



Antioxidant Agents and Their Effects on Shear Bond Strength of Bleached Enamel

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ABSTRACT

Aim: The goal of this study was to find a method to eliminate bond strength reduction after vital bleaching.

Materials and methods: Sixty flat surfaces of enamel central human incisors were prepared by diamond disks. In the first group, the samples immediately bonded to the tooth after bleaching. For the second group, the bleached samples were treated by sodium ascorbate for 1 hours. In the third and fourth groups the treatment was down using a new antioxidant agent for 1 hour and 15 minutes respectively. For the fifth group no bleaching was done. Cylindrical composite resin (Z 100) with a Single Bond adhesive system was bonded to the enamel with a special metal mold. After thermocycling, the samples were loaded at a crosshead speed of 0.5 mm/min. The mode of failures was inspected by the Dino Lite microscope and the microstructure of the debonding surfaces was observed by SEM. Considering normal data, statistical analysis was conducted by ANOVA and Tukey tests ($p = 0.05$).

Results: The fourth group had maximum (21.82), while the first group had the least (9.0971) shear bond strength. The ANOVA test showed a significant difference among the five groups ($p = 0.0002$). There was not any significant statistical difference between the three types of debonding ($p = 0.165$).

Conclusion: The usage of sodium ascorbate or sodium ascorbate with detergent after vital bleaching are effective methods for reducing the damaging effects of bleaching agents on the shear bond strength of composite resin restoration to enamel.

Clinical significance: Using antioxidants is necessary post bleaching and before resin bonding.

Keywords: Antioxidant agent, Bleaching, Bond strength.

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INTRODUCTION

Tooth discoloration can result from intrinsic and extrinsic factors. The management of these discolorations can be done aggressively, such as by using a veneer or crown or more conservatively, such as home and in-office bleaching. In spite of achieving favorable results of these treatments, some studies report some adverse effects such as reduced bond strength,¹ increased surface roughness of amalgam, porcelain and enamel,² raised staining susceptibility of tooth-colored restorations,³ and reduced fracture toughness of the tooth.⁴ Reduced bond strength results from the remnant of peroxide in the collagen matrix and dentinal tubules that break into water and oxygen to interfere with rein infiltration and formation of short and ineffective resin tags or inhibit resin polymerization.^{5,6} The other feasibility is beyond these superficial phenomenons and includes protein denaturation in enamel and dentin causing change in organic content.⁷ Oxidation agents penetrate into enamel porosities and change the microstructure and mechanical properties of enamel which can justify this reduced bond strength and fracture resistance of bleached enamel.^{8,9} Many solutions have been suggested to decrease this problem. The most common method is postponing the restorative procedure, rather than antioxidant agents can be applied after bleaching has been finished.¹⁰ The purpose of this study was to assessment the influence of antioxidants to relieve reduced bond strength after the bleaching process.

MATERIALS AND METHODS

In this study, forty-eight recently extracted intact human permanent maxillary central incisors were collected and kept in 2.5% formalin for 48 hours for disinfection. After extraction, the teeth were cleaned of any residual tissue tags, pumiced and washed under running tap water. The middle

third of all teeth were flatted with a diamond disk with a low speed handpiece with air and water coolant stream and 600 grit silicon carbide paper to obtain a standardized smooth enamel surface suitable for the shear bond strength test. Specimens were sectioned near the CEJ, and then the coronal portion was mounted in a special designed self-curing acrylic resin mold (Acropars TRII, Marlic medical Industries Co.), in which the longitudinal axis of each specimen was horizontally parallel. All the specimens were then randomly divided into five groups. All groups (except the control group) were exposed to carbamide peroxide gel (Opalescence®10%, Ultradent, USA) 8 hours daily for one week according to the manufacturer’s instructions. These groups were immersed in daily artificial saliva and 100% relative humidity for the rest of the day. After bleaching, all the tested groups were rinsed and dried. In each group, samples were bonded depending on applied procedures according to the following description:

Group 1: Enamel surface of each tooth was etched with 35% phosphoric acid (3M ESPE, USA) for 15 seconds, and then rinsed with water and the excess water was removed with tissue paper. Two consecutive coats of Single Bond (3M ESPE, Dental products, St Paul MN, USA) were applied with an applicator. After gently air-drying for 2 seconds, they were light cured with Optilux 500 (Demetron-Kerr, USA) a light intensity of 500 mW/cm² for 10 seconds.

