The Etching Effect of Co2 Laser on The Shear Bond Strength of Bleached Teeth

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ABSTRACT

Background: Tooth discoloration is one of the great esthetic problems in dentistry. Despite vital bleaching, is often considered a first step to improve the appearance of teeth, reports are controversial about the effect of bleaching on the shear bond strengths (SBS) of brackets. Etching of enamel surface can be carried out by acid or laser, there was controversy about the efficiency of CO2 laser as enamel surface etchant.

Objective: The aim of the present study is to detect if there is a significant reduction in SBS of bleached teeth, and to detect the effect of CO2 laser as etchant on both bleached and normal teeth.

Methods and materials: Forty non-carious first premolars are divided into 2 main groups: None- bleached (A) and Bleached (B) groups, of 20 specimens for each group, then the groups were subdivided into 2 subgroups (10 specimens for each subgroup).

Group (B) teeth were bleached with chemically activated 40% hydrogen peroxide, while group (A) teeth were left without bleaching. The subgroups teeth (A1 and B1) were etched with CO2 laser and the subgroups (A2 and B2) were etched with 37% phosphoric acid. After bracket bonding, samples were then thermally cycled for 500 cycles between (5°C and 55°C). Debonding was performed with a shearing force using the universal testing machine, then ANOVA and LSD test were used to specify if there was a significant difference between groups.

Results: there was no significant difference in mean SBS of both phosphoric acid etching and CO2 laser etching in both bleached and normal surface enamel specimens. A and B groups. Whereas there was a significant difference in mean shear bond strength between the CO2 laser etched and the phosphoric acid etched groups with highest mean values in the phosphoric acid etched subgroups.

Conclusion: The results of this in vitro study suggest that hydrogen peroxide bleaching does not affect the shear bond strength of metal orthodontic brackets when bonding occurred 1 week after bleaching and CO2 laser etching has low shear bond strength values making it not suitable for clinical use.

Key words: Bleaching, Etching, CO2 laser, Shear bond strength.

INTRODUCTION

Tooth discoloration is one of the great esthetic problems in dentistry. It has many etiologic factors that are usually classified as being intrinsic, extrinsic, or internalized in nature. Tooth bleaching is one of the treatment options to overcome this problem (1,2). This can be done in 2 ways: either in-office or at home bleaching. In-office vital tooth bleaching has been used for many years in dentistry (1-5).

Teeth-bleaching procedures can lead further enhancement of patient's smile with orthodontic treatment, but these bleaching procedures may reduce the bonding forces of the brackets to enamel surfaces. (6,7), as the bleaching can be used before or after orthodontic treatment.

Despite vital bleaching is often considered a step to improve the appearance of teeth prior to orthodontic treatment. (8,9), reports are controversial about the shear bond strengths of brackets after bleaching. Some studies reported that the shear bond strength of orthodontic brackets with bleached enamel is significantly lower than that of unbleached enamel corresponding to the bleaching type or waiting period after the bleaching procedure (10,11). However, others
did not find significant differences in mean shear bond strength between bleached and unbleached teeth (12-14). This debate in a reduction in enamel bond strength has become a concern in orthodontics, (8,9). However, it is generally agreed, to wait a period of one day up to three weeks to proceed with an adhesive procedure (15-17).

Sandblasting, acid etching and laser are methods used for enamel surface etching. However, some studies suggest that laser etching may produce bonding forces comparable to that produced by acid etching (18-20), while others found that lower bonding forces were produced by laser when used for enamel surface etching (21-23).

The CO2 laser had many applications in dentistry that might differ according to its wavelength bands. The three main CO2 laser wavelengths used in dental treatments are 9300, 9600, and 10600 nm. with a variety of hard and soft tissue effects. (24,25) Bond strength with different laser treatments is not consistent either. Some studies have suggested that there was significant decrease in shear bond strength with laser etching (26,27), while others concluded that laser etching can produce comparable results to those produced by conventional etching (28-30).

