Dental Research Journal

Original Article

Bleaching during orthodontic treatment and its effect on bracket bond strength

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Received: July 2018
Accepted: November 2018

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ABSTRACT

Background: This study investigated the effect of two different methods of bleaching during orthodontic treatment on bracket bond strength.

Materials and Methods: A total of 45 extracted premolar teeth were selected in this experimental study and divided into three groups (office bleaching with 35% hydrogen peroxide, home bleaching with 22% carbamide peroxide, and control). The color of the teeth was assessed initially before the application of bleaching agents and Thermocycling. Orthodontic brackets were subsequently bonded on the treated surfaces. Bleaching procedures were then performed. A final color measurement was performed at two points on the buccal surface both underneath and adjacent to the bracket base. The initial and final color measurements and the bond strengths were compared between the groups using the analysis of variance. $P < 0.05$ was considered as statistically significant.

Results: Bracket bond strength was significantly reduced in both bleaching groups compared with the control group ($P < 0.01$). The color difference before and after the bleaching procedures was significant in the office bleaching group ($P < 0.01$), while the control group did not demonstrate a statistical difference between initial and final color assessments ($P > 0.05$).

Conclusion: Bleaching procedures performed during orthodontic treatment reduce bond strength. Enamel beneath the bracket base experiences a whitening effect though to a lesser degree compared with an uncovered surface.

Key Words: Bleaching, bond strength, orthodontic brackets

INTRODUCTION

Tooth discoloration during orthodontics is a common occurrence during conventional orthodontic treatment and causes frequent patient complaint and dissatisfaction.[1-4] The discoloration is usually due to the accumulation of plaque and stains on tooth surfaces.[5] Although most patients present with a request to whiten the teeth during orthodontic treatment,[6] the usual response has been to delay such a procedure until after the completion of treatment and removal of the brackets.[7] It is common belief that a bleaching procedure during orthodontic treatment is not achievable due to the presence of brackets hindering the diffusion of agents in the labial surface

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Website: www.drj.ir
www.drjjournal.net
www.ncbi.nlm.nih.gov/pmc/journals/1480

How to cite this article: Sardarian A, Malekpour B, Roshan A, Danaei SM. Bleaching during orthodontic treatment and its effect on bracket bond strength. Dent Res J 2019;16:245-50.

of the teeth.[8,9] However, recent studies have shown that bleaching is possible during orthodontic therapy, yielding satisfactory results.[7,10]

The effect of bleaching on the bond strength of orthodontic brackets to enamel surfaces has been widely studied in literature. While some authors reported no changes in bond strength,[11,12] most authors demonstrated a significant reduction in the recorded values.[13-15] It has been suggested that the negative effect of bleaching on bond strength is due to the alterations in enamel structure and composition induced by these bleaching agents.[13] Furthermore, the presence of residual peroxide has been shown to hinder resin polymerization that could also affect the bond.[16] Less defined, fragmented, and shorter resin tags are observed when enamel surfaces are subjected to bleaching before bracket bonding.[17]

There are no studies evaluating the bond strength between orthodontic brackets and enamel surfaces in patients that receive bleaching procedures during orthodontic treatment. Hence, we aimed to investigate the bond strength after subjecting teeth to home- and in-office-bleaching procedures with the bracket bonded to the tooth surface.

MATERIALS AND METHODS

Sample preparation

In this experimental study, 45 premolars, extracted for orthodontic reasons, were selected. Selection criteria were teeth with sound enamel and without any fracture, restoration, white spot lesions, cavities, caries, previous chemical treatment, or areas of enamel hypoplasia.

The teeth were scaled and washed to remove blood, soft tissue, and debris. For the purpose of disinfection, they were immersed in a 10% formalin solution. Subsequently, the teeth were kept in a saline solution at room temperature until the beginning of the experiment. To inhibit bacterial/fungus growth, the solution was changed on a weekly basis.

