Effect of tooth bleaching on orthodontic stainless steel bracket bond strength

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ABSTRACT

Objectives: The objective was to assess the shear bond strength (SBS) of composite resins on stainless steel brackets immediately bonded to previously bleached teeth with 35% hydrogen peroxide and to compare the neutralization effect of various antioxidant agents on the bond strength after bleaching.

Materials and Methods: One hundred sound human maxillary premolars were used for the study. Teeth were divided into 5 groups (n = 20); Group 1 (control), Group 2 (bleach treatment), Group 3 (sodium ascorbate treatment), Group 4 (tocopherol acetate treatment), and Group 5 (retinol acetate treatment). Teeth in Group 3, 4, and 5 were treated as in Group 2, but after that and before bleaching received treatment with sodium ascorbate, tocopherol acetate, and retinol acetate, respectively. Subsequently, teeth were bonded with stainless steel brackets (Ormco) using 3M Transbond XT. After 24 h, each specimen was loaded into a universal testing machine to determine the SBS at debonding. The data were exposed to the analysis of variance, Bonferroni, and Weibull Analysis.

Result: There significant SBS difference (P = 0.000, F = 32.125) between various groups. Group 1 had the highest SBS (12.182 ± 1.41 MPa) and Group 2 the least SBS (6.182 ± 1.49 MPa). Significant SBS differences observed between Group 1 and 2; Group 2 and 3; Group 2 and 4; and Group 2 and 5 (P = 0.000). There was no significant SBS difference between Group 1 and 3; Group 1 and 4; and Group 3 and 4 (P = 1.000). Bonferroni results also indicated that there was a significant difference between Group 1 and 5 (P = 0.002); Group 3 and 5 (P = 0.144); and between Group 4 and 5 (P = 0.008). Weibull analysis indicated that bond strength for a 90% probability of failure, which was highest for Group 1 (13.99 MPa) and lowest for Group 2 (8.49 MPa).

Conclusion: The in-vitro study showed that bleaching with 35% hydrogen peroxide reduced the SBS significantly and this could be effectively reversed by the application of 10% sodium ascorbate, 10% tocopherol acetate, or 10% retinol acetate. Thus, treatment of bleached teeth with antioxidants can be a good clinical option for bonding immediately after bleaching.

Key words: Antioxidants, bleaching, bonding, shear bond strength

INTRODUCTION

Nearly 30% of people benefit from orthodontic treatment and the recent popularity of tooth whitening or bleaching also has a significant impact on the practice of dentistry and orthodontics. Although bleaching of vital teeth has

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been known since 1800’s,[2] the use of peroxide-based tooth whitening materials has increased recently. Some patients who are interested in orthodontic treatment might have had their teeth bleached thus, it seems important to determine whether bleaching would significantly influence the bonding strength of orthodontic bracket adhesives to the enamel surface and how to reverse the effect in case it does.

Previous studies have shown changes in the enamel structure and composition when exposed to 3035% hydrogen peroxide for in-office vital bleaching.[3,4] Some authors such as Türkkahraman et al.[5] and Nour El-din et al.[6] identified a substantial reduction in the bond strength. While Uysal et al.[7] and Bishara et al.[8] found no significant difference in the bond strength between the bleached and the unbleached groups.

The most common recommendation is to delay any bonding procedures after bleaching because the reduction of composite resin bond strength has shown to be transient. However, the recommended post-bleaching period for bonding procedures varies between 24 h and 4 weeks,[9,10] and hence it may be confusing for the clinician.

Thus, this study was conducted to assess the changes in the shear bond strength (SBS) of composite resins immediately bonded to previously bleached teeth with 35% hydrogen peroxide and to evaluate and compare the neutralization effect of various antioxidant agents on the bond strength.

**MATERIALS AND METHODS**

Prior approval was taken from all the patients in the present study. This study was carried out with an objective of assessing the effect of in-office hydrogen peroxide containing bleaching agent on the bond strength of orthodontic bracket adhesives and to assess the efficacy of antioxidants to reverse the effect of bleaching on the same.

