

Effects of Light-cured versus No-mix and Self-etch Primer Adhesives on Enamel Discoloration following Orthodontic Bracket Bonding

Original Article

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Abstract

Introduction:

According to the importance of enamel discoloration and controversy regarding the effect of different orthodontic bonding materials on tooth discoloration, the aim of this study was to determine enamel discoloration following orthodontic brackets using different bonding materials.

Materials and methods: This in-vitro study, 30 recently extracted human premolars with intact enamel were selected and randomly divided into three groups after primary color measurement (T0). In group A, the specimens were bonded using light-cured adhesive (Transbond XT); in group B, Transbond plus self-etch primer was used; and in group C, unite bond (no-mix) was used on the buccal surface of the specimens. Lingual surfaces, however, did not receive any treatment and were considered as the control group. The samples were immersed in a solution of tea and coffee. After 1 week, the second color measurement was performed (T1) and color changes ΔE between pretreatment and post immersion state was evaluated. The third color measurement (T2) was completed after polishing the surfaces with 24-fluted tungsten carbide polishing burs and rubber cups, and color alterations were evaluated between the base and final state.

Results: Statistical analysis revealed that in all groups, the enamel color on buccal surfaces had statistically significant color changes in comparison with palatal surfaces between the three stages of treatment ($P < 0.001$). In groups B and C, ΔE (T0-T2) was clinically significant ($\Delta E > 3.3$), and the specimens in group C had the highest amount of changes in all stages of the treatment.

Conclusion: Bracket bonding on enamel surfaces with a number of bonding materials in this study led to detectable enamel discoloration, which was the highest when using no-mix bonding material.

Key words:

•Adhesives• Tooth Discoloration• Dental Enamel• Orthodontics• Orthodontic Brackets.

Introduction

The enamel around the orthodontic brackets is susceptible to discoloration as a result of bonding, debonding, or adhesive elimination procedures, which can lead to patient concern or dissatisfaction.⁽¹⁻⁴⁾ Moreover, tooth-color changes can arise from enamel decalcification due to poor oral hygiene.⁽⁵⁾

There are two major contributors to tooth discoloration. First, it may result from irreversible penetration of resin tags to the enamel structure at a depth reaching 50 μm .⁽⁴⁾ Because resin penetration into the enamel structure cannot be reversed by debonding and cleaning procedures, the discoloration may remain even after eliminating a layer of the enamel.⁽⁶⁾ The second contributor to enamel discoloration is due to the development of microscopic porosities in enamel during etching procedures. Direct absorption of food dyes and corrosion products of orthodontic appliances to these openings will cause color alterations in enamel.⁽⁷⁾ As the extent of etched enamel is usually more than the bracket base, the remnant adhesive, which is in contact with air, remains uncured in self-cure composites and will be eliminated from the enamel surface.⁽⁸⁾

Therefore, the open enamel rods can absorb colorant agents.⁽⁴⁾ The situation may not be the same when we use self-etched or light-cured adhesives.⁽⁸⁾

In esthetically critical areas, adhesive materials should provide sufficient bonding strength but should also not jeopardize the patient's esthetic demands during the treatment course. Therefore, the colorimetric characteristic of an adhesive material is an important criterion in choosing the appropriate material in esthetic areas. Research has, therefore, been aimed at developing a material to indulge both clinically acceptable bonding strength and esthetic requirements.

The purpose of this study is to compare enamel color changes associated with the use of self-cured, light-cured, and self-etched adhesives in bracket bonding.

Materials and Methods

In this in-vitro study, 30 recently extracted human premolars were selected. The specimens were kept in a 0.1% thymol solution to prevent bacterial growth. The teeth were cleaned with

pumice and a polishing brush, and then were examined by a lens of $\times 4$ magnification (Nikon Inc. Japan) to eliminate those with hypoplastic or cracked enamel. Then the specimens were mounted in acrylic molds and special jigs were made so that the three stages of colorimetric measurements could be performed in the same area of enamel. The teeth were randomly divided into three experimental groups:

- Group A: The specimens were bonded with a light-cured adhesive (Transbond XT) (Unitek, Monrovia, CA, USA).
- Group B: The specimens were bonded with Transbond Plus Self-Etch Primer (3M Unitek, Monrovia, CA, USA).
- Group C: The specimens were bonded with Unite bond (no mix) (3M Unitek, Monrovia, CA, USA).

The color of the enamel on the occlusal third of the buccal and lingual surface was then measured with a colorimeter apparatus (Shadepilot, Degudent, Germany) according to the Commission International d'Eclairage system (CIE), whereby the spectrophotometry method defines colors according to three parameters (L^* , a^* , b^*). The CIE Lab has a lightness scale, L^* , and opponent color axes for redness-greenness versus yellowness-blueness designated as a^* and b^* , respectively. Negative values of a^* indicate green, whereas positive values indicate red, and negative values of b^* indicate blue, and positive values indicate yellow.

