Bond strength of orthodontic brackets bonded to enamel with a self-etching primer after bleaching and desensitizer application

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Objective: The aim of this study was to compare the shear bond strengths (SBS) of orthodontic brackets bonded to enamel with a self-etching primer after bleaching, desensitizer application and combined treatment. Methods: Forty-eight premolars were randomly divided into four groups, each with n = 12 premolar samples. The four groups were; Group 1: 15% hydrogen-peroxide office bleaching agent (Illuminé Office-IO), Group 2: IO + BisBlock Oxalate Dentin-Desensitizer, Group 3: Bis Block Oxalate Dentin-Desensitizer, Group 4: No treatment (control). Twenty-four hours after bonding, the specimens were tested in SBS at a crosshead speed of 5 mm/min until the brackets debonded. The failure mode of the brackets was determined by a modified adhesive remnant index. Results: Bleaching, bleaching and desensitizer treatment, and desensitizer treatment alone all significantly reduced SBS of the orthodontic brackets (p = 0.001). No statistically significant difference was found between Group 1, Group 2 and Group 3 (Group 1-Group 2, p = 0.564; Group 1-Group 3, p = 0.371; Group 2-Group 3, p = 0.133). The predominant mode of failure for the treatment groups (Group 1, Group 2 and Group 3) was at the enamel-adhesive interface leaving 100% of the adhesive on the bracket base. Conclusions: Bleaching and desensitizer treatment should be delayed until the completion of orthodontic treatment. (Korean J Orthod 2010;40(5):342-348)

Key words: Bracket, Adhesive, Bonding

INTRODUCTION

Bleaching is considered the most conservative and economical alternative for improving the appearance of discolored teeth. Vital tooth bleaching can be performed either in the dental office (office bleaching) or by the patient at home (home bleaching). Hydrogen peroxide and carbamide peroxide solutions are widely used as a bleaching agent. The ability of these products to lighten the color is clear but the safety of these bleaching agents is a cause for concern. Pulpal and gingival irritation, changes in salivary pH, alterations in enamel surface morphology, adherence of *streptococcus mutans* to bleached enamel, alterations on composite resins, microleakage of restorations and changes in ultramorphological res-
Table 1. Manufacturers and types of the materials utilized in the study

<table>
<thead>
<tr>
<th>Products</th>
<th>Type</th>
<th>Composition</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illuminé</td>
<td>Office bleaching agent</td>
<td>30% hydrogen peroxide, poly (methyl vinyl ether/maleic anhydride) mixed calcium/sodium salts, titanium dioxide</td>
<td>Dentsply, DeTrey, GmbH, Konstanz, Germany</td>
</tr>
<tr>
<td>BisBlock</td>
<td>Oxalate dentin desensitizer</td>
<td>Oxalic acid</td>
<td>Bisco Inc, Schaumburg, IL, USA</td>
</tr>
<tr>
<td>Transbond Plus</td>
<td>Self-etching primer</td>
<td>Fluoride, no filler, methacrylate ester derivative</td>
<td>3M Unitek, Monrovia, CA, USA</td>
</tr>
<tr>
<td>Transbond XT</td>
<td>Light cure adhesive paste</td>
<td>Quartz silica, Bis-GMA, bisphenol A bis (2-hydroxyethyl ether) dimetacrylate</td>
<td>3M Unitek, Monrovia, CA, USA</td>
</tr>
</tbody>
</table>

Bis-GMA, Bis-phenol A diglycidylmethacrylate.
MATERIAL AND METHODS

Manufacturers and types of the materials utilized in this study are presented in Table 1. Forty-eight freshly extracted human permanent premolars without any caries or visible defect were used. The criteria for tooth selection included intact buccal enamel, no pretreatment chemical agents (e.g., hydrogen peroxide), no cracks caused by the extraction forceps and no caries. The teeth were cleaned and then polished with pumice and rubber cups for 10 seconds and the roots were embedded in polymethyl methacrylate.

The teeth were randomly assigned to 4 groups. Each group consisted of 12 specimens. The four treatment groups were:

Group 1: Teeth were bleached with 15% hydrogen peroxide office bleaching agent (Illuminé Office, Dentsply, Konstanz, Germany) for 60 minutes. Before bonding, the teeth were stored in distilled water for two days at room temperature.

Group 2: Teeth were bleached in the same manner as Group 1, except that after bleaching and before bonding, desensitizer gel (BisBlock Oxalate Dentin Desensitizer; Bisco Inc., Schaumburg, IL, USA) was used. For the desensitizer application, the following procedures were performed: the teeth samples were etched for 15 seconds, rinsed, and then gently air dried for 2 - 3 seconds. BisBlock Oxalate Dentin Desensitizer was applied (dwell time 30 seconds) and rinsed. One-Step Plus (Bisco Inc., Schaumburg, IL, USA) was applied and light cured for 10 seconds.

Group 3: Only BisBlock Oxalate Dentin Desensitizer was applied in the same manner as for Group 2.

Group 4 (control group): Neither bleaching nor desensitizer was applied.

