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Original Research Article

Evaluation of enamel colour changes with orthodontic bonding an in vitro study

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ABSTRACT

Introduction : Aesthetics is an integral part of orthodontics, and color is an important aspect of aesthetics. Hue, value, and chroma are the three objective variables used to describe color. The tooth color exhibits a large variation influenced by the structure of enamel and dentin. Enamel colour alterations may derive from the irreversible penetration of resin tags into the enamel structure at depths reaching 50 μm.

Materials and Methods: Natural Teeth: A total of 80 extracted premolar teeth were collected and then washed thoroughly with plain water and stored in normal saline to prevent them from drying up. Eighty human premolar teeth that had been previously extracted from orthodontic patients. All the teeth selected were cleansed by using a rubber cup and pumice slurry for 20 seconds on a slow speed contra angle hand piece (10,000 rpm), rinsed thoroughly with saline for 10 seconds and air-dried with gentle jets of oil-free compressed air.

Results: In this study shows the frequency distributions of color difference ΔE at various time points in Transbond XT group. The mean difference before treatment and debonding and finishing (ΔE1) was 0.91± 0.43, mean difference before treatment and photogeing (ΔE2) was 1.49±0.85 and mean difference after debonding and finishing and photoageing (ΔE3) was 0.81±0.51. The frequency distributions of ΔE at various time points in Ormco group. The mean difference before treatment and debonding and finishing (ΔE1) was 0.72±0.24, mean difference before treatment and photogeing (ΔE2) was 1.88±0.83 and mean difference after debonding and finishing and photoageing (ΔE3) was 0.97±0.55.

Conclusion: Ormco Enlight showed highest enamel color change of ΔE2 value 2.92 after debonding & finishing. Rely A bond showed least enamel color change of ΔE2 value 2.80. Of all the groups studied there is a significant color change in the enamel but less than the minimum threshold value of ΔE 3.7 units.

1. Introduction

Aesthetics is an integral part of orthodontics, and color is an important aspect of aesthetics. Hue, value, and chroma are the three objective variables used to describe color. The tooth color exhibits a large variation influenced by the structure of enamel and dentin.[1] The other factors such as sunlight in the environment, light scattered from adjacent gingival and perioral tissues, and lip and gum color influence the appearance of the teeth. Tooth color is altered in the oral environment by intrinsic, extrinsic, and internalized discoloration.[2]

Orthodontic treatment in the past had focused mainly on improving occlusal functions, but now esthetic concerns are as important as functional demands. One factor that contributes to optimal tooth esthetics is color. Tooth color results from the interaction between light and the enamel surface that is perceived by the human eye.[3]

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Since the introduction of the acid-etch technique its use for bonding of orthodontic brackets, one of the primary concerns is to return the enamel surface to as near its original state as possible with the minimum amount of enamel loss, at completion of fixed appliance therapy.[4] Bonding, debonding, and clean-up procedures may result in enamel alterations such as microcracks and enamel fractures caused by forcibly removing brackets, as well as scratches, and abrasions caused by mechanical removal of the remaining composite materials.[5]

A previous study has shown that enamel colour variables are affected by enamel bonding and debonding procedures. After removal of orthodontic appliances, a residual amount of adhesive usually remains on the surface.[6] Enamel colour alterations may derive from the irreversible penetration of resin tags into the enamel structure at depths reaching 50 μm. Because resin impregnation into the enamel structure cannot be reversed by debonding and clean-up procedures, some may be left even though a layer of enamel is removed.[7]

Enamel discolouration may occur by direct absorption of food colourants and products arising from the corrosion of the orthodontic appliance even after orthodontic treatment reported that the color of the enamel is also affected by debonding and subsequent cleaning procedures.[8] In addition to the effects of iatrogenic surface roughness, changes in the color of enamel may also result from discoloration of the residual resin that has irreversibly penetrated the surface despite the cleaning procedures.[2]

Resin residuals may change tooth color because of both the internal changes via physicochemical reaction of the adhesive resin and the external changes caused by superficial absorption of food pigments.[9]

However, even under laboratory conditions, it is virtually impossible to eliminate the entire adhesive residue on the enamel surface without the aid of strong magnification.[10] Orthodontics is a unique science in dentistry since it workspace sets on the external surface of enamel when using fixed appliances for treatment. Orthodontists or patients may encounter unwanted changes on the enamel surface or structure, such as discoloration, white spots, microcracks, fractures, and abrasions during and after fixed orthodontic treatment because of e.g. diet, oral care, bonding materials and techniques, composites, appliances, debonding, and clean-up procedures. Bonding materials and composites of Fixed orthodontic treatment are the most prominent factors responsible for enamel color alterations.[11]

2. Materials and Methods

Natural Teeth: A total of 80 extracted premolar teeth were collected and then washed thoroughly with plain water and stored in normal saline to prevent them from drying up.