The aim of the presented study is to detect if there is a significant reduction in the shear bond strength of bleached teeth and to detect the effect of the CO2 laser as an etchant on both bleached and normal teeth.

METHODS AND MATERIALS

Forty non-carious first premolars extracted for orthodontic purposes were used in this study. The criteria for tooth selection included intact buccal enamel; no pretreatment with chemical agents such as derivatives of peroxide, acid, alcohol, or any other form of bleaching; no cracks from forceps; no carry; and no restorations. After extraction he teeth were left un bleached.

The sample was randomly divided into (2) main groups: None- bleached group assigned as (A) and Bleached group assigned as (B), of 20 specimens for each group, then the A and B groups were subdivided into 2 subgroups (A1, A2, B1, and B2), of 10 specimens for each subgroup. Group (B) teeth were bleached with chemically activated 40% hydrogen peroxide (BOOST, Opalescence®, Ultradent, INC. USA). The bleaching material was applied two times (20 minutes each time) for a maximum 40 minutes, then the teeth were washed and kept in distilled water for 7 days before enamel etching. While group (A) teeth were left un bleached.

The subgroups (A1 and B1) were etched with CO2 laser (Ultra Dream Pulse Surgical CO2 laser System, DS-40U, Daeshin Enterprise Co.,Ltd., Korea) emitting at (10600 nm and 5 watt power); the beam is focused by hand-piece with a focal length of 50 mm, Beam profile is a single-mode Gaussian (TEM00), with a spot size (0.2mm) and a distance of 10mm to the enamel surface. the area of 8mm2 (representing the designed bracket position on the buccal surface of the specimen) was irradiated for 20 seconds (sec.) , while the subgroups (A2 and B2) were etched with 37% phosphoric acid (Super etch, etchant gel, SDI ©, Chicago, USA) as the manufacturer guide for 30 sec. then the teeth were washed for 10 sec. then dried for 5 sec.

The same bonding procedure was done for all four subgroups with adhesive primer (Transbond XT; 3M Unitek, Monovia, Calif, USA) applied to the etched surfaces of the teeth in all subgroups. Stainless steel, upper premolar, straight wire brackets type (Pinnacle™, Ortho Technology, Tampa, Florida 33647, USA) with were used in this study, Immediately after applying the adhesive the bracket was placed gently on the middle third of the buccal tooth surface parallel to the long axis of the tooth, after bracket bonding, samples were then stored in distilled water at 37°C for 24 hours.

Thermo cycling was applied for all subgroups of 500 cycles between 5°C and 55°C with the exposure to each bath was 30 seconds, and the transfer time between the two baths was 5-10 seconds (31).

Debonding was performed with a shearing force using the universal testing machine (Tinus-Olsen universal testing machine, H50KT, UK) with a cross-head speed of 0.5 mm/minute. The force required to cause bond failure was recorded electronically and measured in Newton (N), and converted into megapascal (MPa). After debonding, the surface of each tooth was examined under ×10 stereomicroscope (Leica/Meyer Instruments, Houston, TX, USA) and classified according to the adhesive remnant index (ARI) (32) as follows:

ARI 1: Between the bracket base and the adhesive.

ARI 2: Cohesive failure within the adhesive itself, with some of the adhesive, remained on the tooth surface and some remained on the bracket base.

ARI 3: Adhesive failure between the adhesive and the enamel.
ARI 4: Enamel detachment.

The data were collected and statistically analyzed using SPSS (Statistical Package for Social Science), mean, standard deviation, minimum, maximum and percentage values were calculated for all groups. One way analysis of variance (ANOVA) was used to test any statistically significant difference in the shear bond strength of different etching methods and the difference among surface treatment. Least significant difference (LSD) was used to test any statistically significant difference between each two subgroups within the same group.

**RESULTS**

The mean, standard deviation, minimum, maximum values of all groups are summarized in Table 1.

