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Research Article

COMPARISON OF EFFECTIVENESS OF ANTIOXIDIZING AGENTS ON SHEAR BOND STRENGTH OF BRACKETS BONDED TO BLEACHED HUMAN ENAMEL

Thejaswini N., Kala Vani S.V*., Geetika Simhadri and Bhaskar Reddy G

Department of Orthodontics and Dentofacial Orthopedics, C.K.S Theja Institute of Dental Sciences and Research, Tirupati

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A B S T R A C T

Introduction: The purpose of this study was to evaluate and compare the effectiveness of different anti-oxidizing agents (sodium ascorbate, rosemary extract) on the shear bond strength of brackets bonded to human enamel after bleaching with carbamide peroxide (CP).

Methods: Eighty recently extracted maxillary first premolars were divided into four groups. Specimens in Group I (control) (n=20) were bonded without bleaching; specimens in Group II (n=20) were bleached and bonded Group III and Group IV specimens (n=20 each) were bleached, and then treated with 10% sodium ascorbate and rosemary extract respectively before bonding. The specimens were debonded, and the enamel surfaces and bracket bases were examined with a stereomicroscope. The adhesive remnant index was used to assess the amount of resin left on the enamel surfaces after debonding. The shear bond strength data were subjected to 1-way analysis of variance. Multiple comparisons were performed with the Bonferroni test. The level of significance was established at P <0.05 for all statistical tests.

Results: The shear bond strength of brackets bonded immediately after bleaching with 10% CP was significantly lower than that of brackets bonded to unbleached enamel (P<0.001). No statistically significant differences in shear bond strength were noted when the sodium ascorbate and rosemary extract treated groups were compared with the control group (P = 1.00).

Conclusions: Bleaching with 10% CP immediately before bonding results in the reduction of bracket shear bond strength. Treatment of bleached samples with 10% sodium ascorbate solution and rosemary extract reversed the reduced shear bond strength of brackets and could be an alternative to delayed bonding.

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INTRODUCTION

Face-directed treatment is different in that the face and the smile are recognized as a whole. In recent years there is an increased awareness of esthetics within the community. The emerging paradigm in our field is a global esthetic approach with emphasis on a patient-centered interaction that enhances a good occlusion, achieved either solely by an orthodontist or in conjunction with a team of cosmetic dentists and prosthodontist[1].

Samorodnitzky-Naveh *et al*[2] reported in a study that only 43 percent of a U.S. study population was satisfied with their tooth color, and of those dissatisfied, 88 percent would have preferred to have their teeth whitened. More than 100 million Americans whiten their teeth one way or another.

Corresponding author:* **Kala Vani S.V
Department of Orthodontics and Dentofacial Orthopedics, C.K.S Theja Institute of Dental Sciences and Research, Tirupati

About 60% of orthodontic patients inquire about tooth whitening during the initial consultation. Tooth bleaching using oxalic acid was first introduced in 1848[3], followed by hydrogen peroxide (HP) in 1884[4]. Contemporary tooth bleaching systems are primarily based on oxidation by HP or one of its precursors such as carbamide peroxide (CP). The fact that different concentrations of hydrogen peroxide reduce the bond strength of orthodontic brackets bonded to the enamel surface has been proven[5].

Several methods have been proposed to avoid clinical problems related to compromised bond strength after bleaching, such as delay bonding after bleaching[6], removal of the superficial layer of enamel[7], pretreatment of bleached enamel with alcohol and use of adhesives containing organic solvents[8, 9] and use of anti-oxidant agents before the bonding process[10].

Recently, application of antioxidants immediately after bleaching and before bonding proved to improve shear bond strength. If antioxidant treatment of bleached enamel before

bracket bonding reverses the reduction in bond strength of composite resin, it might be an alternative to waiting and could eliminate the need to postpone bonding. In the quest to search for an effective and safe antioxidant, a novel attempt has been done to use natural antioxidants, which have been used in medical research for their strong antioxidant property[11]. Hence the purpose of this in vitro study was to evaluate and compare the effectiveness of different anti-oxidizing agents (sodium ascorbate, rosemary extract) on the shear bond strength of brackets bonded to bleached human enamel surface.

