The Effect of 15% Carbamide Peroxide Bleaching on the Shear Bond Strength of Composite to Enamel

Mortazavi V. [a*], Fathi MH. [b], Ataei E. [c], Khodaeian N. [d]

a Professor, Dept. of Operative Dentistry, Dental Research Center. School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[b] Associate Professor, Biomaterials Group, Dept. of Materials Engineering, Isfahan University of Technology, Isfahan, Iran
[c] Senior Postgraduate Student, Dept of Operative Dentistry, Dental Research Center, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[d] Senior Post Graduate Student, Dept. of Prosthodontics, Dental Research Center. School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran

KEY WORDS

Bleaching;
Adhesive;
Composite.

ABSTRACT

Statement of problem: Carbamide peroxide bleaching has been implicated to adversely affect the bond strength of composite to enamel.

purpose: The purpose of this study was to evaluate the effect of carbamide peroxide bleaching on the shear bond strength of composite to bleached enamel bonded with a three step total etch system; Scotchbond Multipurpose(SBMP), and two simplified all-in-one systems; Prompt L-Pop (PLP) and i bond.

Materials and Methods: Seventy two human molar teeth were randomly assigned to three control and three experimental groups. The experimental groups were subjected to a %15 carbamide peroxide bleaching system. Twenty four hours later, all the control and experimental groups were bonded with cylinders of composite, using three dental bonding agents. After thermocycling, shear bond strengths were determined by a universal testing machine. The data were evaluated using one way ANOVA and Duncan tests ($P<0.05$).

Results: The composite bond strengths of SBMP were 19.52±5.21 MPa to the unbleached and 7.95±4.16 MPa to the bleached enamel. For PLP, the unbleached enamel exhibited bond strengths of 9.66±2.89 MPa and, the bleached one showed a bond strength value of 5.39±0.66 MPa. For i-bond the composite bond strengths were 11.46±4.31 MPa to the unbleached and 6.41±2.01 MPa to the bleached enamel. There was a statistically significant difference between the shear bond strength of the control and experimental groups of each dental bonding agent (SBMP, $P<0.001$, PLP, $P<0.001$, i bond: $P=0.002$).

Conclusion: Bleaching with 15% carbamide peroxide used in this study reduced the bond strengths of the composite to the enamel bonded with a three step total etch and two simplified one step all-in-one dental bonding agents.

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[*] **Corresponding author.** Mortazavi V., Address: Dept. of Operative Dentistry, Dental Research Center. School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran; Tel: 0311-7922856, Fax: 0311-6687080; E-mail: v_mortazavi@dnt.mui.ac.ir

Introduction

Tooth discoloration is becoming a greater concern as more emphasis is placed on esthetics. With the growing awareness of esthetic options, there is a greater demand for solutions to such unpleasant problems as food staining, fluorosis, and tetracycline staining. Tooth bleaching has been used since the late 1870s [1]. In 1989, Haywood and Heymann published an article on patient applied at home bleaching by using carbamide peroxide [2]. Since then, the use of bleaching for improving the esthetics of natural dentition has been widened [3]. Today, the home vital bleaching technique is the most popular bleaching method [4]. With the home or night guard vital bleaching technique, the patient wears custom bleaching trays which contain carbamide peroxide or hydrogen peroxide bleaching solutions for a few hours per day [3].

In its undiluted form, carbamide peroxide has the equivalent concentration of a 35% hydrogen peroxide. It has been proposed that at such concentrations, it can result in chronic inflammation, tooth hypersensitivity, and preneoplastic lesions [5]. However, the current at home bleaching systems use carbamide peroxide diluted to a 10% concentration [6]. This concentr-ation appears to be a safe and effective concentration at which the bleaching of the enamel can be achieved, and has been recommended by American Dental Association's (ADA) [7]. However, most dentists prefer to use carbamide peroxide in a 15% concentra-ction [8].

