ORIGINAL ARTICLE

Shear bond strength of orthodontic brackets after antioxidant treatment on previously bleached teeth: An *in vitro* study

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ABSTRACT

Context: Bleaching of the enamel surface reduces shear bond strength. This can be reversed by use of antioxidants prior to bonding of brackets. **Aims:** The aim of the study was to verify and validate the improvement in bond strength through the application of antioxidant on previously bleached teeth. **Materials and Methods:** Thirty-six sound maxillary and mandibular premolars extracted for orthodontic purposes were collected and divided into three groups of 12. Specimens in Group 1 were bleached with 35% hydrogen peroxide as a bleaching agent. Specimens in Group 2 were bleached and subsequently treated with 10% antioxidant (sodium ascorbate). Specimens in Group 3 served as a control. All specimens were stored in artificial saliva for 24 h prior to the bonding of orthodontic brackets. After bracket attachment, the samples were stored in distilled water for 1-week and then tested for shear bond strength using an INSTRON testing machine. **Results:** The data revealed that there was a significant difference between shear bond strengths of the bleached group; bleached + antioxidant group and the control group. Group 2 showed greater bond strength compared with Group 1, but lesser than the bond strength of the control group. **Conclusion:** The results confirmed the positive effect of antioxidant treatment on the bond strength of orthodontic brackets after tooth bleaching.

Key words: Antioxidants, bleaching, shear bond strength

Introduction

Stains and discoloration, whether intrinsic or extrinsic, are a result of many factors, which makes them difficult to prevent.[1] Bleaching agents have become popular due to their safe, effective and predictable nature.[2] These agents are effective in whitening teeth suffering from discoloration due to food, tetracycline staining, and fluorosis or mottling.[3] Since the first at-home bleaching system was introduced in 1989, several whitening systems have been developed, which have incorporated peroxide — based compounds of varying concentrations.[4] Patients who are aesthetically oriented increasingly request dental bleaching due to its effectiveness and wide availability.[2,4] In addition, the number of adults seeking orthodontic treatment is increasing along with an increased likelihood of these patients reporting a previous history of bleaching.

A disadvantage of tooth bleaching prior to orthodontic treatment is a considerable reduction or loss of bond strength between orthodontic brackets and enamel.[5,6] This is reportedly caused by hydrogen peroxide solutions producing a change in surface morphology, structure and characteristics of enamel.[7,8] This has alerted clinicians to the possibility that peroxide bleaching might have detrimental effects on enamel and subsequently caused a change in bonding efficiency. Several studies have produced conflicting views,[3,5,9,10] but generally determined that a safe period for bonding may vary between 24 h and 4 weeks following the bleaching procedure.[5,12,13]

It has been considered that the pretreatment of bleached teeth with an antioxidant reverses the detrimental effect of the bleaching agent on adhesive bond strength.[11]

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Therefore, the aim of the present study is to verify and validate the use of an antioxidant prior to bracket bonding in order to enhance the bond strength of bleached teeth.

Materials and Methods

This study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, A.B Shetty Memorial Institute of Dental Sciences, Mangalore, Karnataka, India in association with 3M Innovation Center, Electronics City, Bangalore.

Methodology

Thirty-six sound maxillary and mandibular premolars extracted for orthodontic purposes were collected. It was ensured that the buccal enamel was undamaged following extraction, and any residue on the teeth was removed under tap water and using air-water spray. The teeth were stored under refrigeration at 4°C in artificial saliva solution.

Preparation of Specimens

For the purpose of mounting on an INSTRON Testing Machine, the samples were prepared in the following manner. 80 mm × 10 mm × 5 mm brass bars were fabricated and invested in dental plaster to produce a mold. Self-cure acrylic was poured, polymerized and trimmed with cutting disks to a dimension of 40 mm × 10 mm × 5 mm and subsequently finished and polished. Thirty-six bars were fabricated upon, which 36 hollow, open-ended cylinders of 20 mm height and 15 mm internal diameter were cut out of poly (vinyl chloride) (PVC) pipe. Each PVC cylinder was filled with self-cure acrylic into which a premolar tooth was embedded leaving its crown exposed and parallel to a long axis of the cylinder. On the other end of the cylinder, the acrylic bar was inserted parallel to a long axis of the cylinder. In this manner, 36 samples were obtained.