MATERIAL AND METHODS

Eighty extracted human maxillary first premolars were used for this experiment. The criteria for tooth selection were intact buccal enamel; no pretreatment with chemical agents such as derivatives of peroxide, acid, or alcohol; no cracks from forceps; no caries; and no restorations. All the extracted teeth were collected in a bottle with physiological saline, rinsed in tap water, cleaned of blood and periodontal tissue remnants, and stored in physiological saline to prevent bacterial growth during the entire period of the experiment. Subsequently, after pooling of the sample, all the teeth were removed from saline, rinsed thoroughly with distilled water, and dried by a free air stream. Each tooth was then embedded in acrylic blocks prepared with help of an aluminum holder with dimensions of 8 mm width and 20 mm depth and 20 mm height that was filled with DPI RR cold cure acrylic material. The teeth were embedded in such a way that only the crowns were exposed up to the cementoenamel junction and placed in the middle of the aluminum holder. The specimens were stored in physiological saline at all times to prevent enamel desiccation. Storage medium was replaced periodically every one week to minimize deterioration. The specimens were randomly divided into a control (Group I, n = 20) and 3 experimental groups (Groups II, III, IV) that were bleached with 10% CP (n=20 each). Group I specimens were bonded without bleaching. Group II consisted of specimens bonded immediately after bleaching. Group III specimens were bleached and then treated with an antioxidant (10% sodium ascorbate) just before bonding. Specimens in group IV were bleached and treated with rosemary extract before bonding.

In the three experimental groups (Group II, III, IV), a commercial, 10% carbamide peroxide at home bleaching gel (Opalescent Ultradent) was applied on the enamel surfaces of the embedded teeth for 8 hours a day for a period of one week. The specimens were partially immersed in artificial saliva at 37^0C in a tray so that the enamel surfaces coated with bleaching gel did not contact the saliva after the daily bleaching procedure. The specimens were thoroughly rinsed with water and air dried for 30 seconds. For the rest of the day, they were stored in artificial saliva. No further procedures were done for Group II before bonding.

In Group III, after the bleaching, an antioxidant,10 ml of 10% sodium ascorbate (10 mg of sodium ascorbate powder was mixed to 100 ml of distilled water), was applied to the enamel surfaces as an irrigating solution for 10 minutes with a flow rate of 1 ml per minute under continuous agitation. The enamel surfaces were then thoroughly rinsed with distilled water for 30 seconds, later the brackets were bonded. In Group IV, after bleaching, an antioxidant, 10 ml of rosemary extract was applied to the enamel surfaces as an irrigating solution for 10 minutes with a flow rate of 1ml per minute under continuous agitation. The enamel surfaces were then thoroughly rinsed with distilled water for 30 seconds, later the brackets were bonded.The brackets used in this study were. 022-in, stainless steel, mesh-based, preadjusted edgewise MBT first premolar brackets (American Orthodontics). The brackets were bonded with, a light cured Bis-GMA (Bisphenol Glycidyl Methacrylate) composite resin (Ormco). The buccal surfaces of the teeth were rinsed and cleaned with deionized water and dried with an air stream for 10 seconds each. Thereafter, a spot was chosen on the center of the buccal surfaces and the enamel was etched with 37% Phosphoric acid (Ezee etch-37, etchant gel, mission dental, EA08, USA) for 15 seconds followed by rinsing and air drying for 20 secs each. For all teeth that were etched, the frosty white appearance of etched enamel was noticed and a thin layer of orthodontic primer/bonding agent (Ortho Solo, Ormco) was applied with a brush tip applicator and light cured for 20 seconds. Thereafter light cure adhesive was used to bond the respective brackets to the assigned group of teeth. The adhesive was then polymerized using a L.E.D. Curing unit for 40 seconds at 450 nm. After bonding, all the teeth were stored in physiological saline to prevent enamel desiccation, which might affect shear bond strength and were subsequently subjected to debonding procedure.