Although prerestorative carbamide peroxide bleaching is gaining popularity, its effect on the bond strength of the composite has been inconclusive [9]. Clinicians are obviously interested in determining whether any changes in the enamel surface also result in alteration of its adhesive characteristics to restorative bonding materials [5]. There have been reports regarding the interaction between bleaching agents and bond strength of the composite materials to the enamel. Some authors have reported a severe decrease in the average bond strength of the composite to the bleached enamel as compared with the unbleached one [10-16]. However, others have indicated means to counteract the adverse bleaching effects so that there were no statistical differences between the bleached and unbleached groups [17-20]. On the other hand, some studies reported a significant decrease in the bond strength only when the composite was bonded immediately after completion of bleaching [8,21]. Various rationales have been proposed to reconcile these observations. Some studies have examined physical alterations after bleaching as a possible explanation for the changes in bond strength [9]. Several authors have reported a poor bonding surface due to changes in the enamel structure resulting from loss of mineral content, or increased porosity as manifested by an "over etch" appearance with loss of prismatic form [12,18]. Some authors have suggested that the adverse effects of bleaching on bonding are caused by residual oxygen that inhibits resin polymerization [22-23], but roughening the surface eliminates this adverse effect [24]. Dishman *et al* discussed that the quality of the composite bond is compromised due to a decrease in the number of resin tags, suggesting that there may be some kind of polymerization inhibition taking place [21].

Another research proposed that such inhibition can result from bleaching agents that cause oxygen to penetrate and concentrate on the surface of the enamel, thus inhibiting the cure of some resin tags [17]. In this research, it was suggested that the application of an alcohol-based bonding agent may have been able to minimize the inhibitory effects of the bleaching process by the interaction of alcohol with residual oxygen [17]. Moreover, Sung *et al*, in their research explained that the use of alcohol-based bonding agents may result in less compromised composite bond strength when restorative work is to be completed immediately after bleaching [9]. However, some investigations supported the idea that acetone-based bonding agents are more affective in adhesion after enamel bleaching [25-28]. Perdigao *et al* suggest that bleaching with 10% carbamide peroxide gel is not able to change the oxygen concentration in the surface of the enamel significantly but it induces changes in the ultramorphology of the enamel resin bonded interface [29]. With all reported interactions that affect the bond strength of the bleached enamel, the question is raised as to whether the newer dental bonding agents may overcome the detrimental effects of bleaching on the enamel. The purpose of this in-vitro study was to evaluate the effect of bleaching with 15% carbamide peroxide, 24 hours before bonding, on the shear bond strength of the composite to the enamel bonded with a three step total etch and two simplified all-in-one adhesive systems.

Materials and Methods

Seventy two freshly extracted caries-free intact human permanent molar teeth were used. The teeth were stored in thymol-saturated isotonic saline at 4°C to inhibit microbial growth, and used within two month following the extraction. Each tooth had at least one relatively flat surface (buccal or lingual) selected for bonding. Thirty six teeth were used as the control and 36 as the experiment ones. The selected surface of each tooth was then ground using diamond wheel type bur (D&Z, Germany) until a flat enamel surface, a minimum of 5-mm in diameter, was achieved. After this step, the teeth were washed with water and randomly assigned to 6 groups of 12 specimens, 3 control and 3 experimental groups for a total of 72 surfaces.

The experimental groups were subjected to a bleaching regimen with a 15% carbamide peroxide bleaching system (Opalescence, Ultradent Product Inc, USA) of one application per day at 6 hours for 5 consecutive days. Bleach was applied, using custom trays fabricated for each tooth specimen.After each bleaching, the samples were washed under tap water for 30 seconds. All the specimens were stored in saline (Baxter 0.9%, NaCl irrigation solution) at 37°C except during bleaching, while they were placed in humidor (Behdad iran, Iran) at 25 °C. On completion of bleaching, all the specimens were stored in saline at 37 °C for 24 hours before composite bonding was initiated. The control groups were not bleached and were stored under identical conditions as the experimental groups for 24 hours. Before composite bonding, three dental bonding agents (Table 1) were used in all the specimens, with the following groups: 1) Scotchbond Multi-Purpose a) without bleaching (Control). b) With 15% carbamide peroxide bleaching (experiment), 2) Prompt L-Pop a) without bleaching (control). b) With 15% carbamide peroxide bleaching (experiment), 3) i bond a) without bleaching (control). b) With 15% carbamide peroxide bleaching (experiment)