The one-way ANOVA test found that there was a significant difference in mean shear bond strength between the four subgroups with highest mean values in the phosphoric acid etched subgroups (A2 and B2) as shown in Table 2.

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>10</td>
<td>2.313000</td>
<td>1.2418792</td>
<td>.3927167</td>
<td>1.424613</td>
<td>3.201387</td>
<td>.8600</td>
</tr>
<tr>
<td>A2</td>
<td>10</td>
<td>5.808500</td>
<td>4.5305273</td>
<td>1.4326785</td>
<td>2.567556</td>
<td>9.049444</td>
<td>1.1780</td>
</tr>
<tr>
<td>B1</td>
<td>10</td>
<td>2.495330</td>
<td>1.3641854</td>
<td>.4319333</td>
<td>1.519451</td>
<td>3.741209</td>
<td>.4363</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>3.747333</td>
<td>1.1513719</td>
<td>.982756</td>
<td>2.739475</td>
<td>4.755190</td>
<td>.4363</td>
</tr>
</tbody>
</table>

**Table 1: Descriptive statistics of mean, standard deviation, minimum, maximum and percentage.**

<table>
<thead>
<tr>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>82.641</td>
<td>3</td>
<td>27.547</td>
<td>3.255</td>
</tr>
<tr>
<td>Within Groups</td>
<td>304.674</td>
<td>36</td>
<td>8.463</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>387.315</td>
<td>39</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*S = Statistically significant at p < 0.05

The LSD test used to see where the significant difference exists between groups, the test showed that there is significant difference between the phosphoric acid etched normal enamel surfaces specimens (A2) group and both CO2 laser etched (A1 and B1) groups, where as there was non-significant difference in mean SBS of both phosphoric acid etching and CO2 laser etching in both bleached and normal surface enamel specimens (A2 and B2) groups, and A1 and B1 groups, as shown in Table 3.

**Table 2: Descriptive statistics of one way ANOVA test between and within groups.**

<table>
<thead>
<tr>
<th>(I) Groups</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>A1</td>
<td>A2</td>
<td>-3.4955000*</td>
<td>1.3010124</td>
<td>S</td>
</tr>
<tr>
<td>A1</td>
<td>B1</td>
<td>-.1823300</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
<tr>
<td>A1</td>
<td>B2</td>
<td>-2.0595000</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
<tr>
<td>A2</td>
<td>A1</td>
<td>3.4955000*</td>
<td>1.3010124</td>
<td>S</td>
</tr>
<tr>
<td>A2</td>
<td>B1</td>
<td>3.3131700*</td>
<td>1.3010124</td>
<td>S</td>
</tr>
<tr>
<td>A2</td>
<td>B2</td>
<td>1.4360000</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
<tr>
<td>B1</td>
<td>A1</td>
<td>.1823300</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
<tr>
<td>B1</td>
<td>A2</td>
<td>-3.3131700*</td>
<td>1.3010124</td>
<td>S</td>
</tr>
<tr>
<td>B1</td>
<td>B2</td>
<td>-1.8771700</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
<tr>
<td>B2</td>
<td>A1</td>
<td>2.0595000</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
<tr>
<td>B2</td>
<td>A2</td>
<td>-1.4360000</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
<tr>
<td>B2</td>
<td>B1</td>
<td>1.8771700</td>
<td>1.3010124</td>
<td>NS</td>
</tr>
</tbody>
</table>

*The mean difference is significant at the 0.05 level. NS = Statistically non significant at p > 0.05
S = Statistically significant at p < 0.05
The sites of bond failure of all specimens were shown in Table 4, the adhesive-enamel interface failure (ARI 3) was most predominant in group A1 (70%) and group B1 (90%), while the cohesive failure (ARI 2) was most predominant in group A2 (70%) and group B2 (80%), whereas (ARI 1 and ARI 4) were not identified during the examination. As shown in Table 4.

