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The Effect of Bleaching on Orthodontic Bonding – A Comparative in Vitro Study

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Abstract

Objective: To evaluate the effect of bleaching on shear bond strength (SBS) of metallic brackets when self etching primer (SEP) and conventional etching procedures are performed on teeth immediately and 30 days after bleaching.

Methodology: Ninety freshly extracted premolar teeth were randomly divided into two groups of 45 teeth, which were further divided into 3 subgroups contained 15 teeth each (IA, IB, IC, IIA, IIB, IIC). Teeth in group I and group II were etched with 37% Phosphoric acid and Transbond plus SEP respectively. Except for control samples in both the groups, 10% Carbamide Peroxide bleaching gel (opalescence) was applied at two different time intervals (immediately and 30 days before bonding). SBS of these brackets were measured on a universal testing machine. Adhesive remnant index (ARI) scores were determined after the brackets failed.

Results: The bond strengths of group IA, IIA (no bleaching) and group IC, IIC (bleaching 30 days before bonding) were significantly higher ($p < 0.05$) than that of group IB, IIB (bleaching immediately before bonding). No

statistically significant difference found between group IA, IC and IIA, IIC ($p > 0.05$). ARI scores were significantly different among the three subgroups.

Conclusion: Statistically significant decrease in mean shear bond strength values found with SEP than conventional etching which were clinically acceptable. The use of Carbamide Peroxide bleaching agent, a significant reduction in the mean SBS when bonding was done immediately with conventional and SEP systems.

Keywords: Carbamide peroxide, Shear Bond Strength, Self Etching Primer, Universal Testing Machine (Instron).

Introduction

Whitening products can be used before or after orthodontic treatment. Esthetically conscious individuals might generally bleach their teeth. When this is done prior to orthodontic treatment, it becomes imperative to understand the influence of bleaching on bond strength of orthodontic adhesives.

Tooth discoloration can be intrinsic, extrinsic or a combination of both and the treatment of choice is bleaching. Bleaching technique can be classified as in-office and home bleaching. Bleaching systems containing Carbamide Peroxide was introduced by **Haywood and Heymann (1989).**[1] Carbamide Peroxide is commonly used at varying concentrations as night guard vital bleaching agent for home bleaching. Bleaching agents for in office use contain high concentrations of Carbamide Peroxide (35-37%) or Hydrogen Peroxide - H_2O_2 (30-35%), while at home whiteners are composed of low concentrations of these peroxides and are used in a custom tray under the supervision of a dental practitioner.[2]

Conventional bonding systems used 3 steps to prepare enamel surfaces: an enamel conditioner, a primer and an adhesive resin. There are two types of SEP systems. The first one is etch and rinse adhesive system, which combines the adhesive and primer into a single unit. The second type is the self-etch adhesive system which combines etchant, primer and bonding into a single component.[3] Single step etching/primer delivery system has the advantages of simultaneous penetration of the etchant and primer to simplify bonding, hence avoiding technical errors.[4]

Most studies utilize 37 % Phosphoric acid - etch and rinse adhesive system. Consequently, there is currently little information on the effects of bleaching agents on the bond strength of brackets bonded with a self etching adhesive system. Therefore, more investigation is necessary to clarify the interaction between bleaching agents and the self-etching adhesive system. With an increased awareness of esthetic dentistry within the community, tooth bleaching before or after orthodontic treatment has come into vogue.

The purpose of this study is to evaluate the effect of bleaching on shear bond strength and debonding character of metallic brackets when self etching primer and conventional etching procedures are performed immediately and 30 days after bleaching and adhesive remnant index (ARI) scores.

Materials and Methods

Ninety freshly extracted maxillary first or second premolar teeth bonded with pre adjusted edgewise (MBT prescription) stainless steel brackets (Ormco) were used. Inclusion criteria comprised anatomically and morphologically well defined teeth, non caries maxillary first premolar teeth with intact buccal enamel not subjected to pretreatment with alcohol, formalin, or hydrogen peroxide. Exclusion criteria included teeth with restorations, enamel cracks, fractured crowns, fluorosed teeth, hypoplastic teeth. The extracted teeth were cleaned to remove blood or any tissue debris and stored in distilled water at room temperature; water was changed once every week to avoid bacterial growth.

The sample was randomly divided into two groups each group consisted of forty five teeth subdivided into three subgroups with 15 teeth each. The acrylic blocks were color coded to differentiate between different groups. Detailed description of the test groups is given in Table 1 and Figure 1.

