

An In Vitro Comparative Evaluation of Various Newer Bonding Agents on Bond Strength of Bleached Enamel Treated With An Antioxidant

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Abstract: Increased awareness and concern about esthetics has resulted in the popularity of many esthetic enhancement procedures. Certain teeth that have been previously treated with bonded restorations may need their replacement after bleaching for better esthetic results; but it has been found that the adhesion between the bonding agent and tooth surface is hampered after bleaching. Our study aimed to evaluate effect of two bonding agents on shear bond strength of bleached enamel with and without use of sodium ascorbate antioxidant. 60 recently extracted intact maxillary anterior teeth were taken for the study. The samples were divided into 3 groups containing 20 samples each: A-Control group; B-Bleached group; C-Antioxidant treated group. All the three groups were then divided into 2 subgroups each (n=10) according to the adhesive used for composite bonding: 1)- 5th gen bonding agent (Adper Single Bond); 2)- 7th gen bonding agent (Scotchbond Universal). Composite cylinders (3x3 mm) were bonded and shear bond strengths were measured in a universal testing machine. Data were analysed using ANOVA and Tukey's tests. Significant differences were found between all groups; group C showing the highest bond strengths. There were no significant differences between the sub-groups.

Hence forth the above study showed that bleached enamel showed lower bond strength compared to control group with all adhesives; but showed significant improvement with sodium ascorbate treatment. Self-etching adhesive showed lower bond strength compared to their respective total-etch sub groups.

Date of Submission: 01-08-2018

Date of Acceptance: 16-08-2018

I. Introduction

Increased awareness and concern about esthetics has resulted in the popularity of many esthetic enhancement procedures. One of the more conservative technique is tooth whitening by bleaching, as an alternative to invasive therapies such as complete veneer crowns or placement of veneers¹. In certain cases of severe staining, e.g. intrinsic staining such as tetracycline staining; enamel bleaching has been advocated as a preparatory step prior to restoration by acid etching or veneer bonding for better results. Also, certain teeth that have been previously treated with bonded restorations may need their replacement after bleaching for better esthetic results².

But, it has been found that the adhesion between the bonding agent and tooth surface is hampered after bleaching³. The causative factor has been shown to be the oxygen free radicals responsible for the whitening effect; they affect the penetration of the bonding agent into the tubules as well as prevent the complete polymerization of the agent^{1,4,5}. Clinically, a significant decrease in bond strength of composite to bleached enamel was noticed for upto a period of three weeks^{2,6}.

It has been shown that the decrease in bond strength could be affectively reversed with various antioxidants. These are available in various forms and sources and are free oxygen radical scavengers. Also, since they are obtained from natural sources, they are highly biocompatible. Out of the various antioxidants available, sodium ascorbate has been shown to be consistently effective in reversing the effect of bleaching agents on bond strength of composite to the tooth surface⁷⁻¹⁰.

For bonding of esthetic restorations, many systems are employed. The total etch system is a two-step system, where the surface is first treated with phosphoric acid which opens the dentinal tubules, allowing for better penetration of the applied adhesive. In contrast, the self-etch adhesive system is a one-step system, enabling smaller chair time. They eliminate the risk of promoting the collapse of collagen fibers, but the use of weak acids may prevent the adequate penetration of bonding agent¹¹.

II. Material And Methods

60 recently extracted intact maxillary anterior teeth were collected for the study. Teeth with caries or visible cracks were excluded out of the study. The teeth were then stored in distilled water at room temperature until use. The roots of all teeth were separated 3mm below the cemento-enamel junction using diamond coated disc in a slow-speed micromotorhandpiece, under continuous water spray. The teeth were mounted on standardized acrylic blocks such that the buccal surfaces were exposed. These buccal surfaces were then flattened using a No.12 wheel bur (Mani Dental Inc., Japan) in a high speed airtorhandpiece to obtain cut enamel surface.