Group 2: Before applying the adhesive systems as mentioned in group 1, the specimens were treated with 10% sodium ascorbate gel (PH ≈ 7.4) (Dr. Rajabi Pharmacy Co., Mashhad, Iran) for 1 hour.

Group 3: Before applying the adhesive systems as mentioned in group 1, the specimens were treated with the experimental antioxidant (detergent + 10% sodium ascorbate) (Dr Rajabi Pharmacy Co., Mashhad, Iran) for one hour.

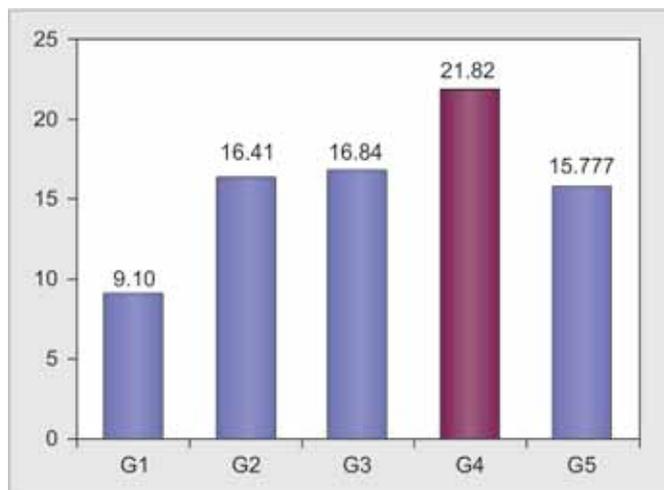
Group 4: All procedure was done similar to group 3 except the application time 15 minutes for the innovate antioxidant agent.

Group 5 (Control): Unbleached enamel surfaces were bonded as mentioned in other groups.

Each specimen was placed in a special mold with a diameter of 3 × 4 mm. The Z 100 resin composite (3M ESPE, Dental products, St Paul MN, USA) was inserted incrementally and light cured for 80 seconds. The restoration sets were stored in distilled water at 37°C for 24 hours and then subjected to 1000 thermal cycles between 5°C and 55°C for 1 minute with a dwell time of 30 seconds, in which the total time of each cycle was calculated at 2':30". The specimens were tested in the shear mode in a jig of the universal testing machine (Zwick/Z250) and a knife edge was applied to the composite-tooth interface at a cross-head speed of 0.5 mm/min. Bond strength values were calculated according to acquired loading values at the time of failure and the specimen was divided into cross-sectional areas and expressed in MPa. The mode of failure of each specimen was inspected by a digital microscope Dino-Lite Pro (AM413T, Anmo Electronics Crop, Taiwan) and categorized as three types of failure: adhesive, cohesive or mixed. When more than 75% of failure was on the interface of the tooth and restorative material, it was named as adhesive failure. When more than 75% of failure was on the tooth or restoration bulk, it was named as cohesive. The microstructure of the failure area was investigated by an electronic microscope in frontal and sagittal views (Magnification 1000 ×). Analysis of variance was applied to compare the bond strength values in the five tested groups. The Tukey’s post hoc test was performed for comparing each of the two tested groups. Fracture mode of specimens was analyzed by the Chi-square test. The level of significance was set at 0.05.

RESULTS

According to Kolmogorov-Smirnov the normal distribution of recorded values were confirmed (p = 0.706). Graph 1 shows the mean values and standard deviation of bond strength of the five tested groups. ANOVA shows statistical differences between tested groups (p = 0.0002). The Tukey HSD test showed statistically different between some two groups (Table 1). No significant difference in mode of failure



Graph 1: Mean values the bond strength of tested groups

Table 1: Results of Tukey HSD analysis at significance level of 0.05

Groups	1	2	3	4	5
1	----	0.014	0.008	0.000	0.030
2	0.014	----	1.00	0.117	0.998
3	0.008	1.00	----	0.176	0.989
4	0.000	0.117	0.176	----	0.061

Table 2. Failure modes of the tested groups

Group	Failure mode		
	Adhesive	Cohesive	Mixed
1	5	3	4
2	4	6	2
3	2	6	4
4	2	3	7
5	2	6	4

was observed ($p = 0.165$, Table 2). The microstructure views of three tested specimens are showed in Figures 1 to 3.

