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Research Article

Effects of Different Orthodontic Adhesives and Adhesive Remnant Removal Technique on Enamel Color Change-An *In Vitro* Study

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Abstract

Aim: To evaluate and compare adhesive remnant removal post debonding of brackets bonded using two different Orthodontic adhesive and enamel color change after removal of adhesive remnant post debonding with a tungsten carbide bur with naked eye and under loupe magnification (3.5 X -420).

Method: Forty extracted premolars were divided into 2 groups according to the adhesive used for the bonding (Group I Enlight and Group II Grengloo adhesive). Both the groups further divided into two subgroups by two different debonding techniques (necked eye and loupe magnification (3.5 X -420). Enamel color was evaluated spectrophotometrically before bonding (T1) and after debonding and polishing (T2). The color parameters were measured for both the adhesive and adhesive removal techniques, and the corresponding color differences (ΔE) between the interval groups were calculated. Results obtained were subjected to Wilcoxon signed rank and Mann Whitney U test to compare color change statistically.

Results: Study revealed that the Grengloo groups showed significantly greater change in ΔL (4.31 ± 1.32 in 2A and 2.85 ± 1.92 in 2B) than the Enlight group. Δa and Δb did not show a significant difference in both the groups. Highest ΔE value was observed in Grengloo adhesive.

Conclusion: Both the adhesive removed with loupe magnification showed less enamel color change than adhesive removed with naked eye. Grengloo, the color changing adhesive showed greater color change after adhesive remnant removal than the conventional adhesive.

Keywords: Enamel Color; Grengloo Adhesive; Loupe Magnification

Introduction

Complete elimination of the residual adhesive resin attached to the enamel surface is mandatory to restore the natural appearance and smoothness of enamel. Incomplete removal of adhesive residues may increase the roughness of the enamel surface, which may lead to color alterations and accumulation of bacterial plaque that may further lead to decalcification and periodontal problems [1]. In addition, penetration of resin tags into the enamel structure may also lead to alteration in enamel color [2].

Many researchers have evaluated a variety of techniques for bracket debonding, resin removal, and subsequent enamel surface polishing [3,4].

Even though the adhesive removal task appears simple and easy, the excess bonding material is often overlooked because the orthodontic adhesive has a similar color to the enamel and may be difficult to detect with the naked eye [5]. It has been stated that the use of a dental loupe by the practitioner may improve the quality of the debonding procedure, causing less enamel damage and better resin removal [6]. Available debonding and clean-up techniques cannot completely clean the vestibular surface of teeth and can lead to temporary alterations of the morphology of the underlying enamel that are visible to the naked eye [7].

Grengloo is a two-way color change adhesive. While bonding the color of Grengloo changes from green to tooth colored and when debonding, a short blast of cool air or water lowers the bonding surface temperature and Grengloo turns green again. According to the manufacturer the color contrast feature aids in fast and accurate cleanup at bonding and debonding.

A thorough clean-up of adhesive remnants post-debonding could be expected to minimize the color change in enamel. To our

knowledge, no study has evaluated the efficiency of post-debonding enamel clean-up using color change adhesives under magnification. Hence this study aimed to evaluate the color change in enamel following debonding of brackets bonded using Grengloo and adhesive clean-up under magnification using a dental loupe.

Materials and Method

Power analysis to calculate sample size showed that a sample of 40 with equal allocation among the groups and satisfying the inclusion criteria would produce more than 99% statistical power (type II error = 0.01) and 5% type I error probability ($\alpha = 0.05$) to be able to detect the difference in outcomes (color change) between the four subgroups. 40 human premolars extracted for orthodontic purposes were selected. The selection criteria were the absence of cracks, hypoplastic or carious lesions, and restorations on the buccal surfaces of the teeth. The selected teeth were divided into 2 groups (n = 20 each), according to the orthodontic adhesive used for bonding the brackets: -Group 1- Brackets bonded with conventional adhesive Enlight, Group 2- Brackets bonded with color changing adhesive Grengloo. The two groups further sub divided into two subgroups (n = 10 each) according to the method of adhesive remnant removal technique; subgroup A= Adhesive remnant removed under naked eye, subgroup B = Adhesive remnant removal under magnification with a dental loupe (3.5 x 420).

The sample teeth were cleaned and stored in distilled water at room temperature. The distilled water was changed weekly to prevent bacterial colonization. Each tooth was embedded in a resin block with the buccal surface exposed. After cleaning with water, the exposed tooth surface was polished with non-fluoride pumice with a rubber cup for 10 seconds, rinsed with water, and dried with compressed air.