Table 1: Detailed Description of The Test Groups

Groups	Sub Groups	Color Coding	Sample Size		Etchent Used
Group – I	Group-I A	White	15	Control	Conventi--Onal Etchent
	Group- I B	Blue	15	Immediately After Bleaching	
	Group- I C	Pink	15	30days After Bleaching	
Group – II	Group- II A	Black	15	Control	Self Etching Primer
	Group- II B	Yellow	15	Immediately After Bleaching	
	Group- II C	Greeen	15	30 Days After Bleaching	

Figure 1: Color coding acrylic blocks

A. Bleaching Procedure

Except for control samples in both the groups, a commercially available 10% carbamide peroxide bleaching gel (Opalescence, Ultradent Products) (Figure 2) was applied to the enamel surfaces of the teeth using a brush.

Figure 2: Carbamide Peroxide

The gel layer was approximately 1 mm thick and was left in place for 6 hours according to the manufacturer's instructions. After completion of bleaching procedure, the specimens were rinsed thoroughly with a three air/water syringe for 30 seconds, followed by air drying, and stored in artificial saliva solution which was changed every day and stored at 37^0C. After repeating of this bleaching procedure for 10 consecutive days, the samples of Group I B and II B were subjected to bonding procedures immediately, and samples of Group I C and II C are immersed in artificial saliva which was changed every day for a period of 30 days and samples were then subjected to bonding procedures.

B. Bonding Procedure

Group I: (Conventional Etchant)

The buccal surfaces of the teeth were polished with pumice slurry and the teeth were washed with distilled water and dried using oil free air. 37% Ortho-phosphoric acid (d-tech) was applied to the labial surface and left for 15 seconds. The acid was then washed away with a spray of water for 10seconds, air dried till a white chalky appearance was seen on the surface. The primer was applied to the etched surface with the help of an applicator brush. The adhesive Transbond XT) was then applied to the base of the bracket and placed required position and excess adhesive was removed. The adhesive was cured using Monitex light emitting diode (LED) curing unit for 20 seconds.

Group II: (Self Etching Primer)

After enamel preparation Transbond Plus Self Etching Primer (Figure 3) was gently applied onto the surface for approximately 3 - 5 seconds with the disposable applicator supplied with the system. Then a moisture free air source was used to deliver, a gentle burst of air to the enamel.

Figure 3: Self Etching Primer

C. Evaluation Of Bond Strength

Debonding was carried out with a Universal Testing Machine (LLYOID- L R 50 K, UK). (Fig 4).

Figure 4: Universal Testing Machine (Instron)

To evaluate the Shear Bond Strength, Force (Newtons) was divided by bracket base area (sq. mm). The base area of the brackets was obtained using digital vernier calipers (9.63 sq.mm). The tests were carried out with crosshead speed of 0.5mm/min.

D. Residual adhesive

The debonded tooth surface was viewed under stereomicroscope (10X magnification). The adhesive remaining on the tooth surface after debonding was then scored according to the Adhesive Remnant Index (ARI). Failure types were classified as follows: Adhesive: Failure at enamel-composite interface, Cohesive: Failure in the restorative material alone or enamel alone, Mixed: A combination of adhesive and cohesive failures.

The results obtained from the shear bond strength testing, the modified ARI scores of the two groups were tabulated. Their mean and standard deviation were calculated and then subjected to statistical evaluation.

Results

The means and standard deviations along with minimum and maximum values for the shear bond strengths of various groups tested are presented in Table 2.

Table 2: Mean, Standard deviation, Test of significance of shear bond strength (M Pa) of Group I and II

Groups	Sub Groups	Mean	SD	P Value
GROUP – I (Conventional Etchant)	I A	21.54	± 5.15	0.016 (Significant)
	I B	17.05	± 3.41	
	I C	21.33	± 4.99	
GROUP – II (Self etching primer)	II A	17.89	±4.51	0.016 (Significant)
	II B	14.72	± 4.77	
	II C	17.71	± 3.53	

SD- Standard Deviation

P value - Statistically Significant if $P < 0.05$.

Statistical Analysis: ANOVA one way test.

The results of the ANOVA indicated statistically significant differences among the groups (P = 0.016). Mean shear bond strength of GROUP I A (21.54 ± 5.15MPa) and I C (21.33 ± 4.99 MPa) are higher compared to GROUP I B (17.05 ± 3.41MPa). However, difference in shear bond strength between the groups were statistically significant (*P* = 0.016). Mean shear bond strength of GROUP II A (17.89 ± 4.51MPa) and II C (17.71 ± 3.53 MPa) are higher compared to GROUP II B (14.72 ± 4.77MPa). However, difference in shear bond strength between the groups were statistically significant (*P* = 0.009).

The Tukey post hoc HSD test showed that statistically significant differences in the mean bond strengths among the groups showed in Table 3.