The labial surface of each premolar sample was cleaned using an ultra-sonic scaler and polished with oil-free pumice using a micro brush and stored according to their group in artificial saliva solution.

Experimental Groups

The samples were randomly divided into three groups, each containing 12 samples; Group 1 being the bleached group, Group 2 was the bleached + antioxidant group and Group 3 served as the control group.

Bleaching Procedure

All 12 samples were washed and air-dried. About 35% hydrogen peroxide bleaching gel (Opalescence Xtra [Ultadent Products Inc.]) was applied to the enamel surface of each embedded tooth using an applicator tip following which the gel was light cured according to the manufacturer's instructions.

After completion of bleaching procedure the samples were thoroughly rinsed with a compressed air/water syringe for 30 s, air-dried and stored in artificial saliva solution for 24 h prior to bonding [Figure 1].

Application of Antioxidant

All 12 samples of Group 2 were treated in exactly the same way as the samples of Group 1. In addition to bleaching, each sample was treated with an antioxidant solution of 10% sodium ascorbate. A volume of 10 ml of the 10% sodium ascorbate solution was dripped onto the enamel surfaces of the embedded teeth and agitated with a sterile brush. After 10 min, the sample was washed with distilled water and stored for 24 h prior to bonding.

Bonding of Brackets

Thirty-six premolar stainless steel, standard edgewise, twin brackets with a mesh base (ODP — Magnum Roth .022) were used in this study. The brackets were bonded to each sample using a chemically cured composite resin (3M Unitek Transbond). Each sample was washed and air-dried. For all samples, etchant was applied to the buccal surface for 30 s after which the tooth was washed with water and dried with compressed air.

An equal amount of light cure primer (3M Unitek Transbond XT Primer) was applied and cured using a halogen light-curing unit for 15 s. Immediately, after the application of primer, equal amounts of 3M Unitek Transbond XT adhesive paste were applied on each orthodontic bracket base. The brackets were seated and positioned firmly in the middle third of the buccal enamel surface. Excessive resin was removed, and the sample was cured using halogen light (QHL-75, DENTSPLY) for 45 s. After bonding, the samples were stored in distilled water for 1-week before testing for shear bond strength [Figures 2 and 3].

Analysis of Shear Bond Strength

The shear bond strengths of the samples were measured with an INSTRON testing machine after the samples were securely clamped and aligned in an upright position on the lower jaw of the machine. A shearing wire was secured on the upper jaw of the machine and was lowered to engage the orthodontic bracket of the sample held by the lower jaw. The crosshead speed of the INSTRON was 100 N at 1 mm/min. The load at failure was recorded and processed using the Lloyd's DAPMAT Software (version 2.31, Hampshire, UK) [Figure 4].

Figure 1: Mounted specimens; Ultradent Opalescence Xtra whitening agent and 10% sodium ascorbate (antioxidant)