Initial color assessment

All three groups of the study were subjected to color assessment, using a spectrophotometer (VITA Easyshade Advance 4.0, VITA Zahnfabrik H, Rauter Gmbh and Co., Bad Säckingen, Germany). The primary color of the enamel surface before bonding orthodontic brackets was measured at the midbuccal aspect of the specimens. Every sample was assessed three times using the device and the average value was recorded. Color quantification was according to the CIE lab system (Commision Internationale de l'Eclairage, L*, a*, b*).[9]

Bonding procedure

Before the acid-etching procedure, the buccal surfaces of the teeth were cleaned using fluoride-free pumice paste and bristle brush using a low-speed handpiece. Then, they were rinsed with water and air-dried.

All samples were etched by a 37% phosphoric acid gel (3M Unitek, Monrovia, Calif, USA) for 30 s. Following application of the acid, the buccal surfaces were rinsed completely for 15 s and dried with oil- and moisture-free air until a frosty white appearance was attained. Subsequently, Transbond XT primer (3M Unitek, Monrovia, Calif, USA) was applied as a thin layer on the teeth surfaces by means of a brush and light-cured for 10 s. Stainless steel brackets (Mini Master Series, American Orthodontics, Sheboygan, Wisconsin, USA) were bonded to the tooth surfaces using Transbond XT adhesive paste (3M Unitek, Monrovia, Calif, USA). The brackets were positioned on the tooth surface according to the FA point (middle of the clinical crown occlusogingivally and mesiodistally, following the long axis of the crown). The excess composite resin around the bracket base was removed with a dental explorer. Curing was performed with light-emitting diode light unit (Litex 696, Dentamerica, California, USA) for a total of 30 s (15 s from mesial and 15 s from distal). After the bonding procedure, the teeth were stored at room temperature in normal saline for 24 h, thermal cycling (Vafaei, Tehran, Iran) was performed at 5 ± 2°C to 55 ± 2°C for 1000 cycles with a dwell time of 30 s and a transfer time of 5 s.

Bleaching procedure

Subsequently, the bonded samples were randomly divided into three groups of 15 teeth by random selection. The first group received no bleaching treatment and served as control. In the second group, the teeth were bleached with a 35% hydrogen peroxide gel (Whiteness HP Maxx, FGM Dental Products, Joinville, SC, Brazil). The third group received bleaching treatment with a 22% carbamide peroxide gel (Whiteness Perfect, FGM Dental Products, Joinville, SC, Brazil).

In the office bleach group, the 35% hydrogen peroxide gel was applied to the entire facial surface of the teeth following the manufacturer's instructions.

The maximum recommended treatment involves three sessions of bleaching which are at least a week apart. Therefore, three 15-min sessions were performed. The teeth were stored in normal saline in-between sessions.

In the home bleach group, 22% carbamide peroxide gel without the dental tray was applied in the facial surface of the teeth. Gel stayed 1 h on tooth surface in each bleaching session. Twelve bleaching sessions were performed with 24-h intervals. The teeth were stored in normal saline in-between sessions.

In both groups, after each tooth whitening session, the gel was removed; the surface was rinsed with water and dried with compressed air.

Bond strength analysis

Each tooth was then embedded in self-curing acrylic resin up to the cementoenamel junction using a mounting jig to ensure a parallel direction of force during bracket debonding. For determining the shear bond strength (SBS), an occlusogingival force was applied with a mechanical testing machine (Zwick/Roell, Germany) to the upper surface of the bracket between the upper wings and bracket base at a crosshead speed of 0.5 mm/min. The maximum force required for bracket debonding recorded in Newton (N), and SBS calculated in megapascal by dividing the force value by the bracket base area (8.82 mm^2).