Eighty human premolar teeth that had been previously extracted from orthodontic patients

The exclusion criteria included:

1. Teeth with caries or restorations on the buccal surface
2. Teeth with enamel defects, hypo-calcifications, or fluorosis on the buccal surface
3. Teeth with visible cracks on the buccal surface
4. Teeth with previous orthodontic history

The teeth are divided into 4 groups

Group	Adhesive	Sample No.
I	Transbond XT	20
II	Ormco	20
III	Rely a Bond	20
IV	Ortho fix	20

All the teeth selected were cleansed by using a rubber cup and pumice slurry for 20 seconds on a slow speed contra angle hand piece (10,000 rpm), rinsed thoroughly with saline for 10 seconds and air-dried with gentle jets of oil-free compressed air.

For the specimen preparation process, only the root portion of the teeth were embedded in the self-cure acrylic resin using L formers. After the sample preparation, the teeth were then analysed for color assessment.

The spectrophotometer (Vita Easyshade) Compact (Vita Zahnfabrik Germany) was used to assess the color of the teeth before bonding, after debonding & finishing and after photoageing.

This device provided precise color measurement. Color assessment was based on the system of the Commission Internationale de l'Eclairage involving 3 color parameters: lightness (L), red/green chromaticity (a), and yellow/blue chromaticity (b).

This system allows for numeric information that relates well to actual visual response and makes it the most popular one for color measurement.

For all study teeth three consecutive measures for each color parameter (L, a, b) were recorded.

The pretreatment values obtained were recorded as L1, a1,b1. The pretreatment and post treatment colors of teeth were determined as the average value of the 3 consecutive measures for each tooth.

2.1. Statistical analysis

The results were analyzed using "Statistical Package for social sciences" SPSS for windows version 20.0. Descriptive statistics, one way ANOVA with repeated measures followed by Bonferroni's post hoc test (for intra group comparison) and one-way ANOVA followed by Tukey's HSD post hoc test (for intergroup comparison) were performed. Confidence interval was set at 95%. P value < 0.05 is considered statistically significant.

3. Results

Table 1 shows the frequency distributions of color difference ΔE at various time points in Transbond XT group. The mean difference before treatment and debonding and finishing (ΔE1) was .91± .43, mean difference before treatment and photogeing (ΔE2) was 1.49±0.85 and mean difference after debonding and finishing and photoageing (ΔE3) was0.81± 0.51. From this we can conclude that there was significant increase in colour change from ΔE1 to ΔE2 indicating that the enamel colour change was affected during orthodontic treatment in transbond XT group and there is significant decrease in color change from E2 to E3.

Table 2 shows the frequency distributions of ΔE at various time points in Ormco group. The mean difference before treatment and debonding and finishing (ΔE1) was 0.72±0.24, mean difference before treatment and photogeing (ΔE2) was 1.88±0.83 and mean difference after debonding and finishing and photoageing (ΔE3) was 0.97±0.55. From this we can conclude that there was significant increase in color change from E1 to E2 indicating that the enamel color change was affected during orthodontic treatment in ormco group and there is significant decrease in color change from E2 to E3.

Table 3 shows the frequency distributions of ΔE at various time points in Rely A Bond group. The mean difference before treatment and debonding and finishing (ΔE1) was 1.32±0.61, mean difference before treatment and photogeing (ΔE2) was 1.82±0.77 and mean difference after debonding and finishing and photoageing (ΔE3) was 1.19±0.84. From this we can conclude that there was significant increase in color change from E1 to E2 indicating that the enamel color change was affected during orthodontic treatment in Rely A bond group and there is significant decrease in color change from E2 to E3.

