Effect of different antioxidants on shear bond strength of office-bleached enamel to composite

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Abstract

Objectives: This study aimed to assess the effect of different antioxidants on shear bond strength (SBS) of office-bleached enamel to composite.

Materials and Methods: This in vitro, experimental study evaluated 66 extracted teeth in six groups. The teeth in group 1 were restored with composite only. In group 2, the teeth were restored with composite immediately after office bleaching (OB). In group 3, the teeth were restored with composite 2 weeks after OB. In group 4, sodium ascorbate (SA) was applied on the teeth immediately after OB, and then they were restored with composite. In group 5, ascorbic acid (AA) was applied on the teeth immediately after OB, and they were then restored with composite. In group 6, vitamin C was applied on the teeth immediately after OB, and they were then restored with composite. The SBS of enamel to composite was measured by a universal testing machine and compared by one-way ANOVA and bonferroni post hoc test .

Results: One-way ANOVA showed a significant difference in SBS of the groups ($P<0.05$). The maximum SBS was noted in group 1 and the minimum SBS was recorded in group 2. Groups 3 and 4 were not significantly different regarding the SBS ($P>0.05$).

Conclusion: Composite restoration of teeth immediately after bleaching results in lower SBS. Antioxidants can compensate for this reduction. SA is the best option for this purpose. If not available, AA or vitamin C can be used as an alternative to SA for this purpose.

Keywords: Antioxidants; Ascorbic Acid; Shear Strength; Tooth Bleaching

Introduction

Shape, color, and leveling and alignment of teeth, especially in the esthetic zone, significantly affect the appearance, and consequently the personality of individuals [1]. By an increased demand for dental esthetics, tooth bleaching has gained increasing popularity as a conservative approach. Different bleaching agents with different concentrations have been used to achieve the desired outcome [2]. Tooth bleaching is performed for correction of tooth discolorations and also to improve the satisfaction of patients with their smile esthetics. Although smile attractiveness depends on a number of factors such as the shape, position, leveling and alignment of teeth, tooth color also plays a major role in this regard. Whiter teeth are more attractive and imply a healthy mouth [2].

Tooth bleaching can be performed by dental clinicians in dental offices, which is referred to as office bleaching (OB), or by patients at home, known as home bleaching (HB). In HB, patients use a tray and bleaching agents for a couple of hours on a daily basis for a limited period of time to lighten the shade of their teeth. OB is often performed by using high concentrations of hydrogen peroxide, which is highly effective for correction of tooth discolorations. Dental

clinicians precisely monitor the process of OB and can discontinue the treatment at any time [3]. In addition to the fact that OB is a precisely monitored procedure, soft tissue is well protected during OB, and this modality brings about favorable results in a short period of time [4]. The bleaching agents commonly used in OB include high-concentration carbamide peroxide (35% to 37%) and hydrogen peroxide (30% to 35%). Low-concentration carbamide peroxide and hydrogen peroxide are used for HB [3].

Composite restorations are commonly used for restoration of anterior teeth. However, if the anterior teeth are scheduled to undergo bleaching after composite restoration, color mismatch may occur between the restored and non-restored parts of the teeth, necessitating restoration replacement. Although some authors reported no change in color of composite restorations after bleaching with carbamide peroxide, composite restorations should still be replaced since bleaching can increase the microleakage of such restorations [4].

The mechanism of action of bleaching agents is based on generation of oxidizing agents such as oxygen and free oxygen radicals that penetrate through the enamel into dentin [5]. Investigations on debonded tooth specimens have shown entrapped residual oxygen molecules in the tooth structure, preventing complete penetration of resin into dentinal tubules and optimal formation of resin tags [6]. A previous study demonstrated that the bleaching agents used for OB or HB significantly compromised the bond strength of composite to enamel when bonding was performed immediately after the bleaching procedure [3].

Evidence shows that the residual oxygen is eliminated after a certain period of time, and resin can optimally bond to the bleached enamel. Accordingly, the optimal interval between the bleaching and bonding procedures is reported to be 24 hours to 4 weeks [7]. However, such long intervals are not often favored by patients requiring immediate esthetic treatments [1].