After primary colorimetric evaluation of the 30 specimens, the L^* , b^* , a^* parameters were recorded (T_0). Then, in group A, the buccal surface of the teeth were etched with 37% phosphoric acid (3M Unitek, Monrovia, CA, USA) for 30 s and were gently air dried. Bonding resin (3M Unitek, Monrovia, CA, USA) was then applied and light cured for 20 s, and upper premolar metal brackets (American orthodontics, USA) were bonded with Transbond XT composite (3M Unitek, Monrovia, USA). These too, were cured for 40 s (Mectron light curing device with intensity of 400 mw/cm^2 , Italy). In group B, Transbond Plus Self-Etch Primer (3M Unitek, Monrovia, CA, USA) was applied on the buccal surface of the specimens for 5 s according to the manufacturer's instructions, and upper premolar metal brackets were bonded with Transbond XT composite and light cured for 40 s. In group C,

cleaning and etching was similar to group A and after etching, the Unite bond adhesive primer (3M Unitek, Monrovia, CA, USA) was applied on teeth and bracket bases. Following this, Unite bond composite (no mix) (3M Unitek, Monrovia, CA, USA) was placed on bracket bases and were positioned onto the buccal surface of the specimens without any further intervention. In all three groups, palatal surface of specimens was considered as the control group for their correspondance group.

After bracket placement all the specimens were stored in a solution consisting 25 ml tea and 25 ml coffee for one week, in an environmental temperature.⁽⁹⁾ After one week, the brackets were detached from the teeth surfaces and colorimetric examination was performed on the same area of the specimens with the same device on buccal and lingual surfaces. L*, b*, and a* were recorded (T1), and ΔE measurements in comparison with pre-bonding conditions were calculated by using the following formula (ΔE_{T0-T1}):

$$\Delta E = \sqrt{((\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2)}$$

After the secondary colorimeter, buccal and lingual surfaces were polished with 24-fluted tungsten carbide polishing burs and rubber prophylaxis cups, respectively. Colorimetric measurements were completed for the third time (T2) and ΔE was calculated in comparison with primary and secondary conditions.

Either quantitative or qualitative statistical analysis was performed for enamel alterations in each group between pre-bonding, after debonding and after polishing procedures. A t-test analyzed the statistical significance in each group between the specimens and the control (palatal surface) group, and qualitative measurement was based on the score of ΔE with 3.3 as the highest amount acceptable. Measures with no clinical importance were analyzed with Fischer's exact test.

Results

The results indicate that after exposure to the coloring solution and after polishing the debonded tooth surface, there were changes of the CIE color parameters for the specimen. ΔE values for all three groups are compared in Table 1.

Table 1. Comparison of ΔE values after debonding (T1) and polishing (T2) with sound enamel (T0) in light-cured (A), self-etched (B) and no-mix (C) composites.

	T0-T1		p-value	T1-T2		p-value	T0-T2		p-value
	B	L		B	L		B	L	
A	3.9 ± 1.19	1.91 ± 0.53	<0.001*	2.63 ± 1.25	0.78 ± 0.47	<0.001*	2.05 ± 0.36	1.37 ± 0.41	<0.001*
B	5.69 ± 1.23	1.98 ± 0.84	<0.002*	2.63 ± 0.61	0.9 ± 0.46	<0.001*	3.49 ± 0.83	1.19 ± 0.44	<0.000*
C	7.22 ± 1.72	1.85 ± 0.75	<0.000*	4.71 ± 1.50	1.18 ± 0.91	<0.001*	4.07 ± 1.65	1.32 ± 0.4	<0.000*

Statistical analysis in each group showed a statistically significant difference between each group and their respective control group (lingual surface) for all three stages of the experiment ($P < 0.05$). Considering the clinically visual amount of discoloration ($\Delta E > 3.3$) in group A, clinically significant discoloration was observed after debonding (T1) in comparison to the sound enamel (T0) ($\Delta E > 3.3$) in buccal but not for the lingual surface. However, there was no significant color difference between buccal and lingual surfaces when comparing T1 with T2, and T2 with T0. In group B and C, all specimens with bracket bonding had clinically unacceptable discoloration on the buccal but not on lingual surfaces, which was not orthodontically bonded. Enamel discoloration on buccal surfaces in the

three different stages revealed that the mean value for ΔE in group C was higher than that of group B and A, when comparing T0 and T1 stages (7.22 ± 1.72 , 5.69 ± 1.23 and 3.9 ± 1.19 , respectively). A higher amount of enamel discoloration was also inspected in group C (no mix composite) in all stages of the experiment.

Discussion

Enamel discoloration associated with orthodontic bracket bonding is a common side effect of orthodontic treatment. In this research, we investigated the effect of three different bonding materials (light cured, self-etch primer, and no-mix composites) on enamel color alterations in three stages including before bonding (T0), debonding (T1), and after polishing (T2). The results were

compared with the control group and showed that there was a significant and clinically detectable discoloration of enamel after debonding in all groups, even after polishing ($\Delta E > 3.3$), except for the light cured composite (group A) ($\Delta E = 2.05 \pm 0.36$).

