

Effect of sodium ascorbate and delayed treatment on the shear bond strength of composite resin to enamel following bleaching

C Türkmen, N Gülerüz¹, PY Atalı

Department of Restorative Dentistry, Marmara University Faculty of Dentistry, Istanbul, Turkey, ¹Private Practise, Istanbul, Turkey

Abstract

Background: The effect of bleaching on enamel surfaces, as well as exploring methods of preventing the weakening of bond strength of two different adhesives to bleached enamel surfaces.

Objective: This study compared the shear bond strength (SBS) of two different adhesives on bleached enamel immediately after bleaching, with a 1-week delay, and following application of an antioxidizing agent after bleaching.

Materials and Methods: The enamel surfaces of 140 incisors were divided into 14 groups. Two unbleached enamel groups ($n = 20$) were prepared as negative controls of the Adper Single Bond 2 total-etch and Clearfil Tri S Bond self-etch adhesives. The remaining surfaces were randomly divided into two bleaching groups treated with 35% Beyond Max ($n = 60$) and 38% Opalescence Xtra Boost ($n = 60$). Each bleaching group was then divided into two subgroups using the total and self-etch adhesive systems. Specimens were bonded immediately after bleaching, after treatment with 10% sodium ascorbate (SA) gel, or after 1-week of immersion in artificial saliva. All groups were restored with composite resin. After thermocycling, SBS was measured and data were analyzed.

Results: In the control groups, there was no statistically-significant difference in SBS between self-and total-etch adhesives. Among all bleaching groups, no statistically-significant differences in SBS were noted, although the SA-treated delayed bonding (1-week) groups had the highest values. The lowest values were noted for the groups bonded immediately after bleaching.

Key words: Antioxidant effect, bleaching agents, dental adhesives, dental enamel, shear bond strength

Date of Acceptance: 14-Apr-2015

Introduction

The esthetics of anterior teeth is an important consideration in contemporary dental practice. Vital bleaching procedures are considered to be one of the most conservative treatments, since they do not need any reduction in tooth structure.^[1-3] Usually, peroxide components are used for tooth bleaching, the most common compounds being hydrogen peroxide (HP), carbamide peroxide (CP), and sodium perborate.^[1-5]

Several techniques have been suggested to compensate for decreased bond strength subsequent to bleaching, including

delayed bonding or a waiting period of 1-day up to 3-weeks, which is the most common and easiest procedure; removal of surface enamel; use of acetone-containing adhesives; use of alcohol on tooth surfaces; and use of antioxidants such as gel or solution forms of sodium ascorbate (SA).^[6-8]

In recent years, SA has been used as an antioxidant to compensate for compromised bond strength subsequent to tooth bleaching. According to the results of a study carried out by Yiu *et al.*,^[9] use of SA significantly compensates for

Address for correspondence:

Dr. PY Atalı,
Department of Restorative Dentistry, Marmara University
Faculty of Dentistry, Büyük Çiftlik Sokak No: 6 Nişantaşı, Şişli,
34365, Istanbul, Turkey.
E-mail: pinar.atali@marmara.edu.tr

Access this article online

Quick Response Code:



Website: www.njcponline.com

DOI: 10.4103/1119-3077.164328

PMID: 26755225

Table 1: Materials used in the study and their mode of application according to the manufacturer's instructions

Material name and manufacturer	Material composition	Manufacturers' directions
CTSB (all in one, self-etch adhesive) (Kuraray, Japan)	MDP, Bis-GMA, HEMA, hydrophobic dimethacrylate, di-CQ, ethanol, colloidal silica, water	Apply the adhesive and rub for 20 s, dry for 5 s diligently Light cure for 10 s
ASB 2 (one bottle, total-etch adhesive) (3M ESPE, USA)	Etchant: 37% H ₃ PO ₄ Adhesive: Bis-GMA, HEMA, diurethan dimethacrylate, silica nanofiller, 1,3 dimethacrylate, ethanol, acrylic acid copolymer, itaconic acid, glycerol, water	Etch with 37% phosphoric acid (15 s) Rinse for 10 s and dry 5 s Apply adhesive in a uniform thin layer and dry 5 s diligently Light cure for 10 s
Clearfil majesty esthetics nano-superfilled composite (Kuraray, Japan)	Bis-GMA, TEGDMA, silanized barium glass powder and colloidal silica, hydrophobic aromatic dimethacrylate, di-CQ	Applied in 2 mm layers. Each layer light cured for 40 s
BM™ (Beyond, China)	Hydrogen peroxide 35%	Light-activated bleaching gel for office bleaching, applied on the enamel surface for 3×20 min
OXB™ (Ultradent, USA)	Hydrogen peroxide 38%	Chemically activated bleaching gel for office bleaching, applied on the enamel surface for 3×20 min
Sodium ascorbate gel (Istanbul, Turkey)	Sodium-L (+) -ascorbate (C ₆ H ₇ NaO ₆ , M=187.11 g/mol). pH: 7.4	After preparing 10% hydrogel, the gel was applied on the enamel surface for 5 min (refreshed every 1 min) and then rinsed for 30 s
Beyond polus whitening accelerator unit (Beyond Nanchang, China)	220 Volt, λ: 480-520 nm, blue light	3×20 min on BM 35% HP bleaching gel
LED light-curing unit (Art, Denmark)	Power: 1000 mW/cm ² λ: 45-470 nm	Curing 10 s for bonding and 40 s for composite