Several methods have been proposed to overcome this problem such as elimination of superficial enamel, treatment of bleached enamel with alcohol prior to the bonding procedure, use of acetone-based adhesives, and application of antioxidants such as 10% sodium ascorbate (SA) gel or solution or 10% alpha-tocopherol solution [7]. Hydrogen peroxide decreases the bond strength of composite to enamel and dentin. This effect is reversible by the application of antioxidants. The biocompatible antioxidants including ascorbic acid (AA) and its salts can neutralize the residual free radicals, and minimize different oxidative compounds. If application of antioxidant on bleached enamel is performed prior to bonding, it may prevent the reduction in bond strength and serve as an alternative to postponing the restorative procedure [1]. Evidence shows that SA applied for 3 hours on the enamel surface after bleaching with carbamide peroxide can reverse the reduction in bond strength. SA is a neutral biocompatible antioxidant [4].

To the best of the authors' knowledge, the effects of SA and AA on the shear bond strength (SBS) of bleached enamel to composite have not been compared. Thus, this study aimed to assess the effect of AA and SA on SBS of office-bleached enamel to composite.

Materials and Methods

This in vitro, experimental study was conducted on 66 premolars extracted as part of orthodontic treatment or due to poor periodontal prognosis within 10 months prior to the study onset. The collected teeth had a sound buccal surface. The study was approved by the ethics committee of Arak University of Medical Sciences (IR.ARAKMU.REC.1398.168), and the patients consented to the use of their extracted teeth for research purposes. The sample size was calculated to be 11 in each group according to a previous study [5] assuming alpha=5%, beta=10% (power=90%)

After cleaning and disinfection, the teeth were immersed in saline until the experiment.

The tooth surfaces were cleaned with a prophy brush and prophylaxis paste. Next, the teeth were mounted in putty such that their buccal surface remained exposed. The teeth were randomly divided into 6 groups (n=11) as follows:

Group 1: The buccal surface of the teeth was etched with 37% phosphoric acid (Ultradent, USA), rinsed for 30 seconds, and dried with air spray. After observing the chalky white appearance of the buccal surface, one layer of Single Bond (3M ESPE, St. Paul, MN, USA) was applied on the surface by a microbrush (Premium Plus, China), thinned with air spray and cured for 20 seconds (LED curing unit, Wood Pecker, China) with a light intensity of 1200 mW/cm^2 according to the manufacturer's instructions. Next, tubes with 2 mm height and 3 mm diameter were placed on the surface , and filled with Z350 composite (A2 enamel; 3M ESPE, St. Paul, MN, USA) and cured for 40 seconds according to the manufacturer's instructions. A #15 scalpel was used to cut and remove the plastic tube. The teeth with the composite cylinder bonded to their buccal surface were then immersed in distilled water.

Group 2: The buccal surface of the teeth was bleached using Maxx Whitening kit (FGM, Brazil) containing 35% hydrogen peroxide according to the manufacturer's instructions. The bleaching agent was applied on the tooth surfaces and light-cured for 20 seconds with back and forth movement of the curing unit over the buccal surface of all 11 teeth in this group. The bleaching agent was agitated on the tooth surface by an applicator every 5 minutes. After 15 minutes, the bleaching agent was washed. This process was repeated 3 times, and then the teeth were immediately bonded to composite as explained for group 1.

Group 3: The buccal surface of the teeth was bleached as explained for group 2. Next, the teeth were immersed in distilled water for 14 days and bonded to composite as explained for group 1.

Group 4: The buccal surface of the teeth was bleached as explained for group 2. Next, 10% SA solution was prepared by mixing 10 g of SA (Fluka-Sigma, Switzerland) and 90 mL of distilled water, and applied on the tooth surfaces by a microbrush. It was rinsed after 10 minutes, and the teeth were bonded to composite as explained for group 1.

Group 5: The buccal surface of the teeth was bleached as explained for group 2. Next, 10% AA solution was prepared by mixing 10 g of AA powder (Merck, Germany) with 90 mL of distilled water. It was applied on the tooth surfaces by a microbrush. It was rinsed after 10 minutes, and the teeth were bonded to composite as explained for group 1.

Group 6: The buccal surface of the teeth was bleached as explained for group 2. Vitamin C solution (Darupakhsh, Iran) was applied on the tooth surface by a microbrush and rinsed after 10 minutes. The teeth were then bonded to composite as explained for group 1.

