

Antioxidant effect on the shear bond strength of composite to bleached bovine dentin

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Abstract

Several studies have shown that compromised bonding to bleached enamel can be reversed with antioxidants. **Aim:** The aim of this study was investigate the effect of the antioxidant treatment on the micro-shear bond strength of a composite resin with a clinically acceptable antioxidant usage time taken into account. **Methods:** Using *in vitro* techniques, the effect of the antioxidant sodium ascorbate (SA) was evaluated on the micro-shear bond strength of a hybrid composite resin (Tetric® A₂ Ivoclar Vivadent) to dentin, which was bleached with 35% carbamide peroxide (Opalescence Quick, Ultradent Products Inc). Thirty-five intact flat buccal dentin surfaces from bovine incisors were randomly assigned to five groups which were subjected to the following treatment protocols: group 1, bleached for 45 min and bonded immediately afterwards; groups 2 and 3, bleached and then treated with 10% SA for 10 and 5 min before bonding, respectively; group 4, stored in distilled water for seven days after bleaching and before bonding; group 5, received no bleaching or antioxidant treatment. After the bonding procedure, specimens were subjected to a micro-shear bonding test. Data were analyzed by ANOVA and a post-hoc Tukey's test. **Results:** One-way ANOVA revealed significant differences in bond strength among the five groups. **Conclusions:** It was found that the shear bond strength was reduced by carbamide peroxide bleaching, and that the antioxidant SA was ineffective at reversing the composite strength at the concentrations and treatment times examined.

Keywords: antioxidant, shear bond strength, composite, bleaching.

Introduction

Hydrogen peroxide bleaching is effective at lightening discolored teeth¹. When bonding is performed immediately after bleaching, hydrogen peroxide and carbamide peroxide (CP) bleaching agents alter the bonding strength of composites to acid-etched enamel²⁻³. Delays in bonding of 1 to 3 weeks are recommended following bleaching, to avoid the clinical problems related to bleaching-mediated compromised bond strength⁴. One mechanism that may account for the lower bond strengths of bleached teeth is the presence of residual oxygen, which inhibits the polymerization of adhesive monomers⁵. Recent studies have revealed that the use of the antioxidant sodium ascorbate (SA) before the bonding process reverses the bleaching-induced reduction in bonding strength⁶⁻⁹. Antioxidants can neutralize free hydroxyl radicals and prevent their adverse biological effect¹⁰. Previous studies have different opinions about the duration of applying the antioxidant. The aim of this study was investigate the effect of this antioxidant treatment on the micro-shear bond strength of a composite resin with a clinically acceptable antioxidant usage time.

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Material and methods

After slaughtering, 35 two-year-old intact bovine incisors were immediately extracted. The teeth were cleaned and sectioned at the cemento-enamel level, pulp was removed using endodontic instruments, and the pulp chamber was rinsed with saline solution. The teeth were mounted with the buccal surface upwards in a self-curing acrylic resin using a heavy-body silicon mold. The teeth were stored in distilled water at 4°C for less than 3 months. Teeth were sectioned buccolingually parallel to the line axes at 2-mm slices, using a low speed machine (Isomet, Buehler Ltd., Lake Bluff, IL, USA) to expose the dentin. The dentin surface was ground (polished) with wet 600- and 1000-grit silicon carbide abrasive paper to create a flat dentin surface.

Specimens were randomly assigned to five groups (1 control and 4 experimental) of 7 teeth each (Table 1). Two or three composite samples were placed over each tooth, for a total of 17 specimens per group. The lingual sides of the teeth were placed in distilled water to simulate the humid condition of the oral cavity.

For the bleaching treatment, a 35% CP bleaching gel (Opalescence Quick, Ultradent Products Inc., USA) was placed on the dentin surfaces of the whole buccal aspect, and the teeth were placed in an incubator at 37°C and 100% humidity for 45 min. One group of teeth received no bleaching, as a positive control group (group 5). For the antioxidant treatment, a 10% SA solution was prepared by solving 10 g of SA powder (Merck KGaA, Darmstadt, Germany) in distilled water. SA solution was prepared immediately before its application on the teeth. Specimens from groups 2 and 3 were treated with 10% SA for 10 min and 5 min, respectively, followed by agitation with SA solution and thorough rinsing with tap water for 30 s. Specimens in group 4 were immersed in distilled water in an incubator at 37°C during 1 week after bleaching.