**Samples**

One hundred sound human maxillary premolars freshly extracted from adolescent subjects for orthodontic treatment were used for the study. All the patients were informed about the study and an informed consent was taken. The criteria for inclusion of teeth in the study were:

- No previous chemical treatment such as hydrogen peroxide or bleaching
- Intact buccal surfaces those were not restored and noncarious
- No hypoplastic areas, cracks or gross irregularities
- Sufficient root length to allow stable embedding in the acrylic resin

The teeth were cleaned of blood and tissue debris and stored in distilled water after extraction.

**Bonding Agent**

Bonding agent used in the study was the Transbond XT (3M Unitek, Monrovia, USA) light cure orthodontic bonding system.

**Bleaching Agent**

A 35% hydrogen peroxide Pola office tooth whitening system (SDI Ltd., Victoria, Australia) was used to bleach the teeth.

**Antioxidants**

Sodium ascorbate, α-tocopherol acetate, retinol acetate (Hi Media Laboratories, Mumbai) was used as 10% solution in water, ethanol, and chloroform, respectively.

**Brackets**

One hundred stainless steel preadjusted edgewise upper bicuspid brackets (Ormco mini 2000 series, Ormco Corporation, Glendora, CA, USA) with 0.022 inch slot and micro etched base with a surface area of 9.63 mm² were used for the study. The brackets were kept in the manufacturer’s packaging until immediately prior to bonding and were handled at all times with bonding tweezers to avoid contamination.

The teeth used for the study were cleaned and then decontaminated with a 0.5% chlorine-T (Hi Media Laboratories, Mumbai) for 1 week at room temperature. The teeth were cleaned and stored in distilled water, which was changed twice weekly to prevent bacterial contamination. The root of each tooth was grooved in apical third with a diamond bur and then mounted in self-curing acrylic till cemento-enamel junction with long axis vertical.

Teeth were then divided into 5 groups randomly with 20 teeth in each group. The buccal surface of each tooth was polished with fluoride free pumice slurry, rinsed, and dried.

**Group 1 (Control)**

The buccal surface was then etched with 37% phosphoric acid for 30 s, rinsed for 15 s, dried, and checked for the frosted appearance. Transbond XT primer was applied to the enamel surface in a thin film with an applicator brush and light cured for 10 s. Transbond XT adhesive was applied to the bracket base and then, the bracket was positioned lightly on the buccal surface of the tooth. Excess adhesive was removed with an explorer and then, cured for 10 s on each side.

**Group 2 (Bleached Group)**

A 35% hydrogen peroxide bleaching agent was mixed and applied with a brush onto the tooth surface in a layer of approximately 1 mm in thickness, ensuring no enamel was visible. It was then exposed to the curing light twice for 10 s and the bleaching agent was kept in place for 16 min before washing away. Brackets were then immediately etched and bonded as in the control group.

**Group 3 (Sodium Ascorbate Treatment)**

Teeth in this group were treated same as in Group 2 except that after bleaching and before etching and bonding, 1 ml of 10%
sodium ascorbate solution was applied on the buccal surface, kept for 10 min with 2 applications during this time, and then the surface was washed with water for 30 s and air dried for 20 s. Then, brackets were etched and bonded as in the control group.

**Group 4 (Tocopherol Acetate Treatment)**
Teeth in this group were treated same as Group 2 except that after bleaching and before bonding, 1 ml of 10% tocopherol acetate solution (Hi Media Laboratories, Mumbai) was applied on the buccal surface.

**Group 5 (Retinol Acetate Treatment)**
Teeth in this group were treated same as Group 2 except that after bleaching and before bonding, 1 ml of 10% retinol acetate solution was applied on the buccal surface.

**Shear Bond Strength Testing**
A universal testing machine (Lloyd Instruments, Fareham, Hants, England) with 1KN load cell and cross head speed 1 mm/min was used for shear testing.

After bonding, all the teeth were stored in distilled water for 24 h. After 24 h, each specimen was loaded into the universal testing machine [Figure 1] for testing with bracket base parallel to the direction of the shear force. The upper member of the machine was fitted with a chisel-shaped blade which was positioned in the occluso-gingival direction and to make contact with the bonded specimen [Figure 2], SBS was determined in the shear mode at a crosshead speed of 1 mm/min until disbanding occurred. The values of failure loads (Newton) were recorded and converted into megapascals (MPa) by dividing the failure load (N) by the surface area of the bracket base (9.63 mm²).

\[
\text{Bond strength (MPa)} = \frac{\text{Failure load (N)}}{\text{Surface area of bonding surface}}
\]

**Weibull’s Analysis**
Weibull’s analysis was used to calculate the probability of failure at given values of applied force as recommended by Fox et al.\(^{11}\) The data were used to derive the Weibull modulus (m) and characteristic strength (\(\sigma_0\)). A higher modulus value indicates greater bond reliability, a small range within a specific group and less variation.