Bis-GMA=Bisphenol a diglycidyl methacrylate; CQ=Camphoroquinone; HEMA=2-hydroxyethyl methacrylate; MDP=Methacryloxydecyl dihydrogen phosphate; TEGDMA=Triethylene glycol dimethacrylate; BM=Beyond Max; OXB=Opalescence® Xtra® Boost; ASB=Adper Single Bond; CTSB=Clearfil Tri S Bond

Table 2: Groups, treatment regimens and agents used in the experiment

Bleaching agent	Adhesive	Treatment regimen	Group (n: 10)
BM™	CTSB (one step, self-etch)	Immediately bonded	1
		After Na-ascorbate	2
		Artificial saliva/1-week	3
	ASB 2 (two step, total-etch)	Immediately bonded	4
		After Na-ascorbate	5
		Artificial saliva/1-week	6
OXB™	CTSB (one step, self-etch)	Immediately bonded	7
		After Na-ascorbate	8
		Artificial saliva/1-week	9
	ASB (two step, total-etch)	Immediately bonded	10
		After Na-ascorbate	11
		Artificial saliva/1-week	12

CTSB=Clearfil Tri S Bond; ASB=Adper Single Bond; BM=Beyond Max; OXB=Opalescence® Xtra® Boost

the decrease in the strength of bonding to dentin with Single Bond adhesive only; however, it is not effective when used with excite adhesive.

Some authors^[1,2,4,10] have advocated use of total-etch adhesives in preference to self-etching ones subsequent to at-home bleaching of dentin and SA application. A waiting time between the bleaching procedure and restorative treatment should be allowed to eliminate the residual oxygen from the dental substrate to return the condition that leads to normal bond strength.^[4,10] Nevertheless, the appropriate

postbleaching time interval is not well established for the office bleaching. Therefore, this *in vitro* study evaluated the potential of 10% SA as an antioxidizing agent to compensate for the decrease in enamel shear bond strength (SBS) with the application of total-and self-etch dental adhesive systems with nanofill composite resin compared with delayed bonding and restoration to office bleaching technique.

Materials and Methods

One hundred and sixty noncarious human maxillary central incisors, without cracks or developmental enamel defects, which had been extracted at most 6 months previously were used in the study. The teeth were stored at 37°C in buffered saline until required. One week before the experiment, all tooth surfaces were cleaned of any debris and soft tissues by ultrasound and immersed in 0.2% thymol solution for 24 h. Before the experiment the teeth were retrieved from thymol, rinsed and kept in distilled water at +4° until required, a period not exceeding 1-week. Teeth were examined under × 20 magnification (Leica Microsystems, Wetzlar, Germany) and those with structural defects such as fissures and defective grooves were discarded (n = 20). Roots were sectioned 1 mm below the cemento-enamel junction. Crowns were fixed in wax and mounted in cold-curing acrylic resin (Panacryl, Arma Dental Co., Istanbul, Turkey), oriented such that the buccal surfaces of the crowns were level with the acrylic and the horizon as much as possible. The specimens were randomly divided into 14 groups of 10 teeth each. The groups were treated as follows:

Table 3: Shear bond strength values (MPa) for the two adhesive systems after different studied procedures

Adhesive	Bleaching agent	Groups	Bond strength (mean ±SD)	P
CTSB (one-step, self-etch)	BM™	Control (nonbleached)	21.27 ± 4.43	0.001**
		Immediately bonded	12.29 ± 2.76	
		After Na-ascorbate	18.19 ± 3.49	
		Artificial saliva/1-week	20.54 ± 2.40	
	OXB™	Immediately bonded	9.87 ± 4.07	
		After Na-ascorbate	12.64 ± 3.03	
		Artificial saliva/1-week	19.02 ± 1.07	
		Control (nonbleached)	23.68 ± 3.20	
ASB (two step, total-etch)	BM™	Immediately bonded	11.18 ± 3.56	0.001**
		After Na-ascorbate	14.51 ± 1.97	
		Artificial saliva/1-week	20.14 ± 3.63	
		Control (nonbleached)	23.68 ± 3.20	
	OXB™	Immediately bonded	8.82 ± 2.55	
		After Na-ascorbate	11.30 ± 1.97	
		Artificial saliva/1-week	20.93 ± 3.82	
		Control (nonbleached)	23.68 ± 3.20	