Stainless steel premolar brackets (Generous Roth Brackets of GAC International Inc., Islandia, NY, USA) were used in this study. The average bracket base surface area was 12.13 mm².

Transbond Plus self-etching primer was gently rubbed onto the surface for approximately 3 seconds with the disposable applicator. Then, a moisture-free air source was used to deliver a gentle burst of air to the enamel. Transbond XT light cure adhesive paste (3M Unitek, Monrovia, CA, USA) was applied on the base of the bracket pad and pressed firmly onto the tooth. Excessive adhesive was removed from the periphery of the bracket base. A LED light source (Elipar Free Light 2; 3MESPE, St. Paul, MN, USA) was used for curing for 20 seconds from each of the mesial and distal sides.

After the bonding procedure, all samples were stored in deionized water at 37°C for 24 hours. A knife-edged shearing blade was secured on the crosshead with the direction of force parallel to the labial surface and the bracket interface. The universal test machine (Zwick Test Machine, Zwick GmbH & Co, Ulm, Germany) was used for the SBS at a crosshead speed of 5 mm/min. Each tooth was oriented so that its facial surface was parallel to the direction of force during the SBS testing. Force was directly applied to the bracket-tooth interface. The load at bracket failure was recorded by a computer connected to the Zwick test machine. The SBS values were calculated in megapascals by dividing the force by the area of the bracket base.

After debonding, the teeth and the brackets were examined under 16X magnification by a stereomicroscope (Leica MS5, Leica Microsystems (SEA) Ptd Ltd., Singapore, Singapore). Any adhesive that remained after debonding was assessed and scored according to the modified adhesive remnant index (ARI). The ARI scale and the definition of scores are exhibited in Table 2.

Comparison among the four groups was performed by using Kruskal-Wallis rank test at the significance level of α = 0.05. Pairwise comparisons were performed by using Mann Whitney U test with Bonferroni correction.

Table 2. The Adhesive Remnant Index (ARI) score²⁰ scale

<table>
<thead>
<tr>
<th>Scores</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No adhesive left on the bracket</td>
</tr>
<tr>
<td>1</td>
<td>Less than 25% of adhesive left on the bracket</td>
</tr>
<tr>
<td>2</td>
<td>25 - 50% of adhesive left on the bracket</td>
</tr>
<tr>
<td>3</td>
<td>50 - 75% of adhesive left on the bracket</td>
</tr>
<tr>
<td>4</td>
<td>75 - 100% adhesive left on the bracket</td>
</tr>
<tr>
<td>5</td>
<td>100% of adhesive left on the bracket</td>
</tr>
</tbody>
</table>
Table 3. The mean shear bond strength (SBS) values (MPa), standard deviations (SD), minimum and maximum values of the groups tested (unit: MPa)

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean ± SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>12</td>
<td>4.53 ± 0.60a</td>
<td>3.82</td>
<td>5.77</td>
</tr>
<tr>
<td>Group 2</td>
<td>12</td>
<td>4.63 ± 0.77a</td>
<td>3.91</td>
<td>6.21</td>
</tr>
<tr>
<td>Group 3</td>
<td>12</td>
<td>4.22 ± 1.18a</td>
<td>3.22</td>
<td>6.56</td>
</tr>
<tr>
<td>Group 4</td>
<td>12</td>
<td>8.81 ± 1.01b</td>
<td>7.87</td>
<td>10.90</td>
</tr>
</tbody>
</table>

Different superscript letters showed statistically different groups. Significance was determined at a probability value of $p < 0.05$. Group 1, Office bleaching + self etch + bracket; Group 2, office bleaching + BisBlock + self etch + bracket; Group 3, BisBlock + self etch + bracket; Group 4, self etch + bracket (control).

**RESULTS**

Descriptive statistics including the mean, standard deviation, minimum and maximum values were evaluated and shown in Table 3 and Fig 1 for each of the groups tested. On the average the control group had statistically significantly higher SBS than the treatment groups with $p = 0.001$. No significant difference was found among Groups 1, 2 and 3 (Group 1-Group 2, $p = 0.564$; Group 1-Group 3, $p = 0.371$; Group 2-Group 3, $p = 0.133$).

The frequency distribution of ARI scores among groups was presented in Table 4 and Fig 2. When all the ARI scores were compared, the control group proved to have statistically significant greater SBS than the treatment groups ($p = 0.001$) and there were no statistically significant differences between Groups 1, 2 and 3 (Group 1-Group 2, $p = 0.397$; Group 1-Group 3, $p = 0.506$; Group 2-Group 3, $p = 0.909$). The predominant mode of failure for the treatment groups (Group 1, 2 and 3) was at the enamel-adhesive interface leaving 100% of the adhesive on the bracket base.

**DISCUSSION**

As more adults are now seeking orthodontic treatment, it is very important to determine whether bleaching significantly affects the bond strength of orthodontic bracket adhesives to the enamel surface. This study was performed to investigate the SBS of orthodontic brackets bonded to human enamel with a self-etching primer after bleaching, desensitizer application and combined treatment.