All the bonding agents were applied based on the manufacturers' instructions (Table 2). Translucent plastic cylinders with the inner diameter of 3mm were then filled with the length of 5-mm composite light cure resin (Filtek Z_{100}, 3M, USA), and bonded to the enamel surfaces. Each cylindrical composite specimen was cured with a curing light (Coltolux 2.5, Colten/Whaldent, USA) for a total of 100 seconds (20 seconds from each direction of occlusal, apical, left, right and top of the cylinder) while moving the light to ensure curing of the entire cylinder. The excess composite was removed with a number 11 scalpel under a×56 stereomicroscope (Russian MBC -10) 48 hours after curing. After bonding was completed, all the specimens were subjected to 500 cycles of thermocycling between 5°C and 55°C water baths, with a dwell time of 20 seconds. After thermocycling, all the specimens were placed in a humidor at 37°C for 24 hours and then shear bond strength was determined with a universal testing machine (Dartec, Series TCIO, England), using a knife–edged loading head at a crosshead speed of 1mm/min. All the specimens were loaded continuously until fracture, and the results were statistically analyzed by one-way analysis of variance (ANOVA) and Duncan test at a significance level of $P<0.05$.

Table 1 Materials used in the study

Product Name	Manufacturer	Composition
Scotchbond Multi-Purpose	3M, St.Paul MN, USA	35% Phosphoric acid, HEMA; Polyalkenoic acid, Copolymer; Water, Bis-GMA; TEGDMA
Prompt L-Pop	3M, ESPE, USA	Water, 4-META, Phosphoric acid, Stabilizer, Fluoride complex with Zinc, Parabenes
i-bond	Heraeus Kulzer, Hanau,Germany	Water;Acetone;4META;Diurethan Dimethacrylate; 2-Hydroxyethyl Methacrylate;2-(n-Butoxy)Ethlyl-4-Dimethylamino Benzoat;2,3-Bornan dion butyl-hydroxy-touol; Glutaraldehyde
Opalescence15%	Ultradent, Products, Inc, South Jordan, UT, USA	15%Carbamide peroxide,Potassium nitrate 0.5% glycerin, carboxypolymethylene,Flouride ion0.11%.
Filtek Z100 composite	3M, St.Paul, USA	Silica , zyrconium (66%, 0.01-3.5µm)

Abbreviations: Bis-GMA: Bisphenol-glycidyl methacrylate; HEMA: 2-hydroxy ethyl methacrylate; TEGDMA: Triethylene glycol dimethacrylate; 4-META:Tetra-methacryloxy ethylpyrophosphate.

Table 2 Dental bonding agents' application protocol

Scotchbond Multi-Purpose:	•Apply 35% phosphoric acid and rub for 15 seconds for enamel etching. •Wash the etched surface for 15 seconds with water syringe. •Dry the surface with an air syringe for 2 seconds. •Apply primer with a brush and dry for 5 seconds. •Apply the adhesive and cure for 10 seconds.
Prompt L-Pop:	• Mix the contents of each stick and apply in 2 layers. • Dry and thin the layers for 5 seconds. • Cure for 15 seconds (optional).
i bond:	• Apply three consecutive layers of i bond and massage for 30 seconds. • Dry gently until no more liquid movements are visible. • Continue drying for more 5-10 seconds. • Cure for 20 seconds.

Results

Shear bond strengths in MPa (Mean±SD) for the groups are shown in Table 3 and Figure1. One-way ANOVA indicated a statistically significant difference among the shear bond strength values of three adhesive systems to the unbleached enamel (P<0.001). However, the adhesives showed no significant differences when applied to the bleached enamel (P=0.08). Duncan test showed statistically significant lower shear bond strengths for i bond and Prompt L-Prompt to the unbleached enamel as compared with Scotchbond Multi-Purpose (P<0.001). But this difference between i bond and Prompt L-Pop was not significant (P>0.05).

For each adhesive system, Duncan test showed a statistically significant difference between the mean shear bond strength values of the experimental and control groups (Table 3). In other words, bleaching could reduce the shear bond strength of the composite to the enamel bonded with the adhesives used in this study.

Table 3 Shear bond strengths (MPa) of the control and experimental groups.