**One-way ANOVA ($P < 0.01$). OXB=Opalescence® Xtra® Boost; BM=Beyond Max; SD=Standard deviation; ASB=Adper Single Bond; CTSB=Clearfil Tri S Bond

Table 4: Post-hoc Tukey HSD test results of the compared bleaching agent groups

Bleaching agent	Compared groups	Self-etch (P)	Total-etch (P)
BM™	Immediately bonded/after Na-ascorbate	0.001**	0.063
	Immediately bonded/artificial saliva (1-week)	0.001**	0.001**
	After Na-ascorbate/artificial saliva (1-week)	0.188	0.001**
OXB™	Immediately bonded/after Na-ascorbate	0.116	0.151
	Immediately bonded/artificial saliva (1-week)	0.001**	0.001**
	After Na-ascorbate/artificial saliva (1-week)	0.001**	0.001**

** $P < 0.01$. BM=Beyond Max; OXB=Opalescence® Xtra® boost; HSD=Honest significant difference

Table 5: Comparison of the bleaching agent groups bond strength values according to adhesive type

Bleaching agent	Groups	Bond strength		P
		Mean ±SD		
		Self-etch	Total-etch	
BM™	Immediately bonded	12.29 ± 2.76	11.18 ± 3.56	0.445
	After Na-ascorbate	18.19 ± 3.49	14.51 ± 1.97	0.011*
	Artific. saliva (1-week)	20.54 ± 2.40	20.14 ± 3.63	0.771
OXB™	Immediately bonded	9.87 ± 4.07	8.82 ± 2.55	0.498
	After Na-ascorbate	12.64 ± 3.03	11.30 ± 1.97	0.258
	Artific. saliva (1-week)	19.02 ± 1.07	20.93 ± 3.82	0.158
	Control	21.27 ± 4.43	23.68 ± 3.20	0.180

Student's *t*-test * $P < 0.05$. BM=Beyond Max; SD=Standard deviation; OXB=Opalescence® Xtra® Boost

Negative control groups

The enamel surfaces were slightly roughened with a coarse diamond burr under water spray. Clearfil Majesty Esthetic anterior composite resin was bonded to the surfaces using a Teflon matrix (4 × 4 × 4) with the one-step self-etch adhesive system Clearfil Tri S Bond (CTSB, $n = 10$) and the two-step total-etch system Adper Single Bond 2 (ASB, $n = 10$) according to the manufacturer's instructions [Table 1].

Bleaching treatment groups (1–12)

In groups 1–6, light activated with a Beyond Polus [Table 1] whitening accelerator unit (Beyond Technology Corp., Nanchang, China), used with 35% HP Beyond Max™

gel (BM; Beyond Technology Corp.) or in groups 7–12, chemically-activated 38% HP gel Opalescence® Xtra® Boost™ (OXB; Ultradent Products, Inc., South Jordan, UT), were placed in direct contact with the enamel surfaces. These two bleaching groups were then divided into two subgroups for the application of total (ASB) and self-etch (CTSB) adhesive systems. Next, each bleaching group was divided into three subgroups of 10 specimens each. Groups 1, 4, 7, and 10 consisted of specimens bonded immediately after bleaching. Specimens in groups 2, 5, 8, and 11 were treated with the antioxidant, 10% SA, while specimens in groups 3, 6, 9, and 12 were immersed in artificial saliva for 1-week after bleaching [Table 2].

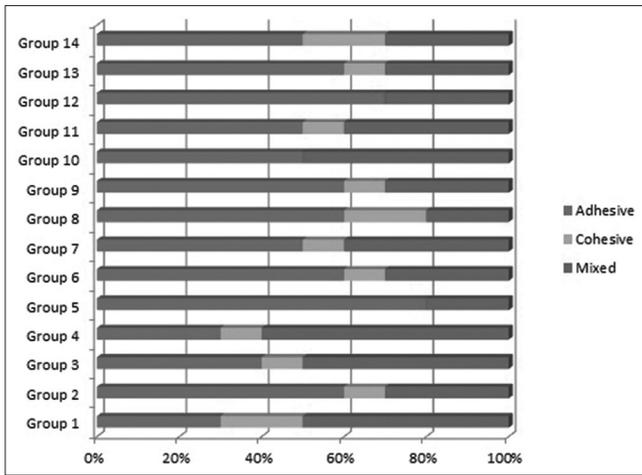


Figure 1: Range of failure types (%)