The samples were divided into 3 groups containing 20 samples each:

Group A- Control Group: The samples did not undergo any pre-treatment. They were stored in distilled water until further use.

Group B- Bleached group: The samples of this group were subjected to a bleaching regimen with 22% carbamide peroxide home bleach (WhitenessPerfect, FGM, Brazil). Using a syringe, about 1-mm thick layer of gel was applied to the buccal surface and kept for 2 hours. The gel was then removed, the teeth were rinsed with water and air dried. This procedure was repeated for 7 consecutive days.

Group C- Antioxidant treated group: The samples of this samples were subjected to a bleaching regimen as described above. Then, 100 gms of sodium ascorbate powder was dissolved into 1 litre of distilled water to obtain 10% sodium ascorbate solution. The samples were immersed in this solution for 10 mins and then rinsed.

All the three groups were then divided into 2 subgroups each (n=10) according to the adhesive used for composite bonding:

Subgroup 1- 5th generation adhesive: The samples were etched with 37% phosphoric acid etchant (IvoclarVivadent, Lichtenstein) for 30 seconds, rinsed for 15 seconds and dried with gentle air stream. 2-3 generous coats of 5th generation bonding agent (Adper Single Bond 2, 3M ESPE, St. Paul, MN, USA) were applied onto the enamel surface with a microbrush applicator for 20 seconds and air dried for 5 seconds. The surfaces were then cured for 10 seconds with a light curing unit (LED D., Guilin Woodpecker, Guangxi, China).

Subgroup 2- 7th generation adhesive: The samples were rinsed; 2-3 generous coats of 7th generation bonding agent (Scotchbond Universal, 3M ESPE, St. Paul, MN, USA) were applied onto the enamel surface with a microbrush applicator for 20 seconds and air dried for 5 seconds. The surfaces were then light cured for 10 seconds.

Composite build-up: Standardized polyacrylic molds (3x3 mm internal diameter) were used for composite build-up. The composite (Filtek Z250 XT, 3M ESPE, St. Paul, MN, USA) was placed in 1mm increments and each was light cured for 20 seconds. The molds were removed to obtain composite cylinders of 3mm diameter and 3mm height.

Shear bond strength Analysis: All the 60 samples were mounted on metal test blocks and subjected to shear bond strength analysis in a universal testing machine (Instron 3382, Instron Corp., Memmingen, Germany). A knife edge shearing rod was used at a cross-head speed of 0.5 mm per minute. The force was applied at the tooth composite interface and the load at failure was recorded by the software (InstronBluehill 2). The shear bond strength of the samples was calculated and expressed in megapascals (MPa). frequency questionnaire was administered to collect detailed information on dietary intake over the past year. Dietary fat and oil intake was assessed as the amount of fat/oil used during cooking and/or added at the table.

III. Result

Statistical analysis was done using one-way analysis of variance (ANOVA) and tukey’s post-hoc tests. The mean composite shear bond strength and standard deviation of the study groups tested is shown in Table 1. As shown in Table 2 and 3 (Tukey’s HSD test), for both the adhesive agents used, only group B (bleached group) showed significantly decreased bond strength compared to other groups. There was no significant difference between the unbleached (control) group and the antioxidant treated group for both the adhesive agents. Also, the bond strengths of self-etch adhesive (subgroup2) were lower than total-etch adhesive (subgroup1) in all groups as shown in Table 4.