DISCUSSION

This study compared the shear bond strength of composite restorations that were treated with different antioxidant treatments after home bleaching with 10% carbamide peroxide. The lowest and the highest mean values of bond strength were obtained for groups 1 and 4 respectively. The results of this study showed that vital bleaching with 10% carbamide peroxide caused an adverse effect on the

bonding ability of the composite to the tooth structure, especially when the restorative procedure must be done immediately after bleaching. This finding is similar to previous reports about destructive effects of carbamide peroxide on bond strength.^{11,12} Many studies evaluated 10% sodium ascorbate as an antioxidant and found that applying this agent is necessary for increasing shear bond strength of resin composite to bleached enamel.¹³ In addition, for obtaining a maximum effect, antioxidant gel must be used 1 hour minimally and this effect was increased by a longer application time.^{13,14} Existence of enamel porosities after bleaching created an over-etched view,^{15,16} and calcium dissolving during the bleaching and restorative process resulted in reduced bond strength. A study claimed that bleaching agents with lower pH (= 3.5) values could result in more significant erosion than those agents with neutral or alkaline pH (= 7.8).¹⁷ Several studies reported that remaining peroxide interfered with resin penetration and polymerization or interacted with them in the interface of tooth and resin

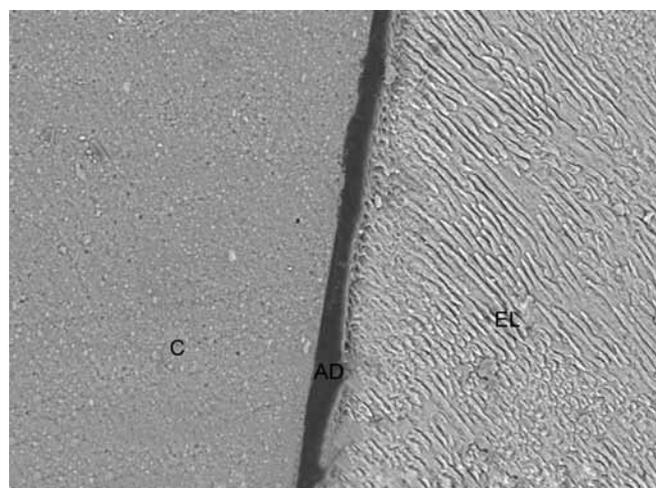
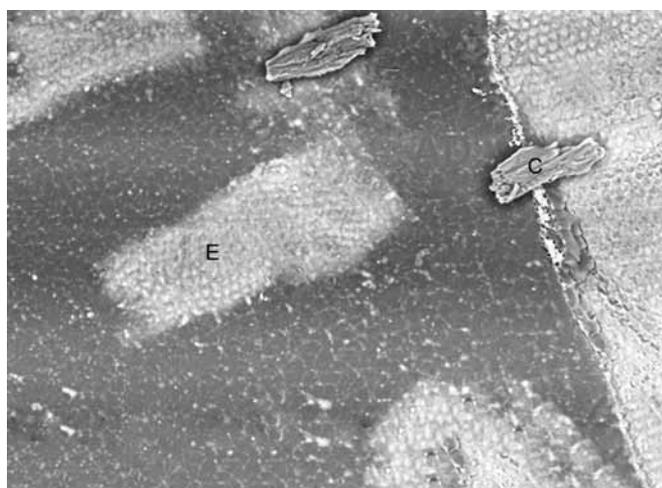


Fig. 1: Specimen microstructure in group 1, (A) labial surface (B) labiolingual cross section ($\times 1000$). Key-hole pattern of enamel rods (E), Longitudinal section of enamel rods (EL), Adhesive (AD), Composite (C)

