedures should be delayed until the completion of orthodontic treatment. If intracoronal bleaching is mandatory, carbamide peroxide should be used as the bleaching agent.

CONCLUSIONS

- Intracoronal bleaching significantly affected the SBS of orthodontic brackets on human enamel.
- Bleaching with sodium perborate affects SBS more adversely than does bleaching with other agents.
- Bleaching procedures should be delayed until the completion of orthodontic treatment.
- If intracoronal bleaching is mandatory, carbamide peroxide should be used as the bleaching agent.

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