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Original Article

Effect of newer antioxidants on the bond strength of composite on bleached enamel

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ABSTRACT

Aim: The study aims to evaluate the effect of the application of two antioxidants on the bond strength of composite resin to bleached enamel. **Materials and Methods:** Eighty enamel surfaces were obtained from forty human extracted premolars. Specimens were randomly divided into four groups ($n = 20$). Group 1: No bleaching (control); Group 2a: Bleaching with 15% carbamide peroxide gel; Group 2b: Bleaching, followed by application of 10% sodium ascorbate gel; Group 2c: Bleaching, followed by application of 5% proanthocyanidin agent. Surfaces were etched followed by application of total etch bonding system, and composite resin cylinders were bonded. Specimens were tested for shear bond strength. **Statistical Analysis Used:** One-way analysis of variance was used for multiple group comparison and *post hoc* Tukey's test for individual group-wise comparison. **Results:** Significantly higher shear bond strength values were observed in Group 2c and 2b as compared with Group 1 and 2a ($P < 0.05$). Among the antioxidants, Group 2c showed significantly higher shear bond strength values than Group 2b ($P < 0.05$). **Conclusion:** It can be concluded that the use of antioxidant before bonding procedures on bleached enamel completely neutralizes the deleterious effects of bleaching and increases the bond strength significantly.

KEYWORDS: Antioxidants, bleaching, composite, proanthocyanidin, shear bond strength, sodium ascorbate gel

Introduction

One of the most frequent reasons patients seeks dental care is discolored anterior teeth. Discolored teeth often present a conscious effort to avoid smiling. Correction of this dental problem can produce dramatic changes in appearance, which results in improved confidence, personality, and social life. These improvements make esthetic dentistry gratifying for the dentist and represent a new dimension of dental treatment for patients. Treatment options for discolored teeth include removal of surface stains, bleaching, microabrasion, macroabrasion, veneering, and placement of porcelain crowns. In an era of minimum intervention dentistry, increasing numbers of patients do not want their teeth "cut down" for crowns and are electing conservative approach such as veneers and bleaching which preserves as much of the natural tooth as possible.[1]

Tooth bleaching can be performed at home and in the dental office. Among bleaching agents, carbamide peroxide bleaching is a safe, well accepted, and an increasingly popular procedure.[2] These bleaching

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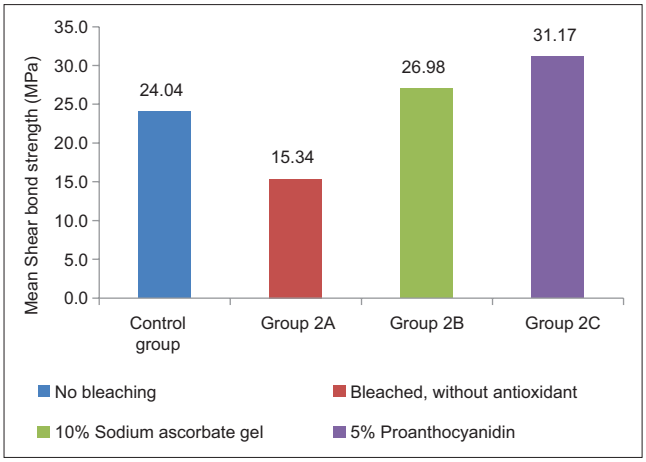

Figure 1: Comparison of mean bond strength between control group and experimental groups

agents despite having many advantages also have some disadvantages.[3] One of the most important complications of the use of bleaching agents is decreased composite resin bond strength to enamel immediately after bleaching procedure.[4] It has also been reported that the weakening of bond occurred both superficially and internally. This could be attributed to the presence of residual peroxide, which interferes with the resin tag formation and inhibits the resin polymerization.[2]

Studies have revealed that reduced bond strength can be reversed by the use of antioxidants such as sodium ascorbate, ascorbic acid, butylhydroxianisole, catalase, ethanol, acetone, glutathione peroxide, alpha-tocopherol, sodium bicarbonate, grape seed extract (proanthocyanidin; PA), and green tea extract (catechins and epigallocatechin gallate).[5]

Since, there is a paucity of information available on the use of the newer antioxidant agents which increase the bond strength of composite resin to bleached enamel; this study was designed to evaluate the effect of application of 10% sodium ascorbate gel and 5% PA agent on the bond strength of composite resin to bleached enamel.