Table no 1: Mean composite shear bond strength and standard deviation of the study groups (ANOVA)

	N	Mean	Std. Dev.	Std. Error
A1	10	28.09	2.72	.86
A2	10	20.59	2.02	.64
B1	10	17.02	1.19	.38
B2	10	15.30	1.36	.43
C1	10	28.88	2.72	.86
C2	10	19.09	2.23	.71
	60	21.50	5.64	.73

Table no 2: Evaluation of bond strength of total-etch adhesive

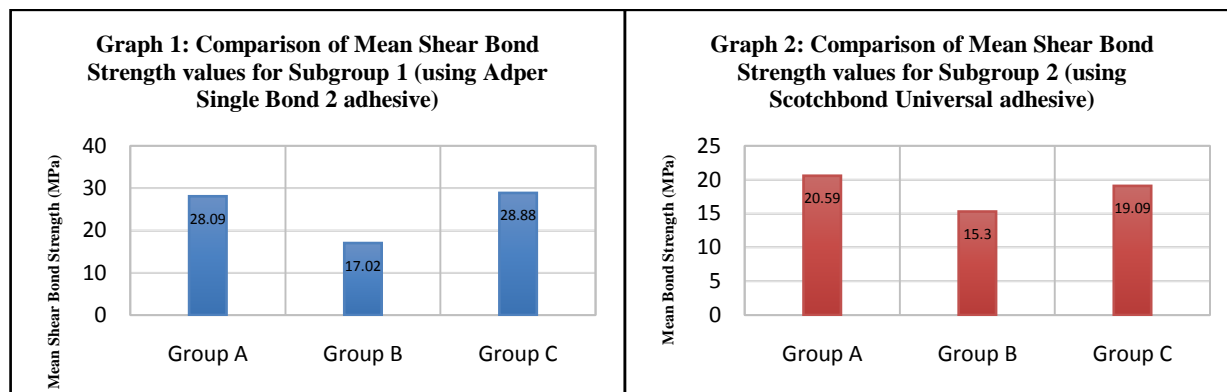
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
A1	B1	11.07(*)	.95	.00 (<0.05)
	C1	-.78	.95	.98
B1	C1	-11.86 (*)	.95	.00 (<0.05)

Table no 3: Evaluation of bond strength of self-etch adhesive

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
A2	B2	5.29 (*)	.95	.00 (<0.05)
	C2	1.50	.95	.77
B2	C2	-3.78 (*)	.95	.01 (<0.05)

Table no 4: Comparison of Subgroups

Groups	Subgroup 1 (I)	Subgroup 2 (J)	Mean diff. (I-J)	Std. Error	Sig.
A	28.09	20.59	7.49(*)	.95	.00 (<0.05)
B	17.01	15.30	1.71	.95	.66
C	28.88	19.09	9.79 (*)	.95	.00 (<0.05)



IV. Discussion

In a day-to-day clinical practice, many a time bleaching and bonding are taken as the treatment plan for certain cases. In the instant life style of the world, the compromised bond strength of resin composites to teeth, after bleaching is of more clinical concern. The prolonged periods of postponing the bonding procedures would increase the patient's anxiety.

In previous SEM observations, the interfaces between resin & bleached enamel are shown to be substantially different from those formed between resin & unbleached enamel. In bleached specimens large area of enamel surface were free of resin & when tags were present they were fragmented, poorly defined and penetrated to lesser depth than unbleached controls^{1,3}. They also displayed a granular & porous surface with a bubbled appearance. It has been suggested that these may be due to gaseous bubbling that could be due to entrapment of peroxide in the sub surface layer of enamel¹². The effect of oxygen might be responsible for polymerization inhibition that might occur at the sub surface layer of the bonding agent, which includes resin tags^{3,5,13}. In accordance with the previous studies, in the present study, immediate bond strength to bleached enamel i.e. Group B in all sub-groups was significantly reduced compared to the control group i.e. Group A.

The adverse effects related to the lower bond strengths following bleaching can be reversed with certain methods. Delayed bonding by immersion of bleached specimens in distilled water or artificial saliva results in complete reversal of reduced bond strengths due to dissolution of entrapped oxygen. Under clinical conditions, saliva may have similar actions after bleaching, but after a prolonged time period of 1-2 weeks^{14,15}. It is also shown that use of alcohol based bonding agents with bleached enamel might be able to minimize the inhibitory effect of bleaching process as the acetone in dentin adhesives displaces surface water containing oxygen¹⁶⁻¹⁸.