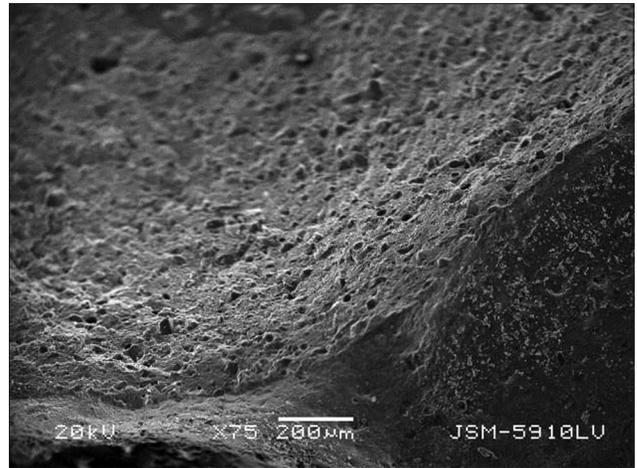


Figure 2: A cohesive failure pattern on an enamel specimen from the self-etch control group. The surface appeared uniform and pore free

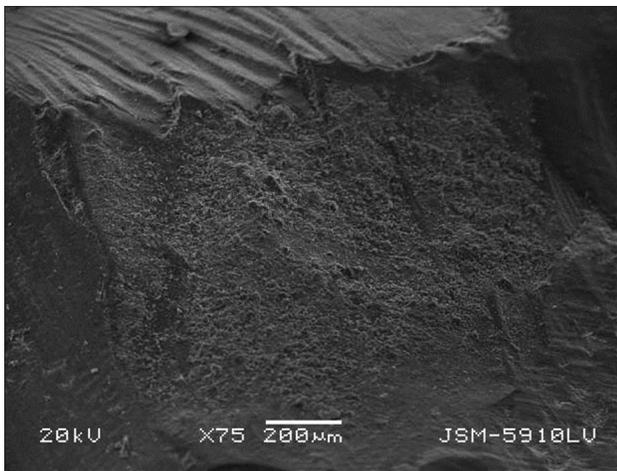


Figure 3: A cohesive failure pattern on an enamel specimen from the total-etch control group. The surface appeared uniform and pore free

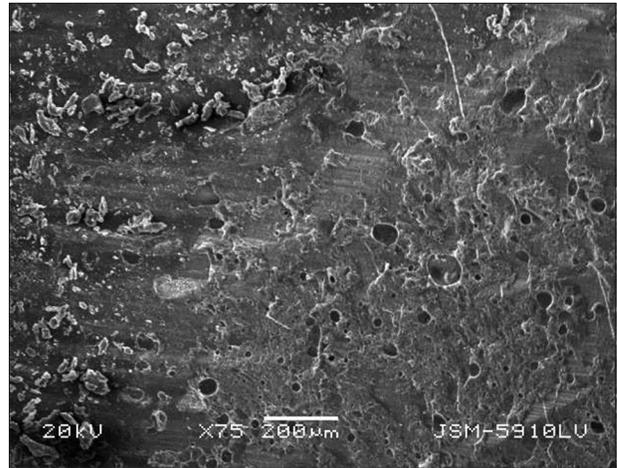


Figure 4: An adhesive failure pattern of group 2 (BM bleaching + Na-ascorbate). The surface appeared granular and porous

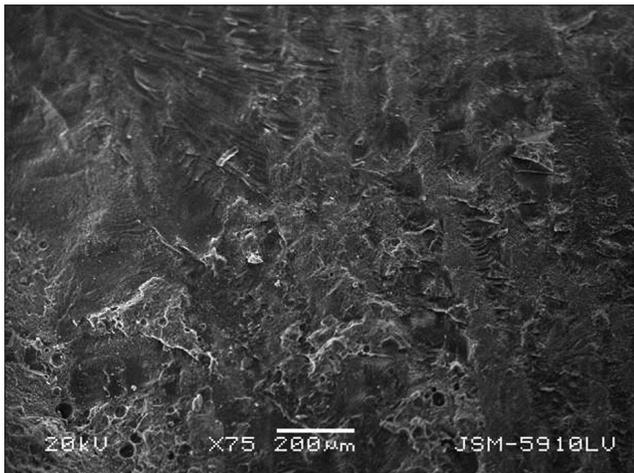


Figure 5: A mixed failure pattern on an enamel surface from group 4 (BM bleaching + immediate total-etch bonding). The surface exhibited a typical etched enamel pattern