Probability of failure is given by:

\[
P_f = 1 - \exp \left( \frac{S}{\sigma_0} \right)^m
\]

Where S: Load applied
\(\sigma_0\): Characteristic strength or scale parameter
m: Weibull modulus or shape parameter

**Statistical Analysis**
Descriptive statistics including the mean, standard deviation (SD), and range were calculated for each of the 5 test groups using SPSS 19 software (IBM). A one-way analysis of variance was used to determine statistically significant differences among the mean SBSs of the 5 groups. If significant differences were present, Bonferroni multiple comparison tests were used to determine which of the means were significantly different from each other. The \(P < 0.05\) was considered as a statistically significant.

**RESULTS**

**Shear Bond Strength**
The mean (SD) SBS of Group 1 (control) was 12.182 (1.41) MPa, of Group 2 (bleached) was 6.182 (1.49) MPa, of Group 3 (10% sodium ascorbate) was 11.336 MPa (2.18) MPa, of Group 4 (10% tocopherol acetate) was 11.947 (2.36) MPa, and of Group 5 (10% retinol acetate) was 9.795 (2.12) MPa [Table 1]. The above results indicate that Group 1 (control) has the highest SBS (12.182 MPa) and Group 2 (bleached) has the least SBS (6.182 MPa) among all the groups tested.

Analysis of variance tests indicated that there is very high significant difference \((P = 0.000)\) of SBS between various groups.
The Bonferroni test indicated that [Table 2]:

- There was a very high significant difference between Group 2 (bleached) and all the other groups. This indicates that bleaching affects the SBS of the composite resin significantly.
- There was no significant difference between Group 1 (control) and Group 3 (10% sodium ascorbate) and Group 4 (10% tocopherol acetate). This indicates that post-bleaching treatment of enamel with 10% sodium ascorbate and 10% tocopherol acetate reversed the effect of bleaching on the SBS.
- There was a significant difference between Group 5 (10% retinol acetate) and Group 1 (control), Group 3 (10% sodium ascorbate), and Group 4 (10% tocopherol acetate). This indicates that 10% retinol acetate reversed the effect of bleaching, but not as much as other two antioxidants.

**Weibull Analysis**
A higher Weibull modulus was ($m = 9.477$) was obtained with Group 1 (control) when compared to all the other groups tested. Group 2 (bleached) had the lowest Weibull modulus ($m = 3.908$) among all the groups. The Weibull modulus obtained for Group 3 was 5.914, for Group 4 was 5.219 and for Group 5 were 5.203.

Above results indicated the higher bond reliability and less variation within Group 1 (control) as compared to all other groups tested. Group 3, Group 4, and Group 5 had higher Weibull modulus than Group 2 indicating greater bond reliability for groups treated with antioxidants post-bleaching.

Shear Bond strength for a 90% probability of failure [Figure 3] for Group 1 (control) is 13.9958 MPa, Group 2 (bleached) is 8.4932 MPa, Group 3 (10% Sodium ascorbate) is 14.0834 MPa, Group 4 (10% tocopherol acetate) is 15.302 MPa, and Group 5 (10% retinol acetate) is 12.5252 MPa. The above results indicate that Group 2 (bleached group) showed the least bond strength for a 90% probability of failure indicating that the significantly less force is required to dislodge a bracket when compared to other groups.

**DISCUSSION**
The present study was undertaken to find the effect of in-office bleaching on the bond strength of orthodontic bonding adhesive to enamel. In the present study, Group 2 showed the least mean SBS among all the groups. The mean SBS of Group 2 is much less than Group 1. Thus, the result of this study demonstrated that the reduction in SBS of composite resin to enamel immediately after bleaching with 35% hydrogen peroxide.