The adverse effects of bleaching treatment on bond strength between resin composite and tooth substrate have been reported before. It has been suggested that a reduction in bonding strength of resin composite in bleached teeth may be due to the presence of active chemicals from bleaching. Residual oxygen may be responsible for the inhibition of resin polymerization and increase in resin porosity. Similar to our study; Türkkahraman et al. evaluated the effect of enamel bleaching on the bonding strength of orthodontic
Table 4. The frequency distribution of Adhesive Remnant Index scores among groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Score 0</th>
<th>Score 1</th>
<th>Score 2</th>
<th>Score 3</th>
<th>Score 4</th>
<th>Score 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Group 2</td>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Group 3</td>
<td>12</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Different superscript letters showed statistically different groups. Significance was determined at a probability value of \( p < 0.05 \). Group 1, Office bleaching + self etch + bracket; Group 2, office bleaching + BisBlock + self etch + bracket; Group 3, BisBlock + self etch + bracket; Group 4, self etch + bracket (control).

Fig 2. Schematic view of frequency distribution of Adhesive Remnant Index (ARI) scores among groups.

Brackets and stated that the use of 35% hydrogen peroxide significantly decreased the bond strength of orthodontic brackets. Uysal and Sisman also suggested that 16% carbamide peroxide bleaching agent applied immediately before bonding significantly reduces the shear bond strength values of self-etching primer systems. Uysal et al. evaluated that office bleaching with 35% hydrogen peroxide did not adversely affect the bond strength of brackets bonded immediately after bleaching or for 30 days after bleaching. However, in the only study that investigated the effects of bleaching and desensitizer treatment on SBS of brackets, the SBS test was carried out immediately after the bonding procedure. In our study, 15% hydrogen peroxide was used as the office bleaching treatment and showed a significantly decreased SBS of orthodontic brackets with self-etch adhesive 24 hours after bonding.

Rinsing of the enamel after application of the self-etching primer is not required. The use of a self-etching primer reduces the number of clinical steps and saves clinical operation time because separate acid etching and water rinsing steps are eliminated and application requires simply drying with air. Transbond Plus self-etching primer was used in this study.

It was found that optimal bond strengths can be achieved with a time delay after the bleaching. Sung et al. has concluded that the use of alcohol-based bonding agents may decrease the effect on composite bond strength when restorative work is to be completed immediately after bleaching. The presence of alcohol may counteract any residual water and oxygen from the bleaching agent.

Patients undergoing bleaching procedures may experience tooth sensitivity as a side effect. Orthodontists may face bonding brackets to hypersensitive teeth treated with desensitizers. The effect of desensitizers on the bond strength of adhesives to dentin is well known. It has been reported that these agents significantly affected the bond strength. Oxalate desensitizing materials consisting of low concentrations of oxalic acid also work well for desensitization. Application of oxalate materials to the exposed dentin results in precipitation of potassium oxalate or ferric oxalate crystals, occlusion of open tubules in cervical dentin, and instant sclerosis of the tubules. They react with calcium ions on dentin and in dentinal fluid to form insoluble calcium oxalate crystals. However, these crystals are either partially dissolved in oral fluids or lost during toothbrushing. In contrast with other ox-
alate desensitizers, BisBlock’s patented technique is unique because it incorporates the total-etch procedure prior to oxalate and adhesive placement. A similar study was conducted by Türkkahraman and Adanir who reported that orthodontic brackets bonded to enamel treated with potassium nitrate (UltraEZ) and oxalate desensitizers (BisBlock) exhibited significantly lower bond strengths than did brackets bonded to untreated enamel. Türkkahraman et al. found that desensitizer application significantly affected SBS of orthodontic brackets on human enamel.

Reynolds suggested that a minimum bond strength of 6 to 8 MPa is adequate for most clinical orthodontic routine clinical use. In the present study, only the control group presented the average SBS value of 8.81 MPa. Other experimental groups exhibited SBS values below 6 MPa.

A modified ARI has been developed to quantify the amount of adhesive that remains on the bracket after a bracket base debonds. The treatment groups exhibited higher ARI scores, often showing 100% adhesive on the brackets than the control group, which had significantly less adhesive remaining on the bracket.

As there are various materials and application procedures, further studies are needed in order to define the effect of bleaching, desensitizer application and combined treatment on SBS of orthodontic brackets bonded to human enamel with a self-etching primer. Further studies should investigate the role of longer time periods between bleaching and desensitizer treatment and orthodontic treatment on the SBS of the brackets.

CONCLUSION

Within the limitations of this in vitro study, we conclude that:

Bleaching and desensitizer treatment significantly reduced bond strength of orthodontic brackets on human enamel with a self-etching primer after 24 hours. It is recommended that bleaching and desensitizer treatment should be postponed until the completion of orthodontic treatment. If it is determined that the patient has a bleaching history prior to applying for orthodontic treatment, the time of bleaching treatment should be established and the orthodontic treatment should be postponed sufficiently to allow for adequate bond strength of orthodontic brackets.

REFERENCES

4. Leonard RH Jr, Austin SM, Haywood VB, Bentley CD. Change in pH of plaque and 10% carbamide peroxide solution