P. value	Mean ±SD	Group	Adhesive system
Scotchbond Multi-Purpose	19.52±5.21	Control	P< 0.001
	7.95±4.16	Experiment	
Prompt L-Pop	9.66±2.89	Control	P< 0.001
	5.39±0.66	Experiment	
i bond	11.46±4.31	Control	P=0.002
	6.41±2.01	Experiment	

SD=Standard Deviation

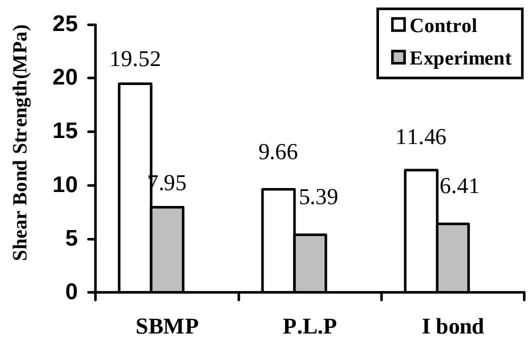

Figure 1 Mean values of shear bond strengths (MPa) of Scotchbond Multi-Purpose (SBMP), Prompt L-Pop (PLP), and i bond.

Discussion

Increasing demands for more esthetic teeth has lead to production and introduction of a great variety of tooth colored restorative materials, adhesive agents and whitening systems. Nowadays, various whitening systems [3-4] and new generations and trends of adhesive agents are available in the markets [24, 30-35].

Clinical and experimental experiences with enamel bondings have proved a reliable bond between the enamel and composite resins [36]. However, recent developments in adhesives and esthetic dentistry, such as introduction of all-in-one dentin/enamel bonding systems and at home bleaching techniques, have changed some of the primary concepts of enamel bonding.

Bond strength of the composite to the unbleached enamel in our study was higher for Scotchbond Multi-Purpose compared with Prompt L-Pop and i bond. Probably, one of the main causes of this finding, being similar to the results of Myazaki's research [37], is the effect of thermal cycles on the bonds of newer simplified systems such as Prompt L-Pop and i bond.

According to the results of this study, bleaching could reduce the shear bond strengths of the composite to the enamel bonded with each one of the three above-mentioned adhesive systems. Several studies have shown that hydrogen peroxide–and carbamide peroxide-based bleaching agents adversely affect the immediate bond strength of resins to the enamel [10-11,38-40]. There are several factors that affect the bond strength of the composite to the enamel after bleaching. Some authors have reported that residual oxygen after carbamide peroxide bleaching and its effect on polymerization of resin tags is the cause of decrease in the bond strength [17]. Several studies have shown an increase in the bond strength after treating the bleached enamel surface with an antioxidant such as sodium ascorbate [16, 41-43].

Some studies have explained that changes in the structure and composition of the enamel after bleaching is responsible for the decrease in the bond strength [12, 18]. It has been reported that while the unbleached teeth show a continuous interface between the resin and enamel, bleached teeth show sparse contact between the resin and enamel and the resin is poorly infiltrated into the enamel surface. It has been concluded that morphologic changes in human enamel, 24 hours after bleaching, are associated with a reduction in the shear bond strength of adhesives [15].

Scanning electron microscopic examination of the fractured specimens in one study indicated that the peroxide-induced reduction in bond strength is related to alterations in the both attachment-surface area at the resin-enamel interface and resin quality [44]. Some authors believe that the type of adhesive can affect the bond strength. Sung *et al* suggested that alcohol-based bonding agents may result in less compromised bond strength immediately after bleaching [9]; however, some studies have explained that acetone-based bleaching agents are more effective [25-28]. But according to some other studies, shear bond strength dos not differ between the acetone-based or ethanol-based adhesives [15, 45-46].

Based on the findings of the current study and previous ones, one or more of the above- mentioned reasons could decrease the bond strength of the composite to the bleached enamel. Considering that in present study bonding agents were applied 24 hours after bleaching, it is reasonable to assume that the suboptimal resin tag formation because of residual oxygen after bleaching is one of the major causes of decreasing shear bond strengths.

Conclusions

Under the circumstances of this study, it was found that:

1. The three-step total etch adhesive (Scotchbond Multi-Purpose) revealed more shear bond strength to the unbleached enamel as compared with two simplified all-in-one adhesive systems (Prompt L Pop, and i bond). However, for the bleached enamel the differences were not significant.

2. Bleaching with 15% carbamide peroxide 24 hours before bonding reduced the shear bond strength to the enamel when either a three-step total etch adhesive agent or simplified all-in-one adhesive agents were used.

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