There was an increase in the amount of ΔE after immersion into the tea and coffee solutions, which reduced significantly after polishing ($P < 0.05$). In the present study, the a^* parameter, which is an indicator of redness-greenness, showed a significant tendency towards redness in three stages of the experiment. Moreover, b^* parameter led towards yellowness in all stages, whereas changes in measures for the L^* parameter revealed the amount of lightness indicated when the enamel color grew darker, especially when compared with its primary condition. The results are consistent with similar studies in which the increase in b^* and decrease in L^* parameters are considered as the major factors in enamel discoloration.⁽¹⁰⁾

Discoloration can be evaluated by colorimeter or human eye.⁽¹¹⁾ However, visual colorimetry can show different results either between different examiners or in different times with the same examiner.⁽¹²⁾ The sensitivity of the human eye in detecting small color differences is limited and the interpretation of visual color comparisons is subjective. There are a majority of factors, such as lighting condition, translucency and opacity, light distribution, and condition of the human eye, which makes visual color assessment vulnerable to errors.⁽¹³⁾ Hence, it was decided to use CIE Lab spectrophotometry to evaluate discoloration. Eliades et al. have mentioned that ΔE values in the range of one unit are considered as a color match⁽⁴⁾, where most studies set the acceptance limit for color matching at 3.3 units. Therefore, we chose this level for the limit of color difference.⁽¹⁾

There are several factors that lead to enamel discoloration after orthodontic treatment. First, enamel damages during bonding, debonding, and adhesive cleaning procedures may lead to color alteration.^(1, 4) Furthermore, the changes can be due to enamel decalcification resulting from poor oral hygiene and colorant foods.⁽⁵⁾ Second, the open enamel rods that have not been filled with resin can absorb colorant agents.⁽⁴⁾ It was reported that tooth surface after debonding

and clean-up was mainly composed of cut enamel prism infiltrated by resin tags, occupying the sites of enamel rods dissolved by acid etching up to 50 μm in the enamel.⁽⁴⁾ After clean-up procedures, the long-term presence of residual adhesive resin in the enamel surface rendered the instability of tooth color, which occurred by direct absorption of exogenous colorants.⁽¹⁴⁾

Zaher et al. investigated the effect of etching and different adhesive materials on enamel discoloration and after polishing they measured ΔE values with a spectrophotometer.⁽¹⁵⁾ They also evaluated the length of resin tags infiltrated into enamel prisms with an electron microscope. The ΔE changes were clinically significant in all study groups ($\Delta E > 3.7$) and they found a significant correlation between the length of resin tags and the amount of color alteration. These results corroborate our findings in this study.

In a study conducted by Traklyali et al., however, enamel discoloration was evaluated after the bonding of five different adhesives and spectrophotometry was measured with an Vita Easys-hade device.⁽¹⁶⁾ In Traklyali's study, $\Delta E > 3.7$ was the clinical limit of color alteration. Hence, enamel discoloration was not clinically detectable, but in our study the amount of ΔE was more than the clinical limit values after bracket debonding. The enamel polishing stage was performed with a tungsten carbide polishing bur in both studies, which may improve enamel surface roughness and light reflection condition. Despite the enamel color improvement after polishing in all groups, the ΔE was still more than 3.3 for groups B and C. The possible reason that the results are not parallel in these studies may be because of different devices used for colorimetry or due to less sensitivity of Vita Easys-hade in comparison with our device.

Residual adhesive debris on buccal surfaces are responsible for the discoloration of enamel. Polishing enamel surfaces are able to eliminate not only adhesive debris but a part of the resin tags and enamel colorants, which may affect enamel color. Residual adhesive resins on enamel surfaces after debonding are cleaned up in a number of ways. A spiral fluted tungsten carbide bur with a low-speed hand piece is reported to produce the finest scratch and the least enamel loss.⁽⁶⁾ Therefore, this method was used in the present study.

The difference between three groups might be due to the type of adhesive and procedure for bracket bonding. In the light cured adhesive (group A), all the etched enamel surfaces were covered by adhesive and cured afterwards. In group B, however, there is a possibility that the etched enamel surface was not covered by an adhesive, and this means that it is more vulnerable to discoloration. In the no-mix adhesive, it is possible that the uncured adhesive is washed away from the enamel surface. Meaning, enamel rods are exposed to colorant materials. Less discoloration on the palatal side confirms that resin tags and etched enamel is a predisposing factor to enamel discoloration.

Conclusion

Within the limitations of this study, the following conclusions were drawn. Enamel discoloration is expected to happen after bracket bonding and exposure to colorant agents in light cured,

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self-etch primer and no-mix adhesives, and was clinically significant in all groups. No-mix adhesives followed by self-etch primer have the highest amount of enamel discoloration after bonding procedure, which is still clinically significant after debonding and polishing. Light-cured adhesive, however, has no clinically significant enamel discoloration after polishing.

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