Recently it has been found that the compromised bonding to acid etched bleached enamel and dentin was reversed with sodium ascorbate, an antioxidant^{4,12,13}. Vitamin C (ascorbic acid) and its salts are non-toxic and are widely used in the food industry as anti-oxidants. It is unlikely that their use on tooth structure would create any adverse biological effect or chemical hazard. It is possible that by restoring the altered redox potential of the oxidized bonding substrate, sodium ascorbate allows free radical polymerization of adhesive to proceed without premature termination and hence reverses the compromised bonding in bleached acid etched dentin or enamel¹⁰.

Certain other biologically available anti-oxidants have also been studied for their reversal effect on enamel bond strength, which include catalases¹², anthocyanins like malvidin chloride and pelargonidin chloride⁹, grape extract^{19,20}, alpha-tocopherol²¹, green tea^{22,23} and pine bark extracts²⁰. Assessing the potency and availability of sodium ascorbate; it is still a popular choice as it shows better or atleast similar effect compared to other materials for reversal of bond strengths of bleached enamel. In the present study irrespective of the bonding agent used, there was reversal of compromised bond strength using sodium ascorbate in Group C (Ascorbate Group). There was no significant difference between Group C (Ascorbate Group) and Group A (Control Group). These findings are in accordance with the previous studies^{4,24,25}.

Bonding to enamel surface relies on resin tag formation in etched enamel to create micro-mechanical interlocking²⁶ where the unfilled phase of resin system penetrates and polymerizes in enamel irregularities. Not only the depth of enamel etching, but also the mechanical properties of adhesives may play important roles in the determination of bond strength.

With the changing scenario in adhesive dentistry, self-etching primer systems are developed to provide shortened bonding procedures, as well as sufficient bonding ability to both enamel and dentin. The self-etch adhesive system is a one-step system, enabling smaller chair time and eliminating the risk of promoting the collapse of collagen fibers¹¹. Concern about the factors affecting the bonding ability of resin composite raises the question as to whether the newer version of bonding systems may overcome the adverse effects of whitening agent on the creation of stable bonding to tooth substrates. The very little information available with regard to the bond strength of self-etch primers on bleached, ascorbate treated enamel, potentiated us to design the present study.

The results of our study indicate that the bond strengths of total-etch adhesives were significantly higher than the self-etch adhesives irrespective of the groups. This decrease in bond strengths is related to the mechanism of bonding, the calcium precipitation for unbleached enamel and the oxygen entrapment of bleached enamel.

The mechanism of bonding to enamel with self-etch adhesives has been reported to be more superficial than that of total etch adhesives and is based on inter and intra crystallite hybridization of 0.6-0.7 μm into enamel²⁷. This shallow etching pattern resulted in limited penetration of self-etching primers into the enamel micro porosities that subsequently reduced micro mechanical retention. Another study stated that the precipitation of calcium on the enamel surface masked the etch pattern and interfered with resin penetration leading to decreased bond strength²⁸.

On bleaching, the etching ability of self-etching primers containing acidic functional monomers might be weakened by the presence of residual ingredients of whitening agent¹¹. The residual oxygen inhibition of resin polymerization⁵ could also be a reason for the reduced enamel bond strengths. Studies have reported that prior etching of enamel significantly increased the bonding effectiveness of self-etch adhesives⁹. Therefore it could be speculated that mild self-etching adhesives should follow an etchant application in enamel bonding to be in par with total etch adhesives.

V. Conclusion

From the results of the present study it could be inferred that:

- Bleached enamel showed lower bond strength compared to control group with all adhesives.
- Sodium Ascorbate treatment showed significant improvement in the bond strength on bleached enamel for both subgroups.
- Self-etching adhesive showed significantly lower bond strength compared to their respective total-etch sub groups.

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