Final color assessment

After the analysis of bond strength and bracket removal, the remaining adhesive on the enamel surface was carefully removed using a high-speed handpiece with a carbide bur. Spectrophotometric measurement was done for a second time to assess color changes. This time the measurements were performed at two points on the buccal surface: one point on the midbuccal where the initial enamel color was measured and the second on a point 2 mm above the area where the bracket was bonded. All points were measured three times and the average values were recorded. The color difference ΔE between the measured points is calculated using the formula:[9]

$$\Delta E = \sqrt{(L_2 - L_1)^2 + (A_2 - A_1)^2 + (B_2 - B_1)^2}$$

Statistical analysis

The Kruskal–Wallis and Mann–Whitney statistical tests were used to compare SBS, Adhesive Remnant Index (ARI) score, and differences in color between the groups. A statistical software SPSS (Version 18; SPSS Inc., Chicago, USA) was used for all calculations. $P < 0.05$ was considered as statistically significant for all comparisons.

RESULTS

The SBSs of each group are shown and compared in Table 1. Based on the recorded values, the control group had the highest SBS (31.4 MPa) which was significantly higher than the home bleach (25.7 MPa) and the office bleach (25.3 MPa) groups. A statistically significant difference was not observed between the bleach groups ($P = 0.51$).

ARI scores are summarized in Table 2. Higher scores meaning larger amounts of remaining composite on enamel surface after debonding were observed in control group ($P = 0.007$). Only three samples in the control group presented with the score of 0 (no composite left on the tooth), while both the bleach groups had nine samples with this score. No difference was observed between the two bleaching groups ($P = 0.38$).

The mean differences between perceived colors in the study groups are shown in Table 3. There are no significant differences between the measurements in the control group. The largest ΔE was observed between the initial color measurement and the two points after bleaching in the office and home bleaching groups. The difference between ΔE of the enamel before and after bleaching (T_2–T_0) was more pronounced in the office bleach compared with the home bleach group, signaling the higher

Table 1: Shear bond strength (MPa) of orthodontic brackets and enamel

Group	Mean±SD‡	Median	P†
Office bleach	25.3±4.5A	26.2	0.006
Home bleach	25.7±7.1A	27.7	
Control	31.45±5.7B	33.4	

†*P* value calculated using Kruskal–Wallis test, ‡Different letters indicate statistically significant differences among groups based on Mann–Whitney test. SD: Standard deviation

Table 2: Adhesive Remnant Index measured for different groups

Group	ARI score†				P‡
	0	1	2	3	
Control	3	6	5	1	0.007
Home bleach	9	5	1	0	
Office bleach	9	6	0	0	

†Score 0: No composite remaining on tooth surface; 1: <50% of composite remaining on the tooth; 2: >50% of composite remaining on tooth; and 3: All of the composite remaining on tooth, ‡*P* value calculated using Kruskal–Wallis test. ARI: Adhesive Remnant Index

Table 3: The difference in perceived color as measured by a spectrophotometer on the enamel surface

Group	Mean color difference (ΔE)†		
	T_0-T_1	T_0-T_2	T_1-T_2
Control	2.13[A]	1.46[A]	1.56[A]
Home bleach	7.35[B]	8.51[B]	4.69[C]
Office bleach	7.2[B]	10.84[D]	4.33[C]

†The values with the same superscript letters demonstrate insignificant differences statistically. T_0: Color measured at midbuccal area before bleaching procedure; T_1: Color measured at midbuccal area after bleaching; T_2: Color measured 2 mm above the bracket position

potential of the office bleaching protocol in tooth whitening ($P < 0.01$). While the enamel under the bracket base demonstrated significant whitening, exposed enamel demonstrated the most change in color.

DISCUSSION

The present study was performed to investigate the effectiveness of two bleaching treatments on tooth color and how these treatments affect bracket bond strength. We demonstrated significant change in color following bleaching treatment on teeth, both in the enamel beneath the bracket and the uncovered adjacent enamel. This is in agreement with previous studies that also demonstrated effectiveness of bleaching agents during orthodontic treatment.[10,18] It is worth mentioning that similar to the results of this study, Jadad *et al*.[10] demonstrated that while areas beneath orthodontic brackets experience the bleaching effect, they are slightly darker than the uncovered enamel.