Table 4 shows the frequency distributions of ΔE at various time points inOrthofix group. The mean difference before treatment and debonding and finishing (ΔE1) was 0.97± 0.48, mean difference before treatment and photogeing (ΔE2) was 2.22±0.65 and mean difference after debonding and finishing and photoageing (ΔE3) was 0.71±0.25. From this we can conclude that there was significant increase in color change from E1 to E2 indicating that the enamel color change was affected during orthodontic treatment in orthofix group and there is significant decrease in color change from E2 to E3.

Table 6 shows the comparison of ΔE1 between various groups. The mean value in TRANSBOND XT was0.91 ±0.43, ORMCO was 0.72 ± 0.24, RELY A BOND was 1.32 ± 0.61 and ORTHOFIX was 0.97 ± 0.48. There was a statistically significant difference (p=0.007) between the four groups. The value of RELY A BOND (1.32 ± 0.61) was significantly higher than ORMCO (0.72 ± 0.24). There was no statistically significant difference between the other groups.

Table 7, shows the comparison of ΔE2 between various groups. The mean value in TRANSBOND XT was 1.49 ±0.85, ORMCO was 1.88 ± 0.83, RELY A BOND was 1.82 ± 0.77 and ORTHOFIX was 2.22 ± 0.65. There was no statistically significant difference (p=0.09) between the four groups.

Table 7 shows the comparison of ΔE3 between various groups. The mean value in TRANSBOND XT was 0.81 ± 0.51, ORMCO was .97 ± 0.55, RELY A BOND was 1.19 ± 0.84 and ORTHOFIX was 0.71 ± 0.25. The value of RELY A BOND (1.19 ± 0.84) was significantly higher than ORTHOFIX (0.71 ± 0.25). There was no statistically significant difference (p=0.11) between the four groups.

4. Discussion

The hypothesis tested in this investigation was that the procedures associated with bonding and debonding may alter the colour variables of the enamel surface. Therefore, the purpose of this study was to assess the enamel colour alterations associated with bonding of orthodontic brackets with an orthodontic resin and a glass-ionomer adhesive. T.Eliades et al.[12]

A study by Trakya et al evaluated enamel colour alterations of five different orthodontic bonding adhesives.[2] The mean color difference before treatment and debonding and finishing & polishing (ΔE1) in transbond XT group in their study was found to be 0.57 ± 0.54 whereas in present study it was found to be 0.91±0.43. This difference in the values can be attributed to the method of polishing (high-speed tungsten carbide finishing bur was used in their study and spiral fluted tungsten carbide bur was used in present study). This indicates that the burs used for adhesive removal affects the color change in the teeth.

Karamouzos et al conducted in vivo studies on tooth color assessment after orthodontic treatment. In his study, he investigated that the colour of the mean difference after debonding and finishing and photoageing (ΔE3) was 2.60±0.76.[5] Findings from the present study between debonding, finishing, polishing and photoageing 1.49± 0.85 in Transbond XT group. This difference in the values can be due to their study was In vivo. In present study was an In vitro.

Faltermeier et al investigated the the colour stability of adhesives during ultraviolet irradiation and exposure to food colourants.[13] The mean difference after debonding and finishing and photoageing (ΔE3) was 0.81±0.51 in present study whereas in their study it was found to be 3.28 ± 0.58 in Transbond XT group. This difference in the values can be due to the duration of photoageing done in both the studies. (photoageing was 24 hrs in present study where as it was 72 hrs. in their study). This shows that duration of photoageing does affect the colour change in the teeth.

Faltermeier et al studied-on discolouration of orthodontic adhesives caused by food dyes and ultraviolet light.[13] In his

Table 1: Distribution ofTransbond XT group based on various ΔE

	Transbond XT				
	N	Minimum	Maximum	Mean	Std. Deviation
ΔE1	15	0.21	2.01	0.91	0.43
ΔE2	15	0.30	2.90	1.49	0.85
ΔE3	15	0.13	2.06	0.81	0.51

Table 2: Distribution ofOrmco group based on various ΔE

	ORMCO				
	N	Minimum	Maximum	Mean	Std. Deviation
ΔE1	15	0.34	1.35	0.72	0.24
ΔE2	15	0.62	2.92	1.88	0.83
ΔE3	15	0.37	2.50	0.97	0.55