Materials and Methods

Forty intact human premolars extracted for orthodontic purpose were collected. All the teeth were thoroughly cleaned free of debris and calculus using scalers and were stored in isotonic saline (D.J. Laboratories Pvt. Ltd., India) until use. Teeth with caries, cracks, or developmental enamel defects were excluded from this study. Carbide disc was used to remove roots at the level of cementoenamel junction. Each crown was sectioned with carbide disc longitudinally to obtain non occlusalbuccal and lingual enamel surface, and a total of eighty enamel specimens were obtained. All specimens were mounted in acrylic resin blocks such that only the enamel surfaces were exposed. Specimens were polished with 320 grit silicon carbide paper to prepare flat enamel surface for treatment and bonding.

The specimens were divided into following four groups. All the groups consisted of twenty specimens.

- Group 1 (20) - No bleaching (control group)
- Group 2a (20) - Bleaching with 15% carbamide peroxide only
- Group 2b (20) - Bleaching with 15% carbamide peroxide followed by application of 10% sodium ascorbate gel
- Group 2c (20) - Bleaching with 15% carbamide peroxide followed by application of 5% PA agent.

Bleaching procedure

Bleaching procedure was carried out on the experimental group using 15% carbamide peroxide (Opalescence PF, India) for 8 h a day for 5 days according to manufacturer's instructions. Carbamide peroxide gel was applied using custom trays fabricated for each tooth specimen. After bleaching procedure, the specimens were thoroughly rinsed with an air-water spray for 30 s and air dried.

Preparation of two antioxidant solutions

After bleaching procedure was completed two antioxidant materials namely 10% sodium ascorbate gel (Leo Chemicals Private Limited, Bangalore, India) and 5% PA solution (Vista Nutrition, Medizen Labs, India) were prepared. Ten percent sodium ascobate gel was prepared by dispersing carbopol in water followed by addition of ascorbic acid and sodium hydroxide. Five percent of PA solution was prepared by dissolving 5 g of grape seed extract in the form the capsules in 100 ml of sterile water. Immediately after bleaching procedure 10% sodium ascorbate gel was applied on Group 2b specimen and 5% PA agent was applied on the Group 2c specimens using a brush. After 10 min, it was rinsed and dried.

Bonding procedure

After application of antioxidant solutions, acid etching procedure was carried out for all specimens according to manufacturer's instruction using 35% phosphoric acid (3M ESPE Scotch Bond, USA) for 15 s, then specimens were washed and air dried.

A total adhesive (3M ESPE ADPER Single Bond 2, USA) was applied to all specimens according to manufacturer's instruction. A plastic tube with internaliamete dr of 2 and 2 mm height was placed onto bonded specimens before curing the adhesive, and then light cured for 30 s. The plastic tube was filled with composite (3M ESPE Filtek Z350 XT, USA) and light cured for 40 s; then tubes were removed.

Shear bond strength analysis

The shear bond strength assessment was done using Instron Universal Testing Machine. The specimens were placed in the Instron Universal Testing Machine

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such that the chisel model (fixture) of the machine would lie perpendicular to the composite cylinders. Force was then applied over the composite cylinders at a crosshead speed of 1 mm/min until the cylinders got detached from the enamel surface.

The amount of load needed to detach the composite cylinders was noted and the bond strength was calculated using the formula:

Bond strength = Force in kilogram needed to debond the composite cylinder × 9.8/total surface area.

