Effects of Fluoride Release on Enamel Color Alteration

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Abstract
The aim of this study is to evaluate teeth discoloration after the usage of adhesive fluoride release. **Material and Method**: 80 extracted healthy premolars divided into two groups were used in the study, with metal brackets being bonded in both groups,. The first group universal adhesive was applied (transbond light cure adhesive paste-Transbond XT), whereas in the second group fluoride releasing bonding material was used (opal bond MV composite and opal seal). The measurement of color parameters was performed using the spectrophotometer vita easyshade 4.0 to calculate ΔL, Δa, Δb, and ΔE. **Statistical Analysis**: 3-way mixed analysis of variances (ANOVA) was used to compare ΔE before using adhesive material and after the procedure. On the other hand, it was used to compare Δa, Δb, and ΔL before and after using adhesive material. The statistical significance level was established at $P< 0.05$. Boferroni correction was used to create mean differences between the results. **Results:** The result of this study showed that ΔE^* values were increased in all groups. The mean difference of ΔE^* value in the first group (3M adhesive material) was 2.54 ± 1.57. At the same time, the ΔE value in opal adhesive group was 4.43 ± 5.4. These results showed that fluoride seal had direct effect on enamel color after a period of three months teeth storage. Results showed above the normal limit and produced visible color change on the surface of the teeth after finishing procedure. On the other hand, ΔL values were increased in both groups, with a significant

difference in the first group (p value 0.04) and with no significant difference in the second group (p value 0.239). **Conclusion:** The highest color changes were observed after the finishing procedure in opal bond MV composites and the opal seal groups. This was done by increasing ∆E value due to the presence of fluoride release adhesive structure. Transbond light cure adhesive past-Transbond XT had acceptable clinical change after the debonding and finishing procedure by increasing ∆E value.

Keywords: Debonding, Teeth, Transbond Light Cure Adhesive Past-Transbond XT, Fluoride, Adhesive

Introduction

Esthetic appearance of the oral cavity is one of the most important aims of orthodontic treatment. Several factors affect the natural color of the teeth, for example: the condition of the light coming from the surrounding environment, the color of gingival tissue and nature of the saliva that provides the tooth hydration, and the reflective index coming from the underlying surface (Goodkind & Schwabacher, 1987; Dawes, 1974).

However, recent studies showed that bonding and debonding of brackets in orthodontic treatment may cause tooth discoloration (Eliades et al., 2001; Trakyali et al., 2009).

Remnant adhesive composite, surrounding the brackets bonded to the tooth or after debonding brackets, helped in the process of accumulation of the plaque of bacteria that may form whitish spots and periodontal problems (Bishara & Trulove, 1990; Quirynen & Bollen, 1995).

At the same time, cleaning up procedures and debonding brackets may cause micro cracks and fractures on the enamel surface that creates damage to the teeth (Pus & Way, 1980; Diedrich, 1981; Sandisson, 1981; Eliades et al., 2001).

The Appearance of white spots lesion on the surfaces of the teeth during and after orthodontic treatment may be caused by hypomineralization of the enamel materials as in procedures of bonding and debonding of brackets. These white spots could cause a big change in the natural color of teeth (Sandison, 2016).

The storage of foods and drinks may also lead to the appearance of stains on the teeth by causing discolorations on the enamel surfaces.

To measure tooth color appearance, two common ways are described. The first method is by visual examination, and it is the most common method used in dentistry for color change examination (van der Burgt et al., 1990). Several factors may influence the matching of visual color examination like external room light, doctor's experience, age and the tiredness of the eyes (Billmeyer & Saltzman, 1981; Preston, 1985; Rubino et al., 1994).

The second method of tooth color examination was done through electronic optical sensors (Panariva, 2004). This method was more accurate than the visual method. Various common systems have been used in researches like tristimulus colorimeters, spectroradiometers, spectrophotometers and digital color analyzers (Joiner, 2004).