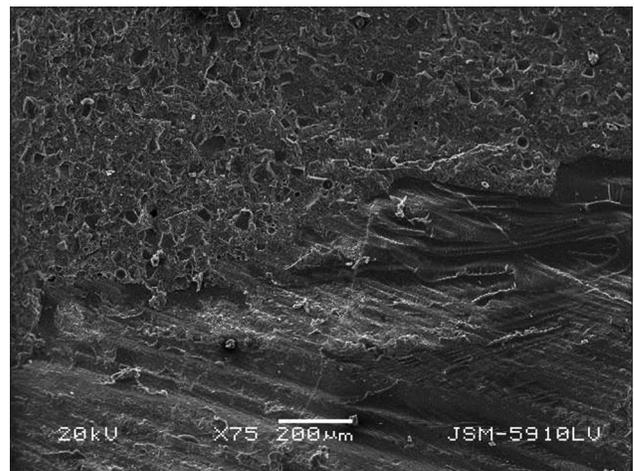


Figure 6: A mixed failure pattern on an enamel surface from group 9 (OXB bleaching + artificial saliva/1-week + self-etch bonding). The surface appears granular and porous

Table 6: Comparison of the adhesives and bleaching agents bond strength values

Adhesive and bleaching agent	Bond strength (mean±SD)	P
CTSB (one step, self-etch)	16.26±5.24	0.629
ASB (two step, total-etch)	15.80±6.11	
BM™	16.14±4.72	0.012*
OXB™	13.77±5.41	

Student's *t*-test **P*<0.05. OXB=Opalescence® Xtra® Boost; BM=Beyond Max; ASB=Adper Single Bond; CTSB=Clearfil Tri S Bond; SD=Standard deviation

Table 7: Types of failure (n:10)

Groups	Adhesive	Cohesive	Mixed
1	3	2	5
2	6	1	3
3	4	1	5
4	3	1	6
5	8	0	2
6	6	1	3
7	5	1	4
8	6	2	2
9	6	1	3
10	5	0	5
11	5	1	4
12	7	0	3
13 (control, self-etch)	6	1	3
14 (control, total-etch)	5	2	3

In the SA (pH: 7.4) groups (groups 2, 5, 8, and 11), 10% SA solution was applied to the enamel surfaces with a sponge pellet once per minute for 5 min. After antioxidant treatment, the enamel surface was thoroughly rinsed with distilled water for 30 s.

Artificial saliva (pH: 7), with an electrolyte composition similar to that of human saliva, was prepared from 1 g sodium carboxymethylcellulose, 4.3 g xylitol, 0.1 g potassium chloride, 0.1 g sodium chloride, 0.02 mg sodium fluoride, 5 mg magnesium chloride, 5 mg calcium chloride, 40 mg potassium phosphate, 1 mg potassium thiocyanate and 100 mL distilled deionized water. The artificial saliva was changed daily. After the specimens (groups 3, 6, 9, and 12) were removed from the artificial saliva, the enamel surfaces were rinsed with an air/water spray for 30 s.

For the bonding procedure, after application of the adhesives according to the manufacturer's instructions [Table 1], Teflon matrix molds were prepared, with a height of 4 mm and a diameter of 4 mm. The composite resin was added to the molds incrementally. Curing was carried out from the top for 40 s using an LED light-curing unit (ART L3, Bonart Co., LTD Marslev, Denmark) at a light intensity of 1000 mW/cm².

All the specimens then underwent a 10,000-cycle thermocycling procedure (Alpha Thermocycling, Istanbul,

Turkey) at 5/55°C with a dwell time of 30 s and a transfer time of 3 s.

Shear bond strength testing

All specimens were mounted and stressed at a shear rate of 0.5 mm/min using a universal testing machine (Zwick Z010, GmbH, Ulm, Germany) with a knife-edged loading head. The maximum load at failure was recorded and converted to megapascals (Mpa) ($SBS [Mpa] = F (N)/\pi r^2$).

Microscopic evaluation

The fractured surface of each specimen was analyzed under a stereomicroscope (Leica MZ 75, Microsystems Digital Inc., Cambridge, U.K.) at magnifications of ×35, ×50, and ×80 to evaluate the mode of failure (by author 1 and 2). Types of failure were classified into the following categories: adhesive failure (between enamel and bond/composite and bond); cohesive failure (within the enamel/resin composite) and mixed type (A combination of adhesive and cohesive failure).

Scanning electron microscopy observation

Following shearing and microscopic evaluation, two failure specimens of each group (total 28 specimens) were randomly selected for scanning electron microscopy (SEM). The surfaces were gold sputter coated (BioRad-SC502, Hemel Hempstead, U.K.) with a thickness of nearly 200 Å and observed under SEM (JEOL JSM-5200, Tokyo, Japan) at 20 kV. Enamel surfaces and some modes of failure were viewed and photographed usually at a magnification of ×75.

Statistical analysis

Statistical analysis was performed using Number Cruncher Statistical System (NCSS, 2007 and PASS 2008 Statistical Software System; NCSS Statistical Software, Kaysville, UT). Differences with *P* < 0.05 were considered as significant. Results were subjected to one-way analysis of variance and a *post-hoc* Tukey honest significant difference test for multiple comparisons. Student's *t*-test was also used for comparison of two-group data.