Bracket bonding procedure

Enamel was etched with 37% orthophosphoric acid for 15 seconds, rinsed with air-water spray for 20 seconds, and air-dried for 10 seconds. A thin layer of orthodontic adhesive primer was applied on the etched enamel surface and light cured for 5 seconds. Orthodontic adhesive was applied on the bracket base and the bracket was positioned on the tooth. After flash removal, the adhesive was light cured was with an LED source for 5 seconds on each side.

Debonding and adhesive removal procedure

Following bracket debonding with debonding pliers, the adhesive remnants were cleaned with a 12- blade tungsten carbide bur; under the naked eye in sub-group A and under loupe magnification (3.5x 420) in sub-group B. Adhesive removal was followed by polishing of the enamel surface with Sof-Lex discs.

Color assessment of enamel surface

Color of the enamel was evaluated at two-time intervals: before bonding (T1) and after removal of adhesive and polishing (T2) using a spectrophotometer. Color evaluation was done in accordance with the CIE (Commission Internationale de l'Eclairage) L*a*b* color system (1931) that uses three parameters to define color: L* coordinate corresponds to a degree of lightness and darkness and ranges from 0 (black) to 100 (white), a* and b* coordinates correspond to the Chroma and represent positions on the red (+)/green (–) and yellow (+)/blue (–) axes, respectively. The premolars were isolated, and the color measurements were taken from the middle third of the teeth. All color measurements were repeated three times and the average was calculated. The difference between the two-color assessments was calculated with the following formula: $\Delta E = [(L2 - L1)^2 + (a2 - a1)^2 + (b2 - b1)^2]^{1/2}$.

Results

Statistical analysis was performed using SPSS version 21.0 (SPSS Inc). Inter-group comparison was done using Kruskal-Wallis test followed by Mann Whitney test for multiple comparisons. Intra-group comparison was done using Wilcoxon sign rank test. Statistical significance was set at $p < 0.05$. Table 1 shows the descriptive statistics for color parameters in all the study groups before bonding and after clean-up. The L value increased in all the groups indicating that the enamel became whiter after clean-up, however significant differences were observed only in Groups 2A and 2B when compared using Wilcoxon sign rank test. Table 2 shows the descriptive statistics for color change in all the study groups. Intergroup comparison for delta E, Delta L, Delta a and Delta b using Kruskal Wallis showed significant differences for only delta E and Delta L. Table 3 shows post hoc comparison using Mann Whitney U test of overall significant ΔE and ΔL measurements for all the subgroups. Significant differences were seen for ΔE for all groups except for group 1A vs 2B and 2A vs 2B. For ΔL all the pairs showed a statistically significant difference except for 1A vs 1B.

Color parameter		N	Mean before bonding	Std. Deviation			Mean after clean-up	Std. Deviation	P value
L1	1A	10	76.0981	3.45298	L2	1A	76.2532	3.14602	0.799
	1B	10	79.4150	2.36543		1B	79.6211	2.97391	0.646
	2A	10	76.1973	2.11122		2A	80.5091	1.67317	0.005*
	2B	10	78.7147	1.52488		2B	81.5698	2.26788	0.005*
a1	1A	10	1.4666	.62311	A2	1A	1.1626	.38221	0.139
	1B	10	.9917	.39010		1B	.8113	.32155	0.093
	2A	10	1.0208	1.39067		2A	1.3197	1.51299	0.508
	2B	10	.2271	.47226		2B	.1097	.33081	0.575
b1	1A	10	11.0591	4.23807	B2	1A	10.0930	2.81021	0.333
	1B	10	9.3416	1.80127		1B	9.7613	2.49081	0.333
	2A	10	10.4302	3.33288		2A	9.7542	4.98407	0.595
	2B	10	10.7758	1.08155		2B	11.2905	2.75114	0.333

Table 1: Descriptive statistics and comparison of color parameters within groups at two time intervals.