Materials and Methods

This study was conducted through eighty extracted teeth. The criteria for the selection of samples were teeth without restorations, attritions, and fractions. All teeth were stored in normal saline to protect them from dehydration and the saline was carefully changed weekly to prevent bacterial growth. All teeth were polished by pumice to clean all the enamel surfaces of the teeth.

Materials Used

The first material group chosen was 3M adhesive (Transbond Light cure Adhesive paste-Transbond XT) with unitek TM miniature twin metal brackets. For the second group, Opal adhesive (opal bond MV composite and opal seal) and avex brackets were chosen.

Acid Etched: Usage of (blue etch) acid etch with a concentration of 36% phosphoric-acid for 20 seconds.

Bonded by Transbond XT Primer and Opal Seal: In each sub-group, after the etched area became frosty white, the enamel bonding agent (40 teeth were bonded with Transbond XT and 40 teeth were bonded with Opal Seal) was placed in a uniform thin coat using a special brush on the enamel surface and activated with LED light cure for 10 seconds. The enamel surface to be bonded had to appear shiny. Then a small quantity of the adhesive paste was placed on the base of the brackets which was fixed at a 4mm distance from the occlusal plane on the teeth surface with a stable pressure. The excess material was eliminated by using a sharp probe without changing the position of the brackets. The adhesive-bracket-tooth interface was exposed to the light curing for 20 Seconds at a distance of 5mm.
The teeth were stored 3 months in artificial saliva at 37^0C.

Debonding and Resin Removal

The brackets were removed using debonding plier. In both groups, the remnant composites were removed with a blade tungsten carbide bur connected to low speed handpiece.

Measurement of the Color Parameters

Measurement of the color parameters was performed using the Spectrophotometer Vita Easyshade 4.0.

The spectrophotometer was used for each tooth twice. The first time was before applying the adhesive material and bonding the brackets, while the second time was after finishing the procedure and removing the adhesive remnants.

The spectrophotometer consists of three main elements: a light source, a way to direct the light source to an object and to receive the light reflected by the object, and a spectrometer which determines the intensity of incoming light depending on the wavelength. As a result of own source of light, tooth color can be determined in any lighting condition. Measurements were performed globally with the aim to determine color parameters: L * (brightness), a * (chromatic parameter in red-green axis), and b * (chromatic parameter in yellow-blue axis).

Measurements were taken before and after establishing the whitening protocol with experimental and commercial materials. The measurements were done at the surface of each tooth. For each area, three measurements were made and their average was calculated. However, this was used in calculating the difference in color using the formula below:

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

Where L1 * (Brightness), a1 * (chromatic parameter in red-green axis), b1 * (chromatic parameter in yellow-blue axis) represent the chromatic parameters before applying the bracket (on the buccal surface). Also, L2 * (Brightness), a2 * (chromatic parameter in red-green axis), b2 * (chromatic parameter in yellow-blue axis) represent the chromatic parameters after finishing procedure protocol (on the buccal surface).

From a clinical point of view, according to the capacity of visual perception of people and the environment, some thresholds have been established. These thresholds include the threshold 50/50% of ΔE_{ab}=1.0 perception and acceptability threshold ΔE_{ab}=3.7. However, threshold 50/50% of ΔE_{ab}=1.0 perception means the limit above, 50% the observers perceive a difference in color and the other 50% do not. The acceptability threshold ΔE_{ab}=3.7 is the extent to which patients will consider color difference to be clinically acceptable.

Statistical Analysis

SPSS (version 8.0) was used in this study to create statistical analysis and to compare the results. 3-way mixed analysis of variance (ANOVA) was used to compare mean ΔE before using adhesive material and after finishing the procedure. Furthermore, it was also used to compare between Δa, Δb,

and ΔL before and after using adhesive material. The statistical significance level was established at P< 0.05.

Boferroni correction was used to create mean difference between the results.

Results

The results of this study CIE color parameters of all extracted teeth before bonding and after the finishing of the procedure. Table 1 shows numbers of teeth used in each group.