Table 3: Multiple comparisons of shear bond strength in Group I and II

	Sub Groups	Sub Groups	Mean Difference	Se	P Value	95% Confidence Interval	
						Lower Bound	Upper Bound
	IA	IB	4.5	1.674	0.027 (S)	0.43	8.565

GROUP I (Conventional etchent)		IC	0.21	1.674	0.991	- 3.853	4.282
	IB	IA	- 4.5	1.674	0.027 (S)	- 8.565	- 0.43
		IC	- 4.28	1.674	0.037 (S)	- 8.35	- 0.215
	IC	IA	- 0.21	1.674	0.991	- 4.282	3.853
		IB	4.28	1.674	0.037 (S)	0.215	8.35
GROUP II (Self etching primer)	IIA	IIB	3.17	1.571	0.012 (S)	- 0.0647	6.988
		IIC	0.17	1.571	0.993	- 3.643	3.992
	IIB	IIA	- 3.17	1.571	0.012 (S)	- 6.988	0.0647
		IIC	- 3.00	1.571	0.015 (S)	- 6.814	0.822
	IIC	IIA	- 0.17	1.571	0.993	- 3.992	3.643
		IIB	3.00	1.571	0.015(S)	- 0.822	6.814

Statistically Significant values that are indicated as (S)

SE – Standard Error

P Value - Statistically Significant $P < 0.05$

S- Significant

Statistical Analysis: Tukey Post Hoc HSD test

Mean differences between IA – IB (4.5 Mpa), IB – IC (-4.28 Mpa), IA – IC (0.21Mpa). No statistically significant differences in the mean shear bond strengths between GROUP IA and IC ($P > 0.05$). Statistically significant differences in the mean shear bond strengths between GROUP IA - IB and IB - IC ($P < 0.05$). Mean differences between II A – II B (3.17 Mpa), II B – II C (-3.00 Mpa), II A – II C (0.17Mpa). No statistically significant differences in the shear bond strengths between GROUP II A and II C ($P > 0.05$). Statistically significant differences in the shear bond strengths between GROUP II A – II B and II B – II C ($P < 0.05$) Table 3.

Independent t-test showed that the shear bond strength when the self etching primer used is significantly lower than when conventional etchant ($P = 0.048$). Statistically significant differences in the mean shear bond strengths are found immediately (IB, IIB); and one month after bleaching(IC, IIC) when conventional and self etching primer are used. ($P < 0.05$) Table 4.

Table 4: Comparision of shear bond strengths between Group I and II

GROUPS	n	MEAN	SD	P VALUE
I A	15	21.54	± 5.15	0.048 S
II A	15	17.89	± 4.51	
I B	15	17.05	± 3.41	0.014 S
II B	15	14.72	± 4.77	

I C	15	21.33	± 4.99	0.030 S
II C	15	17.71	± 3.53	

SD – Standard Deviation

P Value - Statistically significant at $P < 0.05$

Statistical Analysis: Independent sample t - test.

The ARI Scores for the various groups tested are listed in table 5. The results showed that there is significant difference among the six groups (Chi-square = 74.089; *P*-value = 0.000).

Discussion

Vital bleaching has the potentially to alter the surface topography of enamel there by affecting the bond strength of adhesives to enamel. Alterations in bond strength could significantly impact the clinical operative procedures involving resin bonding, such as bonding orthodontic attachments, porcelain, composite veneers or general composite restorations. There have been contradictory reports with regard to the effect of bleaching agents on the bond strength of composites.

Extent of enamel loss following acid etching depends on the type of acid contact, its dissociation constant, the concentration, and the duration of etching procedure. According to **White**[5] SEPs are easily manipulated and used, reducing the chair side time by 65%, resulting in convenience both for the patient and the clinician.

The present study evaluated the use of SEP as compared with the conventional bonding procedure. The use of self etch primer to bond brackets to the enamel surface provided lower shear bond forces which is in accordance with previous study conducted by **Bishara et al. (2001).**[6]

In the presence of saliva, 10 % Carbamide Peroxide releases 3% Hydrogen Peroxide and 7% urea. **Gregus and Klaassen** elaborated that H2O2 is a strong oxidizing agent by virtue of formation of free radicals.[7] **Cotton and Wilkinson**[8] further demonstrated that this nature of H2O2 is attributed to reactive oxygen molecules and H2O2 anions. Thus formed reactive molecules target the long chained, dark colored chromophore molecules and divide them into smaller, less colored and easily diffusible molecules. Carbamide peroxide also produces urea **(Budavari *et al.*, 1989)**[9] that can be in turn decomposed to Carbon dioxide and Ammonia. The basic nature of ammonia facilitates the bleaching procedure **(Sun, 2000).**[10]

The results of the current study showed that there was no statistically significant differences in bond strength between the control group and teeth bonded 30 days after bleaching (mean 17.89 MPa, 17.71 MPa) respectively. Brackets bonded immediately following bleaching significantly lower shear bond strength values (mean 14.72 MPa) with self etching primer which was supported by the previous study performed by **Tancan Uysal (2008).**[11] The reduced shear bond strength values obtained in bleached teeth may be explained by structural change in enamel morphology, poorly defined etch patterns, reduced number, length and the diffusion of residual oxygen from the bleaching agent out of enamel, which inhibits resin tag polymerization.