Table 3: Distribution of RelyA Bond group based on various ΔE

	Rely A Bond				
	N	Minimum	Maximum	Mean	Std.Deviation
ΔE1	15	0.50	2.28	1.32	0.61
ΔE2	15	0.50	2.80	1.82	0.77
ΔE3	15	0.50	2.70	1.19	0.84

Table 4: Distribution ofOrthofix group based on various ΔE

	ORTHOFIX				
	N	Minimum	Maximum	Mean	Std. Deviation
ΔE1	15	0.58	2.50	0.97	0.48
ΔE2	15	0.90	2.90	2.22	0.65
ΔE3	15	0.37	1.22	0.71	0.25

Table 5: Comparison of ΔE1 between various groups.

ΔE	**Group**	**N**	**Mean**	**Std. Deviation**	**P value**	**Post hoc analysis**
ΔE1	Transbond XT	15	0.91	0.43	**0.007*(S)**	Rely A Bond > Ormco
	Ormco	15	0.72	0.24		
	Rely A Bond	15	1.32	0.61		
	Orthofix	15	0.97	0.48		
	Total	60	0.98	0.50		

Table 6: Comparison of ΔE2 between various groups.

ΔE	**Group**	**N**	**Mean**	**Std. Deviation**	**P value**	**Post hoc analysis**
ΔE2	Transbon D XT	15	1.49	0.85	0.09 (NS)	-
	ORMCO	15	1.88	0.83		
	Rely A Bond	15	1.82	0.77		
	Orthofix	15	2.22	0.65		
	Total	60	1.86	0.80		

Table 7: Comparison of ΔE3 between various groups.

ΔE	**Group**	**N**	**Mean**	**Std. Deviation**	**P value**	**Post hoc analysis**
ΔE3	Transbond XT	15	0.81	0.51	0.11(NS)	-
	ORMCO	15	0.97	0.55		
	Rely a Bond	15	1.19	0.84		
	Orthofix	15	0.71	0.25		
	Total	60	0.92	0.59		

study he investigated the colour stability of adhesives during ultraviolet irradiation and exposure to food colourants. The mean difference after debonding and finishing and photoageing (ΔE3) was 0.97±0.55 in present study whereas in their study it was found to be 4.88 ± 0.78 in ormco group. This difference in the values can be due to the duration of photoageing done in both the studies (photoageing was 24 hrs. in present study where as it was 72 hrs. in their study). This shows that duration of photoageing does affect the colour change in the teeth.

Eliades et al assessed in his study the Color alteration of adhesive during treatment and after debonding. He suggested that photoaging induced color changes of the debonded surfaces above the threshold. All adhesives exhibited color change, which in some cases exceeded the clinically detectable color change limit and the extent of the color alterations of aged bonding systems may contribute to enamel discoloration after treatment.[14] Similar conclusion was seen in present study where in photoaging influenced the color changes in the teeth. The mean colour change in ormco group was found to be 8.36± 1.44 in their study where as it was 1.88±0.83 in present study. This difference can be due to one time photogeing in present study and two times photoageing in their study. This shows that the amount of photogeing does influence the colour change.

Corecki et al· in his study on effects of contemporary orthodontic composites on tooth color following short-term fixed orthodontic treatment concluded that the color of teeth was affected by treatment but however no significant differences for color of enamel was observed in their study.[15] The mean total color differences (ΔE) between all measured teeth before and after orthodontic treatment in Rely A bond group in their study was 2.37 ± 1.22 whereas in present study it was found to be 1.32±0.61. This difference in the values can be due to the use of different type of teeth in both the studies (mandibular incisors were used in their study whereas premolars were used in present study) and also the method of polishing in which composite bur was used in our study whereas aluminium oxide disc bur was used in their study suggesting that the type of polishing system also affects the colour change in the teeth.

5. Conclusion

Ormco Enlight showed highest enamel color change of ΔE2 value 2.92 after debonding & finishing. Rely A bond showed least enamel color change of ΔE2 value 2.80. Of all the groups studied there is a significant color change in the enamel but less than the minimum threshold value of ΔE 3.7 units. Photoageing process caused significant color changes in the enamel, hence clinicians should consider time duration of the treatment. Finishing and polishing procedures has significant effect on Enamel color changes, so finishing & polishing has to be done carefully after debonding.

6. Conflict of Interest

None.

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