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	P value
						Lower Bound	Upper Bound			
Delta E	1A	10	3.11396	.854233	.270132	2.50288	3.72504	1.659	4.466	<0.0001*
	1B	10	1.88431	1.147036	.362725	1.06377	2.70485	.684	4.400	
	2A	10	4.48716	1.197305	.378621	3.63066	5.34366	2.162	6.512	
	2B	10	4.17174	1.300897	.411380	3.24113	5.10235	2.258	6.245	
Delta L	1A	10	-.1220	2.50987	.79369	-1.9175	1.6735	-4.10	2.55	<0.0001*
	1B	10	.4595	1.32578	.41925	-.4889	1.4079	-1.39	3.37	
	2A	10	4.3118	1.32732	.41973	3.3623	5.2613	1.02	6.15	
	2B	10	2.8551	1.92422	.60849	1.4786	4.2316	.32	6.02	
Delta a	1A	10	-.4319	.56146	.17755	-.8335	-.0303	-1.17	.36	0.297
	1B	10	-.0460	.13413	.04242	-.1419	.0499	-.26	.19	
	2A	10	-.1006	.49306	.15592	-.4533	.2521	-.87	.36	
	2B	10	-.0392	.75081	.23743	-.5763	.4979	-1.09	1.36	
Delta b	1A	10	-.5350	2.37787	.75195	-2.2360	1.1660	-2.92	3.04	0.197
	1B	10	1.1910	1.26666	.40055	.2849	2.0971	-1.18	2.83	
	2A	10	.4240	1.58623	.50161	-.7107	1.5587	-1.68	2.58	
	2B	10	1.4034	2.27821	.72043	-.2263	3.0331	-1.37	5.01	

Table 2: Descriptive statistics and comparison of color change in all the study groups.

Groups	n	P value ΔE	P value ΔL
1A/1B	10/10	.008*	.705
1A/2A	10/10	.007*	.001*
1A/2B	10/10	.070	.028*
1B/2A	10/10	.001*	.000*
1B/2B	10/10	.003*	.004*
2A/2B	10/10	.597	.019*

Table 3: Post hoc comparison of delta (ΔE) and Delta (Δ L) measurements for all subgroups.

Discussion

Enamel discoloration after orthodontic treatment is often overlooked in daily practice [1]. Removal of adhesive remnants after debonding with various rotary instruments may cause an increase in enamel surface roughness as well as change in the color of enamel [8]. According to Karamouzos., *et al*. the optical characteristics of enamel are changed during orthodontic treatment, with the color change being affected by several factors. External coloring occurs as a result of superficial absorption of food pigment; while internal coloring occurs during ageing [1]. Restoring the enamel to its original condition should be the goal of the orthodontist. A thorough removal of the resin tags which may have penetrated into the enamel surface can minimize these color changes. Improving the vision during the clean-up procedures through use of magnification [6], such as dental loupes as well as improving the visibility of the remnant adhesive with the use of color changing adhesives may result in a better removal of the adhesive remnants. Hence this study tested the change in enamel color after orthodontic treatment using a conventional or a color changing adhesive and removal of adhesive remnants with and without use of magnification.

Tooth color was identified according to the CIE L*a*b system and the difference between two colors was indicated as ΔE [8]. Currently various methods are being used to assess tooth color. These range from visual subjective comparisons using paper, colored porcelain or acrylic resin shade guides, to objective measurements using instruments such as spectrophotometer, colorimeters, and image analysis techniques. In the present study, color of enamel was determined using a spectrophotometer. Spectrophotometer is among the most accurate and most efficient tools for color measurement and assessment of color match in dentistry. It presents data in CIE LAB system. The sensitivity and reproducibility of the system for calorimeter have been previously confirmed [9-11].

Chen., *et al.* conducted a systematic review on the influence of orthodontic treatment with fixed appliances on enamel color and concluded that adhesive system and resin removal methods may be associated with enamel discoloration [12]. Gorucu-Coskuner found that adhesive remnant removal with 12-bladed tungsten carbide bur decreased the L values (shifted to black direction) but the value increased to close to pre-treatment value after polishing with Sof-Lex discs [8]. Hence this protocol was followed in our study.

The results of the present study showed that the L values did not show significant difference between T1 and T2 for the Enlight group. However, there was significant increase in the L value in the Grengloo adhesive group indicating that the tooth color shifted towards white. This finding indicates that the color-changing adhesive facilitated removal of adhesive remnants resulting in a better restoration of the enamel color. The a and b values corresponding to the Chroma did not show significant change in any group. These findings are in agreement with those of Gorucu-Coskuner., *et al.* who compared the effects of orthodontic treatment on enamel color change using different etching techniques, carbide burs and polishing discs and found that although the enamel darkened after adhesive remnant removal with carbide burs, it was restored after polishing. They did not find significant color alteration between pre-treatment and post-treatment [7]. Corecki., *et al.* also performed tooth color measurement after polishing and did not find significant differences. ΔL is the most significant parameter because the human eye can detect change in L more readily than it can perceive change in the other parameters such as a and b [3]. The Grengloo groups showed significantly greater change in ΔL (4.31 in Group 2A and 2.85 in Group 2B) than the Enlight group. Δa and Δb did not show significant difference in the groups.