Table 1. The teeth number used in each group

		Value Label	N
Groups	1.00	Control	80
	2.00	Opal seal	40
	3.00	3M	40

In Table 2, the result of the 3-way ANOVA showed thattime had a significant effect for color parameters. Thus, the parameters of a, L, b, and E were significant with adhesive material.

Table 2. 3-way mixed analysis of variance (ANOVA) for color parameters with respect to the effect of time and adhesive materials

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	L	42.249[a]	2	21.124	3.331	.039
	a	52.233[b]	2	26.116	18.713	.000
	b	233.267[c]	2	116.633	15.778	.000
	E	396.496[d]	2	198.248	18.172	.000
Intercept	L	695645.496	1	695645.496	109705.665	.000
	a	3698.964	1	3698.964	2650.425	.000
	b	48884.033	1	48884.033	6612.824	.000
	E	1723.086	1	1723.086	157.944	.000
Groups	L	42.249	2	21.124	3.331	.039
	a	52.233	2	26.116	18.713	.000
	b	233.267	2	116.633	15.778	.000
	E	396.496	2	198.248	18.172	.000
Error	L	741.899	117	6.341		
	a	163.287	117	1.396		
	b	864.900	117	7.392		
	E	1276.410	117	10.909		

Total	L	696429.644	120			
	a	3914.484	120			
	b	49982.200	120			
	E	3395.991	120			
Corrected Total	L	784.148	119			
	a	215.520	119			
	b	1098.167	119			
	E	1672.906	119			

a. R Squared = .054 (Adjusted R Squared = .038), b. R Squared = .242 (Adjusted R Squared = .229)

c. R Squared = .212 (Adjusted R Squared = .199), d. R Squared = .237 (Adjusted R Squared = .224)

In Table 3, ΔE value increased after debonding and after finishing the procedure for all groups. The mean difference of ΔE value in 3M adhesive group before and after (debonding and finishing procedure) was 2.54± 1.57 with significant difference (p value 0.034). At the same time, the mean difference of E value in opal adhesive group was 4.43±5.4 with a significant difference (p value 0.001).

The mean difference of ΔL value in the first group and the second group increased by 1.415±1.62 and 0.995±3.45 with significant difference in the first group (p value 0.04) and no significant difference in the second group (p value 0.239).

The mean difference of Δa value decreased in the first and second groups (Δa in the first group -1.55±0.7 and in the second group -1.15±1.54). In both groups, there were significant differences (0.001 and 0.001).

Thus, the first group's results show increase in the mean difference of Δb value with 2.25± 2.17. These results were in contradiction with the second group because Δb value decreased with -1.1±3.24. Also, both groups had significant differences in the first and second group (p value 0.34 and p value 0.001).

Table 3. Mean ± SD values of all measured teeth before and after finishing the procedure

Dependent Variable	Group	Mean ± SD	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
L	Group2 Opal	0.99±3.45	0.56307	0.239	-.3726	2.3626

	Group1 3M	1.41 ±1.62	0.56307	0.040	0.0474	2.7826
A	Group2 Opal	-1.15±1.54	0.26416	0.001	-1.7976	- 0.5144
	Group1 3M	-1.55±0.70	0.26416	0.001	-2.1976	-0.9144
B	Group2 Opal	-1.1±3.24	0.60796	0.219	-2.5767	0.3767
	Group1 3M	2.25±2.17	0.60796	0.001	0.7733	3.7267
E	Group2 Opal	4.43±5.40	0.73856	0.001	2.6431	6.2309
	Group1 3M	1.89± 1.57	0.73856	0.034	.1031	3.6909

Discussion

The esthetic consideration was the first goal for most of the patients that needed orthodontic treatment. Therefore, the teeth discoloration during and after orthodontic treatment was an important challenge for all orthodontist.