Physical testing was conducted on an INSTRON Universal testing machine with model number AC-03-0004 with the capacity of 5KN. The specimens along with the acrylic blocks were secured to a jig attached to the base plate of the Universal testing machine. A chisel - edge plunger was attached to another jig of the testing machine and positioned so that leading edge was aimed (occluso gingival direction) at the enamel-adhesive interface. Force was applied perpendicular to the bracket slot until the bond failure at a crosshead speed of 1 mm/ min. The force in Newton (N) was recorded. The shear stresses were calculated by dividing the force in Newton/ cross-sector of the bracket base area and calculated in megapascals (MPa).

Stereomicroscope at 20 X magnification was used for fracture analysis of bonded enamel surface. Failures were classified according to the Adhesive Remnant Index (ARI) [12].

One-way ANOVA test was carried out to assess the SBS values within the groups. Kruskal Wallis and Mann Whitney U tests were carried out to assess the ARI values between different groups. Post hoc tests like Bonferroni test was carried out for multiple comparisons between different groups. Statistical analysis was processed with SPSS 22.0 software system.

RESULTS

Shear bond strengths in MPa (mean $\pm$SD) for the groups are shown in Table I. One-way analysis of variance showed significant differences in bond strength among the 4 groups ($P < .001$). The shear bond strengths of brackets bonded soon after bleaching with 10% CP were much lower than that of unbleached enamel ($P < .001$) as shown by Bonferroni test (Table 2). For the bleaching groups, when the sodium ascorbate treated and rosemary extract treated groups were compared with the control group, there was no statistically significant difference with respect to shear bond strength (P - 1.00). This showed that both antioxidant treatments were significantly effective in increasing the shear bond strength of brackets bonded to bleached enamel. Between Group III & IV antioxidant groups, sodium ascorbate treated and rosemary

extract treated groups respectively, no statistically significant difference in SBS was observed (*P* -1.00).

To assess the amount of resin left on the enamel surfaces after debonding, the ARI was used. Table 3 shows frequency distribution of the ARI scores in various groups. Most of the samples in the groups had an ARI score of 2 (60% in Group 1, 55% in Group III and 65% in Group IV). Fifty percent of samples in Group II had an ARI score of 0. No samples had an ARI score of 3. The Kruskal-Wallis test (Table 4) of fracture analysis data showed that there were statistically significant differences among the 4 groups (*P* <.01). Pair-wise comparison of groups with the Mann-Whitney U test demonstrated that group II was significantly different from the other 3 groups (*P* = 0.001), whereas the other groups showed no difference when compared with each other.

DISCUSSION

Studies suggested that bleaching reduces the shear bond strength of brackets and a waiting period of 2 to 3 weeks was required to proceed with bonding procedure. Such waiting period may not be feasible in case of immediate esthetic requirements. Among all the methods, the antioxidant treatment using sodium ascorbate has shown immediate improvement, whereas other methods showed equivocal results[8, 15].

Table 1 Mean and Standard deviations of shear bond strength values in all groups

Group	N	Min	Max	Mean[#]	Std.deviation
Group I	20	19.40	28.40	24.74[a]	2.41
Group II	20	10.42	19.64	15.69[b]	2.78
Group III	20	19.45	27.37	23.95[a]	2.17
Group IV	20	20.02	28.00	24.43[a]	2.06

Table 2 Post hoc Bonferroni test for multiple comparisons of shear bond strength between different groups

Comparison	Mean Difference	p value
Group I vs Group II	9.05350*	<0.001**
Group I vs Group III	.79150	1.000 NS
Group I vs Group IV	.31150	1.000 NS
Group II vs Group III	-8.26200*	<0.001**
Group II vs Group IV	-8.74200*	<0.001**
Group III vs Group IV	-.48000	1.000 NS

NS-Not significant (p>0.05), **- Highly significant (p<0.01)

The results of our study demonstrated that the reduction in shear bond strength of brackets immediately after bleaching was significant when compared with the control group. These results agree with those of Cavalli *et al*[13] who showed that CP bleaching agents in the range of 10% to 20% adversely affected the bond strength of composite resin to enamel when bonding was performed immediately after bleaching.