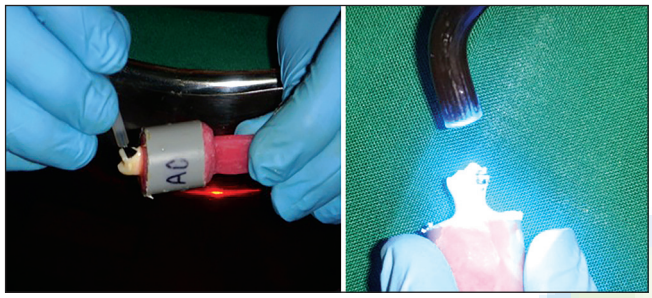

Figure 3: Application of antioxidizing agent and bonding of orthodontic brackets

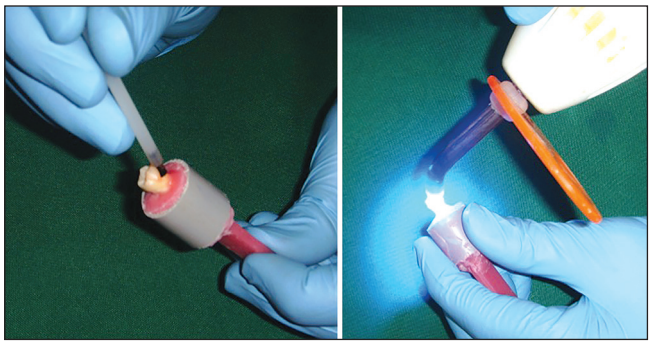

Figure 2: Application and curing of bleaching agent

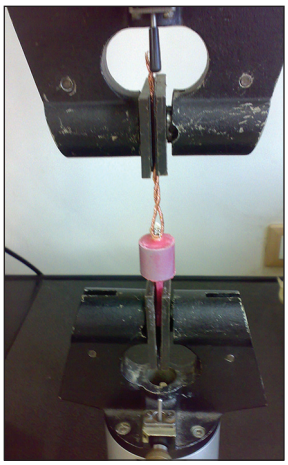

Figure 4: Testing of shear bond strength using INSTRON machine

Results

Table 1 contains the mean, standard deviation and range of the shear bond strength of specimens in each of the three study groups. These descriptive statistics clearly indicate the variation in shear bond strength between the three groups with a maximum bond strength being found in the control group (Group 3) and the minimum in the bleached group (Group 1). It can be observed that Group 2, which was subjected to antioxidant treatment after bleaching shows an improvement in shear bond strength compared with Group 1.

Statistical Analysis of Data

The data described in Table 1 was statistically analyzed using one-way analysis of variance (ANOVA) [Table 2] and Tukey honestly significant difference for multiple comparisons [Tables 3 and 4].

As per Table 2, the ANOVA test revealed a significant difference between bond strengths of various samples under study with a significant difference between shear bond strengths of the bleached group (Group 1) ; bleached + antioxidant group (Group 2) and control group (Group 3).

Table 3 shows that there is a significant difference between the bleached group (Group 1) and control group (Group 3), as well as a significant difference between antioxidant (Group 2) group and control group (Group 3).

The results show that the maximum shear bond strength was found in the control group (Group 3) and the minimum shear bond strength was found in the bleached group (Group 1). The antioxidant group (Group 2) showed higher shear bond strength than the bleached group (Group 1) [Figure 5].

Discussion

For brightening discolored teeth, the use of peroxide releasing agents such as hydrogen peroxide, carbamide peroxide or sodium perborate has become a popular treatment modality, which is comparatively safe.[13]

For effective stain removal, hydrogen peroxide must be able to move through the tooth structure.[13] This is possible because hydrogen peroxide is of low molecular weight and can denature proteins, which increases tissue permeability and allows ions to move through the tooth. However, changes in the enamel structural

and morphological integrity induced by bleaching agents is still controversial and causes orthodontists to question whether bleaching adversely affects bond strengths of brackets bonded to enamel.[3,9,10] Previous studies claim that the alteration in bond strength due to bleaching might be significant with respect to certain materials such as composite resins and bonding of orthodontic brackets.[13] Studies show that bleaching causes changes in the organic enamel matrix, a loss of calcium and a decrease in micro-hardness that are potential causes for the reduction of bond strength.[6,13] It is further claimed that residual oxygen, released by the bleaching agent, interferes with resin infiltration and subsequently affects bond strength.[13] The present study concurs with these claims as samples in Group 1 subjected to bleaching showed lowered bond strength compared with the control group. The delay period after bleaching required to obtain bond strengths comparable to that of prebleached enamel is still debated, but the most accepted postbleaching delay is 7 days.[5]

Table 1: Shear bond strength of different groups in Mpa

Serial number	Group 1 bleached (Mpa)	Group 2 antioxidant (Mpa)	Group 3 control (Mpa)
1	2.875	6.386	4.692
2	2.213	3.617	5.784
3	2.374	3.89	5.980
4	2.707	4.695	6.927
5	3.536	4.705	8.088
6	4.060	5.735	8.647
7	4.523	6.200	9.303
8	4.544	6.664	9.379
9	4.684	6.774	10.244
10	4.725	7.135	10.954
11	6.243	7.137	14.237
12	6.612	9.079	15.373
Maximum	6.612	9.080	15.372
Minimum	2.213	3.618	4.693
Mean	4.091	6.002	9.134
SD	1.424	1.562	3.256