Statistical analysis

The results were tabulated and statistically analyzed using statistical product and service solutions version 17.0 software (SPSS Inc., Chicago, IL, USA). One-way analysis of variance for multiple group comparison and *post hoc* Tukey's test for individual group comparison were used. $P \leq 0.05$ was considered statistical significance.

Results

Group 1 (no bleaching) showed significantly higher shear bond strength than Group 2a (bleached, without antioxidant; 15.34 ± 1.24 MPa). When compared to Group 1 (no bleaching), Group 2b (10% sodium ascorbate gel; 26.98 ± 1.51 MPa), and Group 2c (5% PA; 31.17 ± 1.52 MPa) showed significantly higher shear bond strength values [Table 1 and Figure 1].

Among experimental groups, Group 2a (bleached, without antioxidant) showed the lowest mean shear bond strength values compared to all other experimental groups ($P < 0.05$). Group 2b (10% sodium ascorbate gel) showed significantly higher shear bond strength (26.98 ± 1.51 MPa) than Group 2a (bleached, without antioxidant). When Group 2c and 2a were compared, Group 2c showed significantly higher shear bond strength values (31.17 ± 1.52 MPa). Group 2c (5% PA) showed significantly higher shear bond strength than Group 2c (10% sodium ascorbate gel) [Table 2 and Figure 1].

Table 1: Comparison of mean bond strength between control group and experimental groups

Group	Shear bond strength (MPa)	
	Mean±SD	Range
Control	24.04±0.55	23.07-24.97
Group 2a	15.34±1.24	13.36-18.80
Group 2b	26.98±1.51	23.01-30.32
Group 2c	31.17±1.52	28.36-34.48
Control versus Group 2a	*t*=28.76, *P*<0.001	
Control versus Group 2b	*t*=8.17, *P*<0.001	
Control versus Group 2c	*t*=22.38, *P*<0.001	

Unpaired *t*-test; *P*<0.001, HS. Control group: No bleaching; Group 2a: Only bleaching with 15% carbamide peroxide; Group 2b: Bleaching with 15% carbamide peroxide followed by application of 10% sodium ascorbate gel; Group 2c: Bleaching with 15% carbamide peroxide followed by application of 5% proanthocyanidin agent; SD: Standard deviation; HS: Highly significant

Table 2: Comparison of mean bond strength between experimental groups

Group	Shear bond strength (MPa)	
	Mean±SD	Range
Group 2a	15.34±1.24	13.36-18.80
Group 2b	26.98±1.51	23.01-30.32
Group 2c	31.17±1.52	28.36-34.48
One-way ANOVA	*F*=726.07, *P*=0.00**	
Group-wise comparison	Mean difference	*P*
Group 2a versus 2b	11.64	0.00**
Group 2a versus 2c	15.83	0.00**
Group 2b versus 2c	4.19	0.00**

**Highly significant, *Post hoc* Tukey's test; *P*<0.001, HS. Group 2a: Only bleaching with 15% carbamide peroxide; Group 2b: Bleaching with 15% carbamide peroxide followed by application of 10% sodium ascorbate gel; Group 2c: Bleaching with 15% carbamide peroxide followed by application of 5% proanthocyanidin agent. SD: Standard deviation; HS: Highly significant; ANOVA: Analysis of variance

Discussion

Tooth bleaching can be performed externally, termed nightguard vital bleaching or vital tooth bleaching, or intracoronally in root-filled teeth, called nonvital tooth bleaching.[1] The mechanism of action of bleaching agents is based on a complex oxidation reaction, which releases oxygen free radicals that penetrate through the porosities of the enamel prism to the dentin, possibly due to the low molecular weight (about 30 g/mol) of these substances.[5]