Results

Shear bond strengths in MPa (mean ± standard deviation) for the control and experimental groups under study are summarized in Table 3. Based on the results of the present study, the highest and lowest bond strength values were observed in the control group with CTSB adhesive and in group 10 (OXB immediately bonded with ASB adhesive), respectively. Except for the control groups, the highest SBS value was observed in group 12 (OXB + 1 week in artificial saliva) with ASB adhesive. There were statistically significant differences (*P* < 0.01) among the adhesive groups.

Post-hoc testing indicated differences between groups [Table 4]. In the BM groups, group 1 (immediately bonded with CTSB) showed significantly lower average bond strength than groups 2 (SA + CTSB) and 3 (artfc. saliva/1-week + CTSB) while group 6 (artfc. saliva/1-week + ASB) showed significantly higher strength averages than groups 5 (SA + ASB) and 4 (immediately bonded with ASB) ($P < 0.01$). In the OXB groups, groups 9 (artfc. saliva + CTSB) and 12 (artfc. saliva + ASB) showed significantly higher average bond strength than groups 7 (immediately bonded with CTSB), 10 (immediately bonded with ASB) 8 (SA + CTSB), and 11 (SA + ASB) ($P < 0.01$). No differences were observed between groups 2 and 3, 5 and 6, 7 and 8, and 10 and 11 ($P > 0.05$).

Student's *t*-test was used to identify significant differences between specific mean values [Tables 5 and 6]. In the BM groups, when the SA was applied after bleaching, the bond strength values for the self-etch adhesive group (group 2) were significantly higher than the total-etch adhesive group (group 5) ($P < 0.05$) while no differences were found between the two adhesive systems for the immediately-bonded specimens (groups 1–4) and those immersed in artificial saliva for 1-week (groups 3–6) ($P > 0.05$). Further, in the OXB groups, no differences were observed between the two adhesive system groups (groups 7 to 10, 8 to 11, and 9 to 12) for all three applications. When bleaching agents were compared, the average bond strength of the BM was significantly higher than that of the OXB ($P < 0.05$). However, when the adhesive systems including the control groups were compared, no differences were found ($P > 0.05$).

Analysis of the frequency and type of failure after the SBS test are shown in Figure 1 and Table 7. The highest failure rate was observed for the adhesive type (54%) following by the mixed (36%) and cohesive (10%, $n = 14$) types. According to the adhesive system, the failure types were observed as follows:

Self-etch (CTSB): Adhesive (51%) > mixed (36%) > cohesive (13%).

Total-etch (ASB): Adhesive (56%) > mixed (37%) > cohesive (7%).

Figures 2-6 present the results of SEM observation. The SEM photographs of the fractured specimens in the shear test revealed that all three types of failure were observed in the present study. Cohesive failures were usually observed in the control groups (self- and total-etch groups) [Figures 2 and 3]. In the SEM images of some experimental groups, adhesive (group 2; Figure 4) and mixed (groups 4 and 9; Figures 5 and 6, respectively) failures were observed. SEM photographs of the bleached enamel surfaces [Figures 4-6], especially in the SA group [Figure 4] exhibited a granular and porous

appearance while control groups appeared more uniform and pore-free [Figures 2 and 3].

Discussion

According to the results of the present study, the mean SBS of composite resin to bleached enamel decreased immediately after bleaching. Previous studies have reported a decrease in enamel bond strength after bleaching using the etch-and-rinse adhesives Single Bond and Prime and Bond NT [13], Optibond FL, and Optibond Solo Plus^[1,2] as well as the self-etching adhesives Clearfil SE Bond.^[4,11,12] The decrease has been attributed to the presence of residual oxygen, which inhibits the polymerization of resin free radicals,^[1,11,13,14] as well as to changes in the length and number of resin tags, and changes in the surface topography of the enamel.^[15] Other factors, including elimination of the nonfiber mineral content of the tooth structure, changes in the calcium, phosphorus, sulfur and potassium content of the tooth structure, and changes in the mineral and protein content of the enamel surface,^[1,2,4,8,16] have been postulated as causes for the decrease in bond strength after bleaching.

Previous studies suggested that the subsurface enamel organic matrix could be altered by the oxidizing effect of HP.^[17,18] According to a study by Lai *et al.*,^[7] it is possible that these are not permanent structural alterations, but reversible changes in the redox potential of organic components. CP is a strong oxidizing agent and therefore easily denatures proteins. Urea, as a metabolite of CP, is capable of attacking protein structures and penetrating into the enamel, affecting the surface and the interprismatic regions. Thus, these changes in mechanical properties may be responsible for alterations in the superficial bleached enamel crystallites and the ultrastructure of resin – enamel interfaces.^[19] Furthermore, residual oxygen from a bleaching agent inhibits resin polymerization.