Mpa: Mega pascals, SD: Standard deviation

Table 2: One-way ANOVA test

One-Way Comparison	ANOVA: Mpa (values)				
	Sum of squares	df	Mean square	F	Significant
Between groups	155.549	2	77.775	15.476	0.000
Within groups	165.842	33	5.026		
Total	321.391	35			

Mpa: Mega pascals, ANOVA: Analysis of variance

The purpose of this study was to alter the temporary bleaching reduction in bond strength through the application of antioxidant (sodium ascorbate). Ascorbic acid and its salts are potent antioxidants that can be utilized for the purpose of neutralizing the residual oxygen on bleached teeth.[14] The food industry makes wide use of ascorbic acid as an antioxidant since it is nontoxic. Studies claim that sodium ascorbate treatment of bleached teeth before bonding of brackets reduces the reduction in bond strength caused due to bleaching.[11] Application of antioxidant for 10 min was found to be effective and proved beneficial.[15] It was postulated by Lai *et al*. that an antioxidant in the form of 10% sodium ascorbate permits free radical polymerization of the adhesive resin to proceed without premature termination, which is useful in neutralizing or nullifying the reduction in bond strength due to bleaching.[11]

The results of the present study demonstrate that the antioxidant in the form of sodium ascorbate has a positive effect on the bond strength of previously bleached teeth.[11,15-18]

Clinical Relevance and Implications

In view of the increased incidence of adults seeking orthodontic treatment with a previous history of bleaching, this study brings to light the possibility of reversing the reduction in bond strength of orthodontic brackets after bleaching. This would enable orthodontists to avoid the delay in the bonding procedure after bleaching and also

Table 3: Tukey HSD multiple comparison test

Group (I) Group (J)	Dependent variable: Mpa (values)				
	Mean difference (I-J)	SE	Significant*	95% CI	
				Lower bound	Upper bound
Antioxidant group	−1.910	0.915	0.108	–	0.335
Control	−5.042	0.915	0.000	–	−2.796
Bleached group	1.910	0.915	0.108	−0.335	4.156
Control group	−3.131	0.915	0.005	–	−0.886
Bleached group		0.915	0.000	2.796	7.2882
Antioxidant		0.915	0.005	0.886	5.3776

*The mean difference is significant at the 0.05 level. Mpa: Mega pascals, SE: Standard error, CI: Confidence interval, HSD: Honestly significant difference

Table 4: Tukey's HSD[a] Using Harmonic Mean of Mpa (values)

Group	Number of specimens	Subset for alpha = 0.05	
		1	2
1	12	4.091	
2	12	6.002	
3	12		9.134
Significant		0.108	1.000

Means for groups in homogeneous subsets are displayed. [a]Uses harmonic mean sample size = 12.000. 1 = Bleached group, 2 = Bleached + antioxidant group, 3 = Control group. Mpa: Mega pascals, HSD: Honestly significant difference

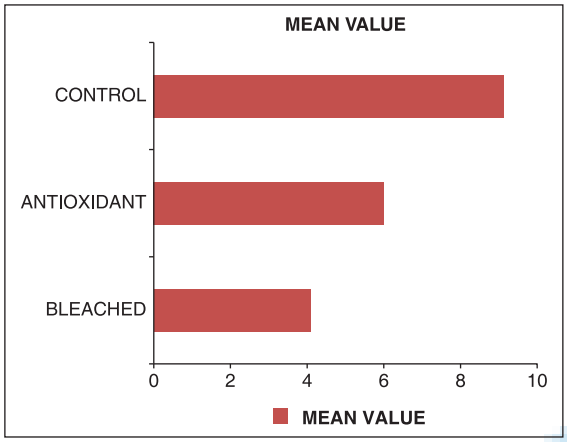

Figure 5: Representing the mean shear bond strength of various experimental groups

enable practitioners to add the aesthetics of bleaching without hampering the mechanical and physical integrity of bond formation.

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