Nightguard vital bleaching introduced by Haywood and Heymann in 1989 is simple, apparently safe, and comparatively inexpensive. Products currently available in the market for nightguard vital bleaching technique use 10% carbamide peroxide with a pH close to neutral. This solution is unstable and dissociates into 3% hydrogen peroxide and 7% urea on contact with tissue or saliva. The hydrogen peroxide further breaks down into oxygen and water, while urea degrades into ammonia and carbon dioxide, which elevate the pH. The oxidizers remove some unattached organic matter from the tooth without dissolving the enamel matrix, and these pigments are removed by diffusion, leading to bleaching. In this technique, after carbamide peroxide breakdown, the concentration of peroxide is lower than previous in-office bleaching techniques. However, home bleaching comprises daily application of 5–8 h for 2–5 weeks.[6,7]

Esthetic restorations require the use of bonding technique. However, it is unknown whether immediate bonding of resin after bleaching procedures decreases the bond strength of these restorative materials.[8-10] This is likely to be caused by delayed release of oxygen that could interfere with resin infiltration into etched

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enamel or inhibit polymerization of resins that cure through free radical polymerization. If the oxygen-rich surface layer of enamel is removed, the composite to enamel bond strength returns to near normal. The exact depth of this oxygen-rich layer of enamel is unknown. However, it must be >5–10 μm; otherwise, the acid etching would have removed it.[11]

Furthermore, some studies have suggested physical alterations in enamel after bleaching with carbamide peroxide. They found an increased porosity of enamel as manifested by an over-etched appearance with loss of prismatic structure. Furthermore, loss of calcium, a decrease in microhardness and alterations in the organic substance, might be factors that contribute to the decrease in the bond strengths.[12,13]

Clinicians should be aware of the outcome of the bleaching treatment and the interactions with further dental treatments, especially additional adhesive esthetic interventions such as composite bonding, or laminate veneers.[14]

Some techniques have been suggested to solve the clinical problems related to post bleaching compromised bond strength. Barghi and Godwin treated bleached enamel with alcohol before restoration,[15] Cvitko *et al*. proposed the removal of the superficial layer of enamel,[11] and Sung *et al*. suggested the use of adhesives containing organic solvents.[16] However, the general approach is to postpone any bonding procedure for a period after bleaching, because the reduction in bond strength has been shown to be temporary.[17] and has been reported to vary from 24 h to 4 weeks.[18,19]

Lai *et al*. in their study suggested that the antioxidant needs to be applied for no less than one-third the bleaching time for it to completely reverse its effects. This corresponds to approximately 3 h, which is a long duration for carrying out restorative treatment in the same visit following bleaching. Shorter application time is clinically desirable. Therefore, the application time of 10 min was chosen in this study, as this duration is considered to be adequate for clinical application of the antioxidant in solution form.[17,20,21]

The present *in vitro* study evaluated the efficacy of two antioxidant agents, namely, sodium ascorbate and PA (grape seed extract) in reversing the compromised bonding to bleached enamel surface by measuring the shear bond strength at the resin-enamel interface.

In this study, treatment of the bleached enamel with 10% sodium ascorbate hydrogel before bonding appeared to restore the reduced shear bond strength of composite resin to enamel. The results concur with the previous studies,[20,22] where similar reversal of bond strength was observed by antioxidant treatment.[23] The possible explanation for this could be the antioxidant ability of sodium ascorbate that helps to neutralize and reverse the oxidizing effects of bleaching agents. Furthermore, sodium ascorbate allows for the free radical polymerization of the adhesive to proceed without premature termination by restoring the altered redox potential of the oxidized bonding substrate.[24]

However, with regards to the concentration of the hydrogel (either 10% or 20%), there was no significant difference observed in the bond strengths between the groups. Kimayi and Valizadeh observed similar findings and suggested that 10% sodium ascorbate hydrogel might be as effective as 20% sodium ascorbate hydrogel in neutralizing the oxidizing agents and increasing the bond strength.[24]