Except for group 2 that a 2-week period was allowed after OB, the other groups were prepared within 2 days to eliminate the effect of time lapse on the results. The prepared teeth were then removed from the putty and mounted in acrylic resin such that the acrylic surface was parallel to the composite-tooth interface. The teeth were immersed in distilled water and underwent SBS testing in a universal testing machine (Z020; Zwick Roell, Ulm, Germany). Load was applied vertically to the composite-tooth interface at a crosshead speed of 1 mm/minute until composite debonding (Figure 1). The SBS was reported in megapascals (MPa). The stress-strain graph was also drawn by the respective software.

Data were analyzed using STATA version 11. The Shapiro-Wilk test was used to assess the normality of data distribution, which showed normal distribution of SBS data in all groups. Thus, the SBS of the groups was compared using one-way ANOVA. The bonferroni post hoc test was used for items that results of ANOVA was significant. All analysis was performed at 0.05 level of significance.

Results

Table 1 presents the mean SBS of the study groups. As shown, the maximum SBS was noted in the control group and the minimum SBS was noted in teeth restored immediately after bleaching (group 2). One-way ANOVA showed a significant difference in SBS of the groups (P=0.000). Post hoc test were performed by the Bonferroni test (Table 2). As shown, the mean SBS of the control group was significantly higher than that of all other groups (all Ps=0.000). The mean SBS at 14 days after bleaching (group 3), and the mean SBS in SA (group 4), AA (group 5) and vitamin C (group 6) groups was significantly higher than the value in group 2 (all Ps=0.000). The mean SBS at 14 days after bleaching was not significantly different from the SBS of SA group (P=0.215). However, the mean SBS at 14 days after bleaching was significantly higher than that of AA (P=0.000) and vitamin C (P=0.000) groups. The mean SBS in SA group was significantly higher than that of AA (P=0.000) and vitamin C (P=0.000) groups. The mean SBS of AA and vitamin C groups was not significantly different (P=0.867).

Discussion

This study assessed the effect of AA and SA on SBS of office-bleached enamel to composite. Group 2, restored immediately after bleaching, showed minimum SBS. The SBS in this group was significantly lower than that in other groups. Nari-Ratih and Widyastuti [8] evaluated the effect of different antioxidants on SBS of teeth subjected to external bleaching to composite resin. They reported minimum bond strength in immediately restored bleached teeth, which was similar to the present findings. Gogia et al. [9] evaluated the effect of different antioxidants on SBS of bleached teeth and reported minimum SBS in immediately restored bleached teeth, which was in agreement with the present results. Similar results were reported by Ismail et al,

[6] in their study on the effect of 2-minute application of 35% SA on SBS of bleached teeth to composite. The present findings and those of the abovementioned studies all indicate a compromised SBS immediately after bleaching. Thus, a 1- to 3-week interval is often recommended for restorative procedures after bleaching in order for the SBS to return to its baseline value [10].

In the present study, the SBS in the group that was restored 2 weeks after bleaching was significantly higher than that of immediately restored group; however, its SBS was still lower than that of the control group. This finding indicates that probably longer time interval is required for the SBS to return to its baseline value. Borges et al. [11] evaluated the effect of bleaching agents on bond strength of composite restorations based on the time passed since bleaching. Similar to the present study, they reported that the bond strength of the teeth restored 2 weeks after bleaching was higher than the immediately restored group but did not reach the SBS of the control group. The group restored 3 weeks after bleaching showed a SBS comparable to that of the control group, indicating that 2 weeks is not sufficient for the SBS to return to its baseline value. Cavalli et al. [12] evaluated the effect of time passed since bleaching on SBS of composite restorations and recommended waiting for 3 weeks before composite restoration of bleached teeth. Their results were in agreement with the present findings. Nari-Ratih and Widyastuti [8] reported that the SBS of teeth restored 2 weeks after bleaching was insignificantly lower than that of the control group. Bulut et al. [13] reported that the SBS of bleached teeth restored 1 week after bleaching was insignificantly lower than that of the control group. Difference between the results of the abovementioned two studies and the present study may be due to the use of different bleaching agents since Bulut et al. [13] used 10% carbamide peroxide while we used 35% hydrogen peroxide for bleaching. In total, it appears that as the time interval between bleaching and composite restoration increases, a higher SBS is achieved and the value approximates that of the control group.