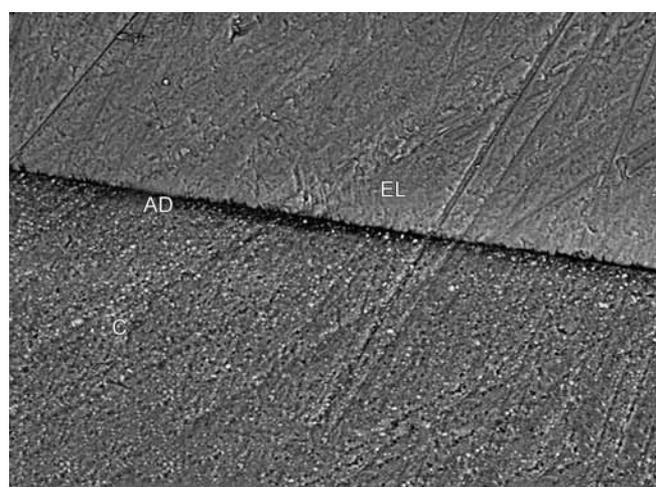
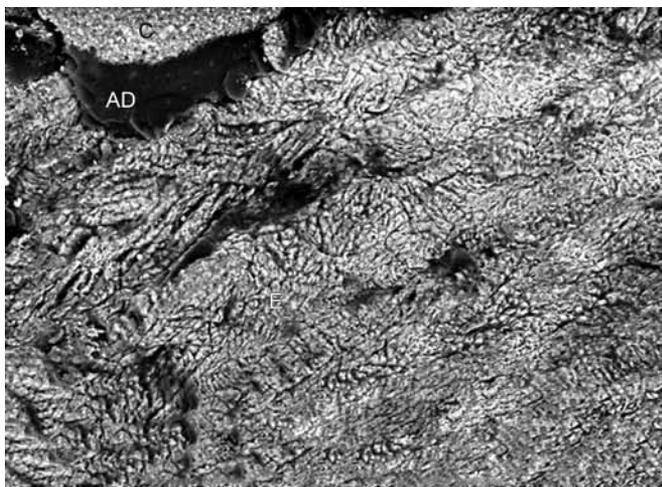


Fig. 2: Specimen microstructure in group 2 (Bleaching + sodium ascorbate + bonding), (A) labial surface (B) labiolingual cross section ($\times 1000$). Key-hole pattern of enamel rods (E), Longitudinal section of enamel rods (EL), Adhesive (AD), Composite (C)