In the present study, CTSB, which is a one-step self-etching adhesive, demonstrated the highest bond strength compared with etch-and-rinse adhesive (ASB), which is not consistent with the claims of the manufacturer; however, these claims have also contrasted with the results of other studies.^[1,5,20] The differences between these two adhesives were significant. Apart from the control groups, the highest SBS values were observed in group 12 (OXB + 1-week in artificial saliva) with ASB adhesive. A previous study^[10] reported a significant decrease in bond strength of the self-etching CTSB adhesive to bleached enamel; however, for the single bond etch-and-rinse system this decrease was not significant. The discrepancies in the results have been attributed to the greater tendency of self-etching primers to be inhibited by CP.^[10] Self-etching primers contain acidic resin monomers which simultaneously etch the enamel surface and penetrate it. Considering the acidity

of CTSB (pH: 2.5) it seems its weaker etching potential compared to phosphoric acid (pH: 0.6) results in a weaker bond strength in the unbleached state and subsequent to bleaching procedures.

Enamel removal can also restore bonding strengths to their normal levels. Barghi and Godwin^[21] 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 acetone. This has led others to recommend the use of alcohol-based bonding agents, particularly when restorative work is performed immediately after bleaching.^[5] The adhesive systems used in the present study were ethanol-and water-based bonding agents. Spyrides *et al.*^[22] demonstrated that adhesives containing ethanol and water reversed the reduction in bond strength in 10% CP-treated dentin. In another study using an alcohol-based adhesive, there was no difference between bleached and unbleached enamel in terms of bond strength, and use of an alcohol-based bonding agent made application of the resin composite possible immediately after the bleaching process. Ethanol is known to increase the bond strength of enamel by decreasing surface water.^[5,23]

Ascorbic acid and its salts are well-known antioxidants and are capable of reducing a variety of oxidative compounds, especially free radicals.^[4,8,13] Previous studies have demonstrated the potential protective effect of ascorbic acid *in vivo* against HP-induced damage in biological systems.^[1,2,4,8,13,24] In the present study, treatment of the bleached enamel with 10% SA before bonding was not effective in restoring the reduced SBS of composite resin to enamel for two concentrations of HP. These results concur with those of Tabatabaei *et al.*^[13] who have shown that the reduced bond strength of composite resin to bleached enamel was not effectively reversed by 10% SA treatment for 5 or 10 min. In contrast, Türkün and Kaya^[4] and Muraguchi *et al.*^[8] concluded that treatment of the bleached enamel surface with 10% SA reverses the reduced bond strength and might be an alternative to delayed bonding, especially when restoration is to be completed immediately after bleaching.

Scanning electron microscopy photographs of bleached specimens treated with ascorbic acid revealed the enamel surface being etched free of a surface smear layer. This was probably due to the high acidity of the 10% SA used in this study. It is likely that ascorbic acid was effective in maintaining the bond strength of the resin material not only by reducing the residual oxygen, but also by etching the tooth surface.

In the present study, the ascorbic acid-treated specimens usually showed adhesive failure, indicating that this treatment was ineffective in enhancing bond strength.

This result disproves the hypothesis that the application of ascorbic acid to bleached surfaces provides adhesives with bond strengths equivalent to those of nonbleached surfaces. However, it seems that various bonding agents yield heterogeneous results regarding the strength of bonding to dental tissues immediately after bleaching, in delayed bonding or after application of an antioxidant; therefore, further studies are required to establish proper treatment modalities for clinical applications.

Conclusions

It can be concluded that the bleaching of enamel results in reduced bond strength of composite resin to enamel; however, different adhesives demonstrate varying degrees of strength reduction. In general, the use of etch-and-rinse adhesives after bleaching results in a higher bond strength compared to self-etching adhesives. Furthermore, application of a 10% ascorbic acid solution for 5 min to the bleached enamel surface was not very effective in preventing the reduction in the ability to bond to bleached enamel. A delay of 1-week after bleaching was enough to restore bond strength to initial levels in total-and self-etching adhesives.

The chemical composition of the adhesives appears to be an important factor in compensating for the reduction in bond strength after bleaching. More studies are required on various bonding systems.