In this study, treatment of the bleached enamel with 10% sodium ascorbate and rosemary extract before bonding appeared to effectively restore the reduced shear bond strength of orthodontic brackets. Shear bond strength values of bleached teeth treated with 10% sodium ascorbate were (23.95+2.17MPa). These values were similar to the shear bond strength values exhibited by control group (24.74+2.41). These results were parallel with those reported by Lai *et al*[14], Bulut *et al*[15], Kunjappam *et al*[16], Turkun *et al*[17], Torres *et al*[18] and Muraguchi *et al*[19] which have shown that reduced bond strength of composite resin to bleached enamel was effectively reversed by antioxidant (10% sodium ascorbate) treatment. The application time of 10% sodium ascorbate solution was kept at 10 minutes in accordance with the study of Bulut *et al*[15]. This application time was found to be adequate to reverse the reduction in bond strength as suggested by previous studies of Turkun *et al*[17] and Thapa *et al*[20]

Ascorbic acid and its salts are well-known antioxidants that can reduce various oxidative compounds; especially free radicals. Previous studies have demonstrated the protective effect of ascorbic acid in vivo against hydrogen peroxide-induced damage in biologic systems. Rosemary is one of the most effective spices, widely used in food processing. The antioxidant properties of rosemary, *Rosmarinus officinalis* L. (Labiatae), have been known for centuries.In the present study, treatment of the bleached enamel with rosemary extract before bonding appeared to restore the reduced shear bond strength of orthodontic brackets. The shear bond strength values obtained with rosemary extract were (24.43+2.06MPa).These values were comparable to the shear bond strength values obtained with the control group (24.74+2.41MPa). No studies have been conducted so far to evaluate the effect of rosemary extract on the shear bond strength of brackets bonded to bleached tooth enamel to compare our results.

Table 3 Frequency distribution of ARI scores in various groups

Score	Group I		Group II		Group III		Group IV	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
0	0	0	10	50.0	0	0	0	0
1	8	40	9	45.0	9	45.0	7	35.0
2	12	60	1	5.0	11	55.0	13	65.0
3	0	0	0	0.0	0	0	0	0
Total	20	100	20	100	20	100	20	100
Median	2		0.5		2		2	
Mean	1.60 ± 0.50		0.55 ± 0.60		1.55 ± 0.51		1.65 ± 0.48	

Group I- Bonded without bleaching, Group II- Bleached with 10% CP without use of an antioxidizing agent, Group III- Sodium ascorbate, Group IV-Rosemary extract.

Table 4 Kruskal Wallis test for intergroup comparison of ARI values in different groups

ARI	N	Mean Rank	Mean	SD
Group I	20	48	1.60	0.50
Group II	20	18	0.55	0.6
Group III	20	46.25	1.55	0.51
Group IV	20	49.75	1.65	0.48
Total		80		
Chi sq value	30.42		P value	<0.001**

**-statistically highly significant (p<0.01)

The frequency distribution of ARI scores in the present study showed that most of the samples in Group I, III and IV had an ARI score of 2 which means that most common site of bond failure was at the bracket/adhesive interface. These results are in agreement with the Bulut *et al*[15], Aulakh *et al*[21] and Adanir *et al*[22] which also showed that the most common site of bond failure was at the bracket/adhesive interface of the bleached teeth which were treated with 10% sodium ascorbate. In Group II (bleached, immediately bonded) 50% of samples had an ARI score of 0 (i.e. no adhesive left on the tooth surface). Bulut *et*

al[15] also demonstrated that 50% of teeth which were bonded immediately after bleaching had an ARI score of 0. No studies have been done so far to compare ARI scores on bleached enamel surfaces treated with rosemary extract.

CONCLUSIONS

Within the limitations of the study, following conclusions were drawn

1. Bleaching with 10% CP immediately before bonding results in the reduction of bracket shear bond strength.
2. Treatment of bleached samples with 10% sodium ascorbate solution and rosemary extract reversed the reduced shear bond strength of brackets and could be an alternative to delayed bonding.
3. There was no statistically significant difference between the mean shear bond strength values of the brackets bonded to bleached enamel treated with rosemary extract and those which were treated with 10% sodium ascorbate solution.
4. Most of the samples in the present study had an ARI score of 2 indicating that the most common site of bond failure is bracket/adhesive interface.

In conclusion, both 10% sodium ascorbate and rosemary extract could be used as an alternative to delayed bonding, as they produced bond strength comparable to that of the control group.

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