The CIE L a^*b^* system is considered to be the standard color space and the mathematical magnitude of color change is indicated

as ΔE. The human eye has restricted capability to see such difference and cannot perceive ΔE value below 1. The ΔE values between 2 and 3.7 represent the clinically perceivable but acceptable range of difference. It has been reported that ΔE values of 3.7 and higher cannot be acceptable under clinical conditions. Therefore, as with previous studies, 3.7 was accepted as the threshold value for ΔE [8].

In the present study the highest ΔE value, 4.48 ± 1.19 was observed in the Group 2A (Grengloo adhesive in which the resin was removed by naked eye) followed by 4.17 ± 1.30 in Group 2B (Grengloo adhesive in which resin removal was under magnification). Although this was above the threshold value of 3.7, the color change was towards white. ΔE in the Enlight group was below the threshold value (3.11 ± 0.85 in Group 1A and 1.8 ± 1.14 in Group 1B). ΔE was significantly different between Groups 1A and 1B indicating that enamel color change in the Enlight group was less when adhesive was removed under magnification. However, magnification did not seem to make a difference in the Grengloo group, since ΔE was not significantly different between groups 2A and 2B.

Very few studies have evaluated the influence of using different adhesives on enamel color change. Trakyali., *et al*. evaluated enamel color alteration with five different orthodontic adhesives, one of which was a color changing adhesive Blugloo. They did not find significant difference in ΔE in groups bonded with Blugloo [13]. None of the tested adhesive groups showed clinically detectable change in ΔE. Other studies have compared color change using etch and rinse adhesive systems with self-etch systems (SEP) and RMGIC. Boncuk., *et al*. found the maximum color alteration with etch and rinse systems [1]. Joo., *et al.* and Zaher., *et al.* also found that the SEP system showed less stain susceptibility [2,14]. Eliades., *et al*. evaluated the enamel color change associated with bonding of brackets with a "No-mix" adhesive resin (Unite) and glass ionomer adhesive (GC, Fuji Ortho). They found that all differences noted exceeded the threshold for clinical detection. The greatest differences were recorded for the baseline-debonding interval for both the adhesives investigated [12]. Karamouzos., *et al*. found that chemically cured resin was associated with greater color change than light cured composite [12].

In the present study, the alteration in enamel color in all the study groups was also quantified according to the threshold value of ΔE < 3.7. In the Enlight group, 20% of the sample in sub-group A and 10% in sub-group 1B showed color change > 3.7. In the Grengloo group, 70% of the sample showed a color change >3.7 in both the sub-groups, but this change was towards the light side. Gorucu-Coskuner., *et al*. found visible color alteration in 60% of their sample after polishing with Sof-Lex discs [8].

According to Kim., *et al*. and Zaher., *et al*. infiltration of enamel by resin tags may change the refractive index of the enamel modifying the diffusely reflected light component and hence influencing color parameters. Moreover, the change in enamel surface caused by finishing procedures may alter the seculars light component (L* value) of the color parameters, which is highly sensitive to the cleaning and finishing procedure. In addition, any enamel loss during finishing procedure would affect the degree of light reflected form the tested surface [2].

The null hypothesis was rejected: when ΔE values were compared, significant difference was observed between the two adhesive groups. Grengloo, the color changing adhesive showed a greater color change than the conventional adhesive, but the change was towards the lighter side. Removal of adhesive remnants was better under magnification in the Enlight adhesive group but did not make a difference in the Grengloo group. Baumann., *et al*. found that use of dental loupes resulted in less enamel damage and composite residue [15]. In contrast, Mohebi., *et al*. did not find any difference, either in time taken or surface roughness of enamel when using a tungsten carbide bur alone or under magnification with a dental loupe [6].

Lack of saliva, the food coloring, and the inability to simulate the mechanic abrasion caused by brushing are the limitation of this methodology [1]. However, considering that enamel discoloration may occur by direct absorption of food colorants (Eliades., *et al.* 2004) even after orthodontic treatment, long term clinical studies are necessary to verify this.

Conclusion

- Removal of adhesive remnants was better under magnification in the Enlight adhesive group but did not make a difference in the Grengloo group.
- Using color changing adhesive resulted in better restoration of enamel color post clean-up.

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