References

1. Khoroushi M, Aghelinejad S. Effect of postbleaching application of an antioxidant on enamel bond strength of three different adhesives. *Med Oral Patol Oral Cir Bucal* 2011;16:e990-6.
2. Khoroushi M, Saneie T. Post-bleaching application of an antioxidant on dentin bond strength of three dental adhesives. *Dent Res J (Isfahan)* 2012;9:46-53.
3. Souza-Gabriel AE, Vitussi LO, Milani C, Alfredo E, Messias DC, Silva-Sousa YT. Effect of bleaching protocols with 38% hydrogen peroxide and post-bleaching times on dentin bond strength. *Braz Dent J* 2011;22:317-21.
4. Türkün M, Kaya AD. Effect of 10% sodium ascorbate on the shear bond strength of composite resin to bleached bovine enamel. *J Oral Rehabil* 2004;31:1184-91.
5. Dabas D, Patil AC, Uppin VM. Evaluation of the effect of concentration and duration of application of sodium ascorbate hydrogel on the bond strength of composite resin to bleached enamel. *J Conserv Dent* 2011;14:356-60.
6. Kimyai S, Valizadeh H. The effect of hydrogel and solution of sodium ascorbate on bond strength in bleached enamel. *Oper Dent* 2006;31:496-9.
7. Lai SC, Tay FR, Cheung GS, Mak YF, Carvalho RM, Wei SH, *et al.* Reversal of compromised bonding in bleached enamel. *J Dent Res* 2002;81:477-81.
8. Muraguchi K, Shigenobu S, Suzuki S, Tanaka T. Improvement of bonding to bleached bovine tooth surfaces by ascorbic acid treatment. *Dent Mater J* 2007;26:875-81.
9. Yiu CK, Garcia-Godoy F, Tay FR, Pashley DH, Imazato S, King NM, *et al.* A nanoleakage perspective on bonding to oxidized dentin. *J Dent Res* 2002;81:628-32.
10. Moule CA, Angelis F, Kim GH, Le S, Malipatil S, Foo MS, *et al.* Resin bonding using an all-etch or self-etch adhesive to enamel after carbamide peroxide and/or CPP-ACP treatment. *Aust Dent J* 2007;52:133-7.
11. Unlu N, Cobankara FK, Ozer F. Effect of elapsed time following bleaching on

- the shear bond strength of composite resin to enamel. *J Biomed Mater Res B Appl Biomater* 2008;84:363-8.
12. Türkün M, Celik EU, Kaya AD, Arici M. Can the hydrogel form of sodium ascorbate be used to reverse compromised bond strength after bleaching? *J Adhes Dent* 2009;11:35-40.
 13. Tabatabaei HM, Arami S, Nojournian A, Mirzaei M. Antioxidant effect on the shear bond strength of composite to bleached bovine dentin. *Braz J Oral Sci* 2011;10:33-6.
 14. Nour El-din AK, Miller BH, Griggs JA, Wakefield C. Immediate bonding to bleached enamel. *Oper Dent* 2006;31:106-14.
 15. Josey AL, Meyers IA, Romaniuk K, Symons AL. The effect of a vital bleaching technique on enamel surface morphology and the bonding of composite resin to enamel. *J Oral Rehabil* 1996;23:244-50.
 16. Joiner A. Review of the effects of peroxide on enamel and dentine properties. *J Dent* 2007;35:889-96.
 17. Seghi RR, Denry I. Effects of external bleaching on indentation and abrasion characteristics of human enamel *in vitro*. *J Dent Res* 1992;71:1340-4.
 18. Hegedüs C, Bistey T, Flóra-Nagy E, Keszthelyi G, Jenei A. An atomic force microscopy study on the effect of bleaching agents on enamel surface. *J Dent* 1999;27:509-15.
 19. Perdigão J, Francci C, Swift EJ Jr, Ambrose WW, Lopes M. Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. *Am J Dent* 1998;11:291-301.
 20. Swift EJ Jr. Critical appraisal. Options for dentin/enamel bonding: Part I. *J Esthet Restor Dent* 2010;22:72-7.
 21. Barghi N, Godwin JM. Reducing the adverse effect of bleaching on composite-enamel bond. *J Esthet Dent* 1994;6:157-61.
 22. Spyrides GM, Perdigão J, Pagani C, Araújo MA, Spyrides SM. Effect of whitening agents on dentin bonding. *J Esthet Dent* 2000;12:264-70.
 23. Kalili KT, Caputo AA, Yoshida K. Effect of alcohol pretreatment on composite bond strength to bleached enamel. *J Dent Res* 1993;72:283.
 24. Brennan LA, Morris GM, Wasson GR, Hannigan BM, Barnett YA. The effect of vitamin C or vitamin E supplementation on basal and H₂O₂-induced DNA damage in human lymphocytes. *Br J Nutr* 2000;84:195-202.

How to cite this article: Türkmen C, Gülerüz N, Atalı PY. Effect of sodium ascorbate and delayed treatment on the shear bond strength of composite resin to enamel following bleaching. *Niger J Clin Pract* 2016;19:91-8.

Source of Support: Nil, **Conflict of Interest:** None declared.