Tooth bleaching before bonding orthodontic brackets has been shown to reduce bond strength.[19,20] This reduction has been attributed to residual peroxide or reactive oxygen species on the tooth surface following the procedure that prevents subsequent polymerization of orthodontic adhesives.[16] Furthermore, resin tags formed in bleached enamel present with malformations and reduced strength causing weak bonds.[17]

As the result of this *in vitro* study, it showed that both bleaching procedure types (home and office) reduce the bond strength of orthodontic brackets to the enamel. It has been postulated that peroxide agents and free radicals present in bleaching products are able to move in all directions through the dental structure due to their low molecular weight. They can penetrate under the bracket-adhesive interface that could affect the resin tags, and in turn, reduce the bond strength of the brackets.[8,17] Moreover, these active ingredients can compromise the strength of the enamel by oxidation of its organic and inorganic counterparts.[7] It is interesting to note that existing literature has shown that treatment of tooth surfaces with antioxidant agents reverses the reduction of bond strength that is observed in bleached enamel.[21]

The office bleach treatment with 35% hydrogen peroxide had the least SBS, while the control group presented with the highest. Although the home bleach treatment had a less detrimental effect on bond strength, the difference between the two was not significant. The slight difference observed may be due to higher concentrations of peroxides in the office bleach compared to the home treatment. The same higher concentration could also be the reason for the higher difference of color in T_2-T_0 between the home and office bleaching groups. This difference in color was not observed in the enamel under the bracket, and the T_2-T_1 was not statistically significant between the bleach groups. The only explanation for this finding is that the infiltration of the enamel beneath the bracket is limited to a certain extent and increasing the concentration of the peroxides does not influence this phenomenon. This hypothesis has been previously proven by authors investigating bond strength of orthodontic brackets to bleached enamel, that is, an increase in concentration of whitening agent could lead to lower SBS.[20,22] Furthermore, the effect of bleaching agents on the morphology and hardness of the enamel surface is in correlation with the concentration of its active ingredients.[23]

The ARI scores also reflected the SBS values. The scores were higher in the control group suggesting that the bond at the composite enamel interface is stronger compared to that of the bleach groups. This further strengthens the hypothesis that bleaching agents act on the resin tags inside the enamel surface. There was no significant difference between the bleaching groups regarding ARI scores.

Based on the results of the present study, we can conclude that bleaching procedures can be performed during orthodontic treatment to improve tooth color. While the area underneath the bracket will also experience whitening, it is to a lesser extent than that of adjacent enamel. This difference between the two areas is of little importance, while the treatment is in progress as the enamel under the brackets is not visible but may cause a two-color tooth once bracket debonding is performed. Patients should be informed

of this possible consequence and a second bleaching appointment may be needed after bracket removal. While reductions of bond strength were observed following the bleaching procedures, the SBS remained far from the minimum bond strength of 6–8 MPa that is believed to be adequate for orthodontic treatment.[24] That being said since previous reports have shown that bleaching products based on 8% and 10% hydrogen peroxide concentrations effectively improve tooth color,[10,25] the practitioner should refrain from using higher concentrations if possible.

The present study used an *in vitro* approach and was the first to investigate the effects of bleaching after bonding of orthodontic brackets on bond strength. For this purpose, the authors used thermocycling as a tool to simulate intraoral conditions before SBS measurement. While the procedure is widely accepted in literature, we acknowledge potential deviations from *in vivo* conditions. *In vivo* aging and cyclic loading of the bracket tooth bond due to daily masticatory needs may cause an even more meaningful difference in bond strength between the groups. We suggest future research to investigate the effect of antioxidant treatment and lapse of time on reversing the adverse effects of bleaching on bond strength.

CONCLUSION

- Bleaching can be performed effectively during conventional orthodontic treatments
- Enamel under the bracket is bleached but not to the same extent as uncovered enamel
- Tooth bleaching during orthodontic treatment reduces SBS of brackets bonded to enamel.

Financial support and sponsorship
Nil.

Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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