Considering the significance of saving time, finding methods to return the compromised SBS to the baseline value is imperative [10]. Residual radicals that remain in the tooth structure after bleaching damage the periodontal tissue, elicit inflammatory reactions, and can lead to external root resorption. Accordingly, some researchers recommended the application of antioxidants to neutralize the free radicals and increase the composite to enamel bond strength compromised by bleaching [10,14-16]. Considering the possible variations in the efficacy of different antioxidants for this purpose, this study compared three commonly used antioxidants. The results showed that SA yielded the best results and provided a SBS comparable to the SBS of restoration at 14 days after bleaching. Nari-Ratih and Widyastuti [8] reported that application of 10% SA increased the SBS compared with the SBS of teeth restored immediately after bleaching but could not yield a SBS comparable to that of the control group. Their results were in line with the present results. Golia et al. [9] used 10% SA for 10 and 20 minutes and showed that its application for 10 minutes increased the SBS but not to the level of the control group. Its application for 20 minutes yielded results similar to the present findings. Application of 10% SA for 120 minutes increased the SBS comparable to that of the control group. Thus, it appears that application of 10% SA increases the SBS in a time-dependent manner. Subramonian et al. [17] compared the effects of three different antioxidants on SBS of composite restorations. They showed that application of 10% SA for 10 minutes increased the SBS but not to the level of the control group. Kimiyai et al. [18] compared the efficacy of application of SA in gel and solution forms for 10 minutes on SBS of orthodontic brackets after bleaching and showed that both forms equally enhanced the SBS but could not reach the value to that of the control group.

In the present study, the SBS values were comparable after the use of AA and vitamin C, and the obtained values were higher than the SBS of teeth restored immediately after bleaching and lower than the SBS of SA group. Talebian et al. [19] assessed the effect of 10% AA on bond

strength of fiber post to composite resin after bleaching with 24% hydrogen peroxide. They showed that application of 10% AA for 10 minutes increased the bond strength in a time-dependent manner. Their results were in accordance with the present findings. Khamverdi and Talebian [20] assessed the effects of AA, ethanol, and acetone on microtensile bond strength of fiber post and composite resin after treatment with hydrogen peroxide. Although their methodology was different from the present study, both studies indicated that application of AA increased the bond strength but not to the level of the control group. Muraguchi et al. [21,22] demonstrated that application of AA on bleached teeth increased the SBS to the level of unbleached teeth. Their results were different from the present findings because in the current study, application of AA increased the SBS but not to the level of the control group. This difference in the results of the two studies can be due to the use of 35% hydrogen peroxide in the present study versus 30% hydrogen peroxide and sodium perborate in their study. Also, we used Single Bond (5^{th} generation) while they used Clearfil SE Bond (6^{th} generation).

Vitamin C and AA are often considered as one product in the literature. However, vitamin C has some additives compared with AA. Thus, we evaluated vitamin C and AA in two different groups. The results revealed that AA was superior to vitamin C in improving the SBS but the difference between the two did not reach statistical significance.

This study had some limitations. It had an in vitro design. Thus, the effect of oral environmental conditions could not be evaluated. Future studies are required on other types of antioxidants and the effect of duration of application on the results.

Conclusion

After bleaching treatment, composite restorations should be postponed for 2 to 3 weeks. Otherwise, antioxidants should be used to improve the SBS. SA is ideal for this purpose, followed by AA and vitamin C. The latter two were equally effective but inferior to SA.

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Tables

Table 1. Mean SBS (MPa) of the study groups

Group	Mean	Std. deviation	Minimum	Maximum
Control (bonding only)	۱۴۳٫۲۳	۱۰٫۲۱	۱۳۱٫۵۹	۱۶۲٫۹۱
Bonding immediately after bleaching	۵۱٫۹۴	۷٫۹۸	۴۰٫۰۳	۶۲٫۸۹
Bonding 14 days after bleaching	۱۱۷٫۸۱	۴٫۵۱	۱۰۷٫۷۳	۱۲۳٫۶
Bonding after SA application	۱۱۴٫۵۶	۷٫۱۰	۱۰۲٫۶۵	۱۲۴٫۳۷
Bonding after AA application	۹۲٫۸۳	۶٫۵۱	۸۵٫۳۱	۱۰۲٫۴۵
Bonding after vitamin C application	۹۲٫۲۶	۹٫۲۲	۷۸٫۳۷	۱۰۶٫۷۳

Table 2. Pairwise comparisons of the groups regarding SBS (MPa) by the Bonferroni test

Groups	Mean SBS	Mean difference	P value
Control	۱۴۳٫۲۳	۹۱٫۲۸	۰٫۰۰۰
Restoration immediately after bleaching	۵۱٫۹۴		