Several etiological factors affected optical characteristics of the enamel surface during orthodontic treatment. For example, using phosphoric acid etching increased the microscopic roughness of the enamel surface leading to enamel discoloration and loss of about 10-20µm by dissolution of apatite crystallites (Eliades et al., 2001; Silverstone, 1985). On the other hand, debonding brackets and removing remnant adhesive material could affect external tooth morphology and reform texture modification. This also has a significant effect on the natural tooth color (A). As a result, the use of tungsten carbide bur to minimize enamel damage during the removal of adhesive remnants was recommended (Trakyali et al., 2009; Joiner, 2004; Pus & Way, 1980; Zachrisson & Artun, 1979).

On the other hand, individual facial characteristics affected tooth color appearance such as age, sex, skin color, lips, and color of the gums (Alkhatib, 2005).

The dental material structure affected the smoothness of the enamel surface and could lead to the discoloration of the teeth.

Two factors could affect the color change of polymers: the external factors such as enamel absorption of diet color pigmentation and superficial absorption, and the internal factor like chemical structure (da Costa et al., 2010; Corekci et al., 2010; Trakyali et al., 2009; Dietschi et al., 1994; Lazzetti et al., 2000; Leibrock et al., 1997).

The major reasons for using fluoride release in adhesive orthodontic material was to inhibit decalcification during the treatment, white spots around the brackets and antibactericidal effect. At the same time, the fluoride releasing material had positive effect on the hardness and elastic modulus of enamel (Seyed Hamid Raji et al., 2014).

On the other hand, Eser T. and Daniel R. observed that using fluoride releasing materials did not reduce demineralization or white spots during orthodontic treatment (Eser Tufekc€ et al., 2014).
Therefore, the mean objective of this study was to evaluate teeth discoloration after using fluoride releasing adhesive on 40 extracted teeth and to measure teeth color changes after three months of storage in artificial saliva at 37^0C. Also, it compares the results with other universal adhesive material.

Increasing bonding strength was the reason behind choosing the same manufacturer company of adhesive material and brackets to avoid any statistical error (Elsaafin Mahmoud et al., 2017). Teeth discoloration in human life is generally more possible with external factors, for example smoking and drinking coffee. With the addition of orthodontic treatment, the rate of tooth discoloration will increase.

L value referred to the degree of lightness in the munsel system, and the value of L between 0 (black) and 100 (white). So the acceptable level of ΔL value was set at 2.0 unit because if ΔL will increase more than 2.0 unit, the humane eye can observe that change (Chung, 1994).
a value is the measurement of redness (a value more than 0) or greenness (a value less than 0), while b value is important to calculate the rate of yellowness (b> 0) or blueness (b<0).

The acceptable level of ΔE value was set between 1 to 3.7 unit(Agoston et al., 1979; Johnston & Kao, 1989).
Bonding materials have direct effect on tooth discoloration and ΔE between 0.85 to 1.51 units (Trakyali et al., 2009).

This study showed that ΔE values increased in all groups and the mean difference of ΔE values in first group (3M adhesive material) 2.54±

1.57 with a significant difference (p value 0.034). This difference was acceptable and did not show visual difference in the result. At the same time, the ΔE value in opal adhesive group was 4.43±5.4 with significant difference (p value 0.001). This result showed that fluoride seal had direct effect on enamel color after three month of teeth storage. Results were above the value limit and produced color changes on the surface of the teeth after finishing procedure.

On the other hand, ΔL values increased in both groups with a significant difference in the first group (p value 0.04) and with no significant difference in the second group (p value 0.239).

Conclusion
- The adhesive material has a direct effect on tooth discoloration.
- The highest color change was observed after the finishing procedure in opal bond MV composite and opal seal group by increasing ΔE value caused by having fluoride relies adhesive structure.
- Transbond light cure adhesive paste-Transbond XT had acceptable clinical change after debonding and finishing procedure by increasing ΔE value.
- All groups showed significant difference before and after the finishing of the procedure in ΔE, ΔL, Δa, and Δb except opal seal group which had no significant difference in ΔL and Δb.

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