For the bonding treatment, two or three composite cylinders were applied to each sample. Application of the self-etching non-rinsing primer dentin adhesive system (Clearfil SE Bond, Kuraray Medical Inc., Japan) was according to the manufacturer's instructions. The above adhesive was used in this study because it is a current and clinically acceptable adhesive. The bonded surfaces were light-activated for 10 s using a visible light-curing unit (Optilux 501; Demetron Kerr, Danbury, CA, USA) with an output intensity level of 410 mW/cm². Silicon tubes (0.7 mm internal diameter and 2 mm length) were placed on the dentin surface, and dental composite (Tetric Ceram, Ivoclar-Vivadent,

Liechtenstein) was inserted into the tubes in one step. Each specimen was totally cured for 80 s. After curing, the silicon was removed and the specimens were subjected to 1000 thermal cycles between water baths of 5°C and 55°C, with a dwelling time of 15 s each. Specimens were then stored in distilled water at 4°C for one week.

The micro-shear bond strength was measured with a micro-shear testing machine (Bisco, Schaumburg, IL, USA) using a wire and loop method. The loop was prepared with orthodontic ligature wire, with one side placed around the sample and the other side around the testing machine rod. Specimens were loaded at a speed of 0.5 mm/min. Bond strengths (MPa) were calculated using the load required to debond the specimen.

Results were subjected to one-way ANOVA followed by a post-hoc Tukey's test at a 0.05% significance level. Statistical analysis was processed with SPSS for Windows XP. Differences with $P < 0.05$ were considered significantly different.

Results

The results of the micro-shear bond strength tests are summarized in Table 2. One-way ANOVA revealed significant differences in bond strength among the five groups. The post-hoc test indicated differences between groups 1 (CP + bonding), 2 (CP + SA for 10 min), 3 (CP + SA for 5 min) and groups 4, 5. The CP and two antioxidant groups (groups 2 and 3) showed significantly lower bond strength averages than the positive control (group 5) and the group where specimens were immersed in water for 1 week (group 4). No differences were observed when groups 2, 3, and 1 were compared with each other, and group 4 was not significantly different from group 5 (Table 2).

Discussion

In the present study, it was found that bleaching treatments of 35% CP decreased the micro-shear bonding strength of a hybrid composite resin to dentin. The use of 10% SA for 10 or 5 min before bonding was unable to neutralize the oxidizing effects of the bleaching agent.

Bond strength reduction by CP may be caused by the presence of residual peroxide, which can interfere with resin attachment and inhibit resin polymerization^{5,7-8}. Previous scanning electron microscopy studies have shown that

Table 1: Groups, treatment agent used in the experiment.

Group	Treatment Agent	Sodium Ascorbate Treatment	Delayed Bonding
G1	35% carbamide peroxide	-	-
G2	35% carbamide peroxide	10 min	-
G3	35% carbamide peroxide	5 min	-
G4	35% carbamide peroxide	-	1 week
G5	No bleaching	-	-

Table 2: Mean micro-shear bond strength values, standard deviation and range of each group.

Group	Treatment	Mean(SD)	Range
G1	Bleach	15.46(8.48)b*	11.09-19.82
G2	Bleach + Antioxidant (10 min)	15.69(6.73)b	12.22-19.15
G3	Bleach + Antioxidant (5 min)	15.18(5.097)b	12.56-17.80
G4	Bleach + Distilled water (1 week)	24.04(8.99)a*	19.41-28.66
G5	No bleach	23.79(8.52)a	19.41-28.17

Different letters indicate statistically significant difference at $p < 0.05$.

bleached resin interfaces display a few short, fragmented resin tags compared to interfaces with unbleached enamel. The bleaching of human tooth alters the enamel surface characteristics, causing surface loss and increased surface porosity^{2,9}. These alterations may affect the bonding of composite resin, and contribute to microleakage if it is restored with a bonded composite¹¹.