Sodium ascorbate was used in gel form instead of solution since gel form is more acceptable clinically. Patients can apply gel in the same tray used for bleaching, thus reducing the chairside time.[22,24] The manipulation of solution is more difficult than gel, and the efficiency of sodium ascorbate solution is swift and short-term. In addition, solution should be used several times before bonding procedure.[25]

In this study, another antioxidant used was PA which was found in high concentrations in natural sources such as grape seed extract, cocoa beans, pine bark extract, cranberries, lemon tree bark, and hazelnut tree leaves. Grape seed extract was chosen for this study since it yields a 10% higher concentration of PAs. This PA is designated as PA B2-3′-0-gallate. PAs are high molecular weight polymers comprised the monomeric flavan-3-ol (+) catechin and (−) epicatechin. Oligomeric proanthocyanidin complex (OPC) contains multiple electron donor sites (hydroxyl sites) that bind to unstable molecules called free radicals by donating its hydrogen atoms. OPC also recycles other antioxidants such as Vitamin C and glutathione by removing the free radicals they bind with and freeing them up to interact again with other free radicals. The presence of gallic acid also increases the free radical scavenging activity.[26]

Therapeutic applications of OPCs in the field of medicine for the treatment of various vascular disorders are well documented. These compounds also demonstrate antibacterial, antiviral, anticarcinogenic, anti-inflammatory, and antiallergic properties. *In vitro* studies have confirmed that the free radical scavenging ability and the antioxidant potential of OPCs are fifty times greater than Vitamin C and twenty times greater than that of Vitamin E.[26,27]

The present study showed that the shear bond strength of Group 1 (unbleached group) is significantly greater than that of Group 2 (bleached group). These findings are in accordance with the studies performed by various other authors such as Titley *et al*.,[28] Stokes *et al*.,[27] Miles *et al*.,[29] and Spyrides *et al*.[30]

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The results of our study showed that the shear bond strengths of both Group 2b (10% sodium ascorbate applied) was significantly greater than that of Group 2 (bleached). Similar findings were reported by Torres *et al*.[31] who used 10% sodium ascorbate solution for a period of 20 min and found improvement in shear bond strength compared to bleached enamel but lower when compared to unbleached enamel. Kimyai *et al*.[32] showed that the bond strength of teeth treated with 10% sodium ascorbate for 10 min was significantly higher than bleached and immediately bonded teeth.

In the literature, sodium ascorbate has proven its efficacy as an antioxidant in the reversal of reduced bond strength to bleached enamel, but literature is scarce on studies using grape seed extract as viable alternatives to sodium ascorbate. There are many reports of using these products in medicine for centuries as therapeutic agents. Hence, in this study, emphasis was placed on the use of grape seed extract as an antioxidant before bonding procedure was performed on bleached enamel.

This study shows that treatment with Grape seed extract (Group 2c) increases bond strength significantly compared with Group 1, 2a, and 2b. This could be attributed to the following:

1. The specificity of OPCs for hydroxyl free radicals
2. The presence of multiple donor sites on OPCs that trap superoxide radicals
3. The esterification of (−) epicatechin by gallic acid in OPCs, which enhances the free radical scavenging ability.[33,34]

The present study indicated that the shear bond strength of the antioxidant group (Group 2c) is higher than all the other three groups. In addition, the shear bond strength of the bleached group (Group 2a) is significantly lower than all the other three groups. This implies that the use of antioxidants increases the bond strength to bleached enamel.

Conclusion

Within the limits of this study, the following conclusions were drawn:

1. Bleaching of enamel reduced the shear bond strength
2. Application of antioxidants immediately after bleaching showed significantly increased bond strength
3. Among the antioxidants tested in this study, Grape seed extract (PA agent) was the most effective antioxidant in reversing the bond strength; hence, it may be an innovative option for esthetic treatment after bleaching.

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Conflicts of interest

There are no conflicts of interest.

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