<table>
<thead>
<tr>
<th>Groups</th>
<th>ARI 1</th>
<th>ARI 2</th>
<th>ARI 3</th>
<th>ARI 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0 (0.0)</td>
<td>3 (30.0)</td>
<td>7 (70.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>A2</td>
<td>0 (0.0)</td>
<td>8 (80.0)</td>
<td>2 (20.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>B1</td>
<td>0 (0.0)</td>
<td>1 (10.0)</td>
<td>9 (90.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>B2</td>
<td>0 (0.0)</td>
<td>7 (70.0)</td>
<td>3 (30.0)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

Values are presented as number (%)

DISCUSSION

A stable bracket-adhesive interference is biomechanically important in order to transfer the forces the activated archwire to the tooth, bonding of brackets has been a critical issue. In order to select good adhesive and bracket combination, an in vitro investigation of shear bond strength is so important to evaluate the bonding efficiency of orthodontic adhesive systems. With an increasing demand for adult treatment, some patients might not only with well-aligned teeth but also they want whiter looking teeth that could present challenges to orthodontist. A number of bleaching products and techniques are now available to patients via the clinicians and over the counter for use by consumers without professional supervision. These products differ in terms of agent, concentration, application frequency, product format, application mode, and light activation.

The one week waiting period after bleaching is applied in the present study as it was the mostly used waiting protocol in the majority of studies, but some authors used a more than one week waiting period from bleaching to the time of adhesive application.

Although, with this difference in the waiting period after bleaching agent application, the effect of the bleaching agents on the shear bond strength was a matter of controversy among authors, some studies showed that there was no significant difference between the bleached teeth and non-bleached teeth in one week waiting or less period, the present study showed comparable results to the above-mentioned studies that in one week post-bleaching waiting there is no significant difference in the shear bond strength between bleached and non-bleached teeth which comparable with above-mentioned studies, while some authors concluded that the bleaching agents lower the shear bond strength values in one week waiting period.

It's well-known to the orthodontist that the etching technique has a direct effect on the shear bond strength of the brackets. The ability of laser irradiation to remove the smear layer and shorter etching procedure without the need for washing and dryness has been reported, but still there are some contradicting findings of the use of lasers for enamel etching.

Because of its thermal effects and its energy is absorbed by water, the use of (10600nm) CO2 laser as on the hard tissues like teeth is a matter of controversy, some authors suggested that (10600nm) CO2 laser were used only in the soft tissue surgeries, where as others used it in some in vitro studies. This is the cause for selection of CO2 laser in this study due to the limited studies to test the efficacy of CO2 laser as an etchant on bleached teeth.

Regarding the shear bond strength, there is controversy considering the efficiency of using (10600nm) CO2 laser as enamel etchant, some authors suggested that CO2 lasers produce significantly high shear bond strength values but still not sufficient to meet the requirements of bracket bonding, whereas others found that it presents lower shear bond values that were not satisfied the clinical levels. The results of the present study are comparable with the findings of the above studies with mean value of (2.5MPa) but still lower than those values produced from acid etching groups.

The clinical importance of ARI score is due to its ability to indicate the position of failure sites, in the present study ARI scores in the laser etched groups (ARI 3) these results mean that the mode of failure is closer to the enamel-adhesive interface, with decreasing time for adhesive removal from tooth surface. Whereas in the acid etched groups (ARI 2) is predominant which means that the bond failure site is at the adhesive-bracket base interface, resulting in minimal risk for enamel fractures.

The small sample size represents a limitation in the presented study this is due to that most of patients...
who extract sound maxillary first premolar are orthodontic patients who their treatment plan include such kind of extraction and patients with aggressive periodontal diseases and the number of those patients are very low, this may explain this limitation in the presented study.

CONCLUSION

The results of this in vitro study suggest that hydrogen peroxide bleaching does not affect the shear bond strength of metal orthodontic brackets when bonding occurred 1 week after bleaching and CO2 laser etching has low shear bond strength values making it not suitable for clinical use.

REFERENCES