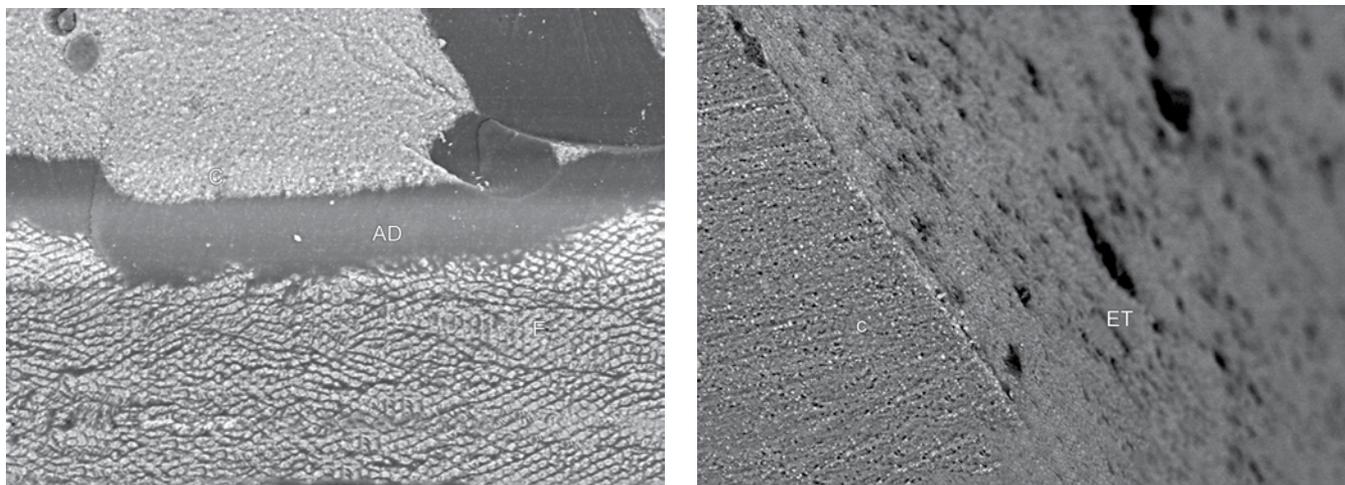


Fig. 3: Specimen microstructure in group 4 (Bleaching+ experimental sodium ascorbate + bonding), (A) labial surface (B) labiolingual cross section ($\times 1000$). Key-hole pattern of enamel rods (E), Oblique section of enamel rods (ET), Adhesive (AD), Composite (C)

composite.^{18,16} Ascorbic acid and its salts have been accepted as an antioxidant that can cause a significant decrease in the amount of free radicals and make a protective effect of them in biological systems.^{9,14,19,20} Vidhya et al,²¹ showed higher bond strength values in specimens with proanthocyanidin than those subjected to sodium ascorbate. In contrast to a study that reported the bonding process can be performed immediately after bleaching,²² in this study, treating the enamel surfaces with antioxidant agents before bonding resulted in a desirable effect to strengthen the adhesion. This finding confirmed the results of previous studies.^{23,24} Lai et al,²⁵ immersed the bleached specimens in 10% sodium ascorbate for 3 hours, but this was not convince. In order to decrease the sodium ascorbate application time, a new formulation was introduced in this study and was applied on the bleached enamel surface with two various times. According to one study, immersing the bleached teeth in the new antioxidant agent made a significant improvement in sealing ability;²⁶ and for maximum effectiveness, antioxidant gel should be applied to enamel for at least 60 minutes;¹⁴ therefore, preparation time of 1 hour and 15 minutes was considered for the experiment. In groups 2 and 3, teeth were stored in various antioxidant gels for one hour and in group 4 innovate antioxidant was applied for 15 minutes. The results showed no significant differences between these treatments, but bond strength values were higher for the new antioxidant than the conventional antioxidant especially with shorter time application. It can be explained by the existence of Tween 80 as a detergent in this new antioxidant agent. This element increases the surface energy of enamel resulting in higher bond strength than other groups. However, it seems reaming longer time of Tween 80 on the bleached enamel may produce ingredients that interfere with resin bonding. So, lesser time is needed for positive influence of innovate antioxidant and it means saving time consume and chairside moments. In the current study, the reversed bond strength

values after antioxidant therapy was around the threshold level of unbleached and standard enamel bond strength (18 MPa). In comparison the mode of failure, the present study revealed that with increasing the bond strength the number of adhesive failure was decreased, but the type of cohesive and mixed failure were increased. In a study, Lai et al did a SEM and TEM evaluation of bleached enamel with 10% carbamide peroxide and found a porous pattern, extended etching with obvious voids and a slight etched pattern of bleached enamel, but the surface treated with 10% sodium ascorbate did not have any abnormal structure.²⁵ SEM frontal views revealed large porosities and voids in group 1. In a sagittal view, resin composite adapted well to the surface of the specimens in groups 2,3,4 and 5, but there were a considerable gap in composite-enamel interface in group 1. More long-term clinical and *in vitro* investigations are recommended to evaluate the effect of the composition of this new antioxidant in relation to increasing bond strength after extra and intracoronal bleaching, the questionable application of self-etch adhesives and other new tooth colored restorative materials, and decreasing the application time of antioxidants that to be more practical.

CONCLUSION

Considering the limitations of this study, it can be concluded that bleaching causes enamel bond strength reduction, but using 10% sodium ascorbate or 10% sodium ascorbate mixed with detergent are helpful solutions to diminish the destructive effects of bleaching agents on bond strength.

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