Bleaching can significantly reduce the relative concentrations of calcium and phosphorous and cause morphological alterations in the most superficial enamel crystallites¹². Peroxide-containing bleaching agents affect the organic phase of enamel, affecting both the outer and inner enamel surfaces¹³. Theoretically, enamel pores, dentin and dentin fluid can all act as peroxide/oxygen reservoirs^{12,14}. Dentin may be the most important reservoir of the three ones¹⁵, and is more affected by hydrogen or carbamide peroxide due to its lower mineral content and more organic matrix. Thus, dentin proteins may be denatured by hydrogen-based materials that produce morphological changes, which could negatively impact resin performances^{12,16}. In particular, since the surface calcium levels affect dentin bonding¹³, it is predicted low shear bond strength values for dentin samples after bleaching.

Several methods have been proposed to avoid the clinical problems related to bleaching-associated reduced bond strength. The most common recommendation is delayed bonding for composite resin restorations¹⁶⁻¹⁸. Studies have identified 2 weeks as a satisfactory waiting period between bleaching and composite restoration for enamel and dentin^{17,19}. Some *in vitro* studies indicate that the immersion of specimens in distilled water, saliva, or saline reverses the reduced enamel or dentin bond strength^{2-3,16}. It is observed that the immersion of specimens in distilled water for 7 days after bleaching effectively reversed the reduced dentin bonding strength.

Enamel removal can also restore bonding strengths to their normal levels²⁰. Barghi et al.¹ reported that the adverse effects of enamel bleaching on bonding can be reduced or eliminated by treating the bleached surface with a water displacement solution, such as a dentin-bonding agent that contains acetone¹. This has led others to recommend the use of alcohol-based bonding agents, particularly when restorative work is performed immediately after bleaching²¹.

The inorganic and organic components of both dentin and cementum are reportedly affected by 3% hydrogen peroxide²², which remains active in the pulp chamber or dentin tubules after bleaching due to its interaction with certain dentin components. Catalase has been suggested as

an effective adjunct following bleaching to prevent the adverse effects of hydrogen peroxide¹⁰. Turkun et al.⁶ found that the bond strength of composite resin to bovine enamel increased after treating bleached teeth with 10% SA for 10 min⁶. Another report showed that antioxidant treatment for 10 min immediately after bleaching reversed the tensile bond strength of brackets²³. Zhao et al.²⁴ speculated that peroxide ions may be temporarily substituted for the hydroxyl radicals in the apatite lattice, producing a patite. It may be that these lattice substitutions are thermodynamically unfavorable, and may be reversed by an antioxidant⁹. On the other hand the use of SA to reverse bleaching-related oxidation required a substantial treatment time that may not be clinically acceptable⁹. Another study found that the use of a 10% SA hydrogel for 3 h before bonding neutralized the oxidizing effects of bleaching, increasing the enamel bond strength²⁵. Also, Similar studies reported that compromised bonding can be reversed with 3 h application of hydrogel or solution from of sodium ascorbate²⁶⁻²⁷. Results of another study showed that the antioxidant gel should be applied to enamel for at least 60 min for maximum effectiveness²⁸. Nevertheless, it is sought to reverse the bleaching-associated reduction in bond strength by neutralizing the residual oxygen with 10% SA, it is found that SA treatment before composite bonding was ineffective. Also, in an *in vitro* study to investigate the neutralizing effect of antioxidant agents on the bond strength of bleached enamel, Gomes Torres et al.¹⁵ found that only catalase application increased the bond strength relative to the PC (positive control) group, and none of the tested treatments could completely neutralize the deleterious effects of bleaching. Although it could have been effective if the application time were increased to at least one-third of the bleaching time, this may not be clinically acceptable. Therefore, it is recommended that treatment be postponed for 1 week after bleaching.

The results of this study showed significant differences in bond strength among the five groups. The CP and two antioxidant group showed significant lower bond strength means than the control and distilled water-immersed (delayed bonding) groups. The effects of SA at different forms could be studied.

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