This is in accordance with the results found by Cavalli *et al.*[10] Nour El-din *et al.*[6] Cacciafesta *et al.*[9] and Türkkahraman *et al.*[5] The results of the present study were not in accordance with the results obtained by Uysal *et al.*[7] and Bishara *et al.*[8]

In the present study, Group 3 has significantly higher mean SBS than Group 2. This indicates that 10% sodium ascorbate increased the bond strength after bleaching to almost the same value as the unbleached group. Group 4 has significantly higher mean SBS than Group 2. The SBS of Group 4 is slightly higher than Group 3 but there is no significant difference between the two.

![Weibull curve of bond strength and probability of failure](image)

**Table 1: Mean shear bond strength**

| Groups   | N  | Mean±SD   | Range        |
|----------|----|-----------|--------------|
| Group 1  | 20 | 12.182±1.41 | 8.747 to 14.728 |
| Group 2  | 20 | 6.182±1.49  | 2.682 to 8.626  |
| Group 3  | 20 | 11.336±2.18 | 7.572 to 17.130 |
| Group 4  | 20 | 11.977±2.36 | 6.260 to 19.142 |
| Group 5  | 20 | 9.795±2.12  | 5.203 to 15.245 |

SD: Standard deviation

**Table 2: Bonferroni multiple comparison test**

| Group (I) | Group (J) | Mean difference (1-J) | Standard error | Significance |
|-----------|-----------|-----------------------|----------------|--------------|
| Group 1   | Group 2   | 6.00030               | 0.618040       | 0.000         |
| Group 3   | Group 2   | 0.84630               | 0.618040       | 0.000         |
| Group 4   | Group 2   | 0.23525               | 0.618040       | 0.000         |
| Group 5   | Group 2   | 2.38735               | 0.618040       | 0.000         |
| Group 1   | Group 3   | −6.00030              | 0.618040       | 0.000         |
| Group 2   | Group 3   | −5.15400              | 0.618040       | 0.000         |
| Group 4   | Group 3   | −5.76505              | 0.618040       | 0.000         |
| Group 5   | Group 3   | −3.6129S               | 0.618040       | 0.000         |
| Group 1   | Group 4   | −0.84630              | 0.618040       | 0.000         |
| Group 2   | Group 4   | 5.15400               | 0.618040       | 0.000         |
| Group 3   | Group 4   | 0.6110S               | 0.618040       | 0.000         |
| Group 5   | Group 4   | 2.15210               | 0.618040       | 0.000         |
| Group 1   | Group 5   | −2.38735              | 0.618040       | 0.000         |
| Group 2   | Group 5   | 3.61295               | 0.618040       | 0.000         |
| Group 3   | Group 5   | −1.54105              | 0.618040       | 0.000         |
| Group 4   | Group 5   | −2.1S210               | 0.618040       | 0.000         |

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The mean SBS of Group 5 is found to be 9.795 MPa (SD = 2.1242). Although, the SBS of this group is significantly lower than the Group 1, Group 3, and Group 4, but is still significantly higher than the Group 2 (bleached group). This may be because of the smaller capacity of retinol to scavenge free radicals as compared to ascorbate and tocopherol acetate. Weibull’s analysis was used to calculate the bond reliability and the probability of failure at a given value of applied force. Weibull analysis in this study indicated that bond strength for 90% probability of failure, which is highest for Group 1 (13.99 MPa) and lowest for Group 2 (8.49 MPa).

The present study has a few limitations. It must be remembered that the in-vitro SBS values might be higher than the in-vivo values[12,13] and further in-vivo clinical trials will assist in validating the present findings. A further study on these lines with the adhesive remnant index can be done. Present investigation used only one bleaching agent and variation in bleaching agent and different concentration effect could not be seen as shown by Akin et al[14] and Pithon et al[15] This study also did not use debonded bracket or did not compare the effect of treatment with different concentrations of antioxidants with the tooth for different time frames.

CONCLUSION

The following conclusion can be drawn from the present study:

Bleaching reduced the SBS significantly when compared to the control group, the effect of which was reversed significantly by the post-bleaching treatment with antioxidants (10% sodium ascorbate), 10% tocopherol acetate, and (10% retinol acetate). The retinol acetate increased the reduced bond strength after bleaching, but the effect was less than that of sodium ascorbate and tocopherol acetate.

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Nil.

Conflict of Interest

There are no conflict of interest.

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