Uysal et al.[12] suggested that a bonding delay of atleast 2 to 3 weeks would be beneficial after storing the samples in artificial saliva for 30 days. In the experimental setup of the present study, the bleached teeth in group 3 were stored in accordance with previous study to simulate oral conditions. Previous studies have demonstrated that when immersed in distilled water, artificial saliva, or even saline solution, the invitro specimens resulted in a complete reversal of the reduced enamel bonds. However, **Cacciafesta et al.**[13] found that groups in which bonding was done immediately or 1 week after bleaching, the shear bond strength values have lowered significantly compared to unbleached controls.

Reynolds[14] suggested that bond strength values of 6 to 8 MPa is adequate for most clinical orthodontic purposes. The bond strength values obtained in the current study were greater than the minimum requirement suggested in the above study Table 2. However, clinical conditions may be significantly different when compared to an in vitro setting. Moreover, temperature and humidity conditions of the oral cavity are highly variable. Owing to the differences between in vivo and in vitro conditions, exportation of findings would be inappropriate.

Bulut et al.[15] reported that the residual oxygen in the enamel structure of bleached teeth creates a bubbly appearance of adhesive resin. In a similar study **Bulut et al.**[16] observed that a period of seven days after bleaching was adequate to obtain satisfactory tensile bond strength for clinical conditions. **Cavalli et al.**[17] emphasized that a period of up to three weeks is needed before resin – enamel bond strength values return to those obtained for unbleached enamel. **Turkun et al** [18] noted that the changes in enamel surface morphology observed immediately post bleaching returned to nearly normal values. In the literatue, the commonly suggested post – bleachng time ranges from 1 to 3 weeks before bonding.[12,13,16,19]

Rahul **at al.**[20] concluded that at-home bleaching did not affect the SBS significantly whereas in-office bleaching decreased SBS values of metal, ceramic, and composite brackets significantly. It is preferable to use metal or ceramic brackets than composite brackets for bonding 24 h after bleaching. **Deepthi et al.**[21] suggested that bleaching with 35% hydrogen peroxide reduced the SBS significantly and this could be effectively reversed by the application of 10% sodium ascorbate, 10% tocopherol acetate, or 10% retinol acetate. The use of 10% carbamide peroxide bleaching does not significantly decrease SBS values, In contrast, use of 38% H_2O_2 bleaching significantly decrease these values according to **Mehmet et al.**[22]

The quality, number and penetration depth of resin tags play a significant role in determining the bond strength of resin to enamel. Some studies have reported that reduced bond strengths are because of introduction of peroxide ions into the apatite network which then replaces hydroxyl ions and thus producing apatite peroxide. With time period the peroxide ions have catabolized and the hydroxyl ions are re-incorporated into apatite structure and reverse the structural changes produced by peroxide ions.

To overcome adverse effects related to the lower bond strength values caused by bleaching, delaying of bonding procedures until 24 hours to 2 weeks after bleaching.[23] The other methods include the removal of superficial enamel,[24] use of solvents, acetone - based adhesive systems or antioxidants.[25] Bleaching treatment also causes chemical softening of the composite materials and reduces the durability of resin-based restorations.[26]

In the present study, ARI scores were compared that indicated there were significant differences among the three groups. In Group 1 A, IIA and 1 C there was a higher frequency of bond failures at adhesive – bracket interface. In IB and IIB mostly adhesive failures. Bleached teeth had more adhesive failures (at resin-enamel interface), whereas unbleached teeth had more cohesive failures (within the resin). Hence, frequency distributions of the failure sites in the current study revealed differences in the quality of the bond formed among the tested groups.

Conclusion

In the view of the findings of the present study the following conclusions are drawn:

Statistically significant decrease in mean shear bond strength values were found with self etching primer than conventional etching which were clinically acceptable.

No statistically significant difference in the shear bond strength values were found between control group and 30 days after bleaching. Immersing the bleached teeth in artificial saliva for 30 days prior bonding resulted in shear bond strength which were comparable to that of control group.

Bleaching and bonding with conventional as well as Self Etching Primer significantly alters the site of failure during debonding. Bleached teeth showed more adhesive failures (at resin-enamel interface), while unbleached teeth showed more cohesive failures (within the resin) hence, frequency distributions of the failure sites in the current study clearly indicated differences in the quality of the bond formed among the experimental groups.

Abbreviations

SBS - Shear Bond Strength

SEP - Self Etching Primer

H 2O 2 – Hydrogen Peroxide

LED – light Emitting Diode

ARI - Adhesive Remnant Index

UTM – Universal Testing Machine (Instron)

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