Control	١٤٣٫٢٣	٢٥٫٤٢	٠٫٠٠٠
Restoration at 14 days after bleaching	١١٧٫٨١		
Control	١٤٣٫٢٣	٢٨٫٦٦	٠٫٠٠٠
Restoration after SA application	١١٤٫٥٦		
Control	١٤٣٫٢٣	٥٠٫٣٩	٠٫٠٠٠
Restoration after AA application	٩٢٫٨٣		
Control	١٤٣٫٢٣	٥٠٫٩٧	٠٫٠٠٠
Restoration after vitamin C application	٩٢٫٢٦		
Restoration immediately after bleaching	٥١٫٩٤	٦٥٫٨٦	٠٫٠٠٠
Restoration at 14 days after bleaching	١١٧٫٨١		
Restoration immediately after bleaching	٥١٫٩٤	٦٢٫٦١	٠٫٠٠٠
Restoration after SA application	١١٤٫٥٦		
Restoration immediately after bleaching	٥١٫٩٤	٤٠٫٨٩	٠٫٠٠٠
Restoration after AA application	٩٢٫٨٣		
Restoration immediately after bleaching	٥١٫٩٤	٤٠٫٣١	٠٫٠٠٠
Restoration after vitamin C application	٩٢٫٢٦		
Restoration at 14 days after bleaching	١١٧٫٨١	٣٫٢٤	٠٫٢١٥
Restoration after SA application	١١٤٫٥٦		
Restoration at 14 days after bleaching	١١٧٫٨١	٢٤٫٩٧	٠٫٠٠٠

Restoration after AA application	٩٢٫٨٣		
Restoration at 14 days after bleaching	١١٧٫٨١	٢٥٫٥٥	٠٫٠٠٠
Restoration after vitamin C application	٩٢٫٢٦		
Restoration after SA application	١١٤٫٥٦	٢١٫٧٦	٠٫٠٠٠
Restoration after AA application	٩٢٫٨٣		
Restoration after SA application	١١٤٫٥٦	٢٢٫٣٠	٠٫٠٠٠
Restoration after vitamin C application	٩٢٫٢٦		

Restoration after AA application	٩٢٫٨٣	٠٫٥٧	٠٫٨٦٧
Restoration after vitamin C application	٩٢٫٢٦		

Figures

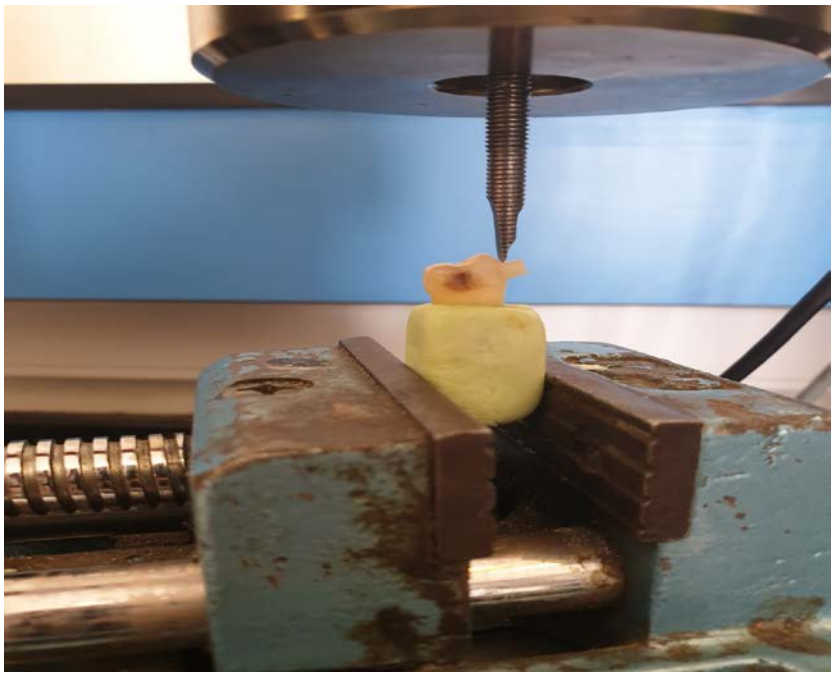

Figure 1. Load application to the composite-tooth interface in the universal testing machine for measurement of SBS