Effects of green tea on the shear bond strength of orthodontic brackets after in-office vital bleaching

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The application of bleaching agents before placement of resin-bonded fixed appliances significantly, but temporarily, reduces bond strength to tooth structure. Antioxidants have been studied as a means to remove residual oxygen that compromises bonding to bleached enamel. This in vitro study evaluated whether green tea (GT) could restore the shear bond strength between bonded orthodontic brackets and bleached enamel. Six experimental groups were compared: group 1, no bleaching plus bracket bonding (positive control); group 2, bleaching with 35% hydrogen peroxide (HP) plus bracket bonding (negative control); group 3, 35% HP plus 10% sodium ascorbate (SA) plus bracket bonding; group 4, 35% HP plus 10% GT plus bracket bonding; group 5, no bleaching plus 10% SA plus bracket bonding; group 6, no bleaching plus 10% GT plus bracket bonding. Results suggested that GT, like SA, may be beneficial for bracket bonding immediately after bleaching.

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Since Haywood & Heymann introduced vital bleaching in 1989, this method has been among the most sought after and performed esthetic treatments.[1] Bleaching of discolored teeth can be performed before or after treatments involving fixed orthodontic appliances. However, the application of bleaching agents before adhesive restoration or the placement of resin-bonded fixed appliances significantly reduces bond strength to tooth structures.[2-4]

The application of composite resin to bleached enamel and dentin surfaces after home or office bleaching procedures reduces shear bond strength (SBS) due to the presence of oxygen or peroxide remnants in tooth structures, which prevents polymerization of the resin bonding agent and the development of sufficient resin tags in etched enamel.[3,5] However, this decrease in SBS has been shown to be temporary; the recommended waiting times for bonding procedures after bleaching have ranged from 24 hours to 4 weeks.[4-7]

Delayed treatment after bleaching is not always practicable, given that many patients require rapid treatment. Thus, the use of antioxidants to remove residual oxygen that compromises bonding to bleached enamel has been examined. Researched antioxidants include sodium ascorbate (SA), grape seed extract, α-tocopherol, catalase, sodium bicarbonate, glutathione, and organic solvents such as ethanol and acetone.[2,3,8-14] None of these alternatives has been used clinically to restore the adhesiveness of bleached enamel, and these products have short shelf lives that can be affected by certain storage conditions (temperature, time, and light exposure); thus, the postponement of restorative procedures is most commonly recommended.[5,15]

In recent years, the use of green tea (GT) and its derivatives—such as epigallocatechin gallate (EGCG)—has been widely studied in dentistry.[16-19] Berger et al reported that GT was able to restore SBS to bleached enamel.[18] However, the use of GT before bracket bonding has not been studied. The current study was conducted to test the hypothesis that the application of GT immediately after bleaching treatment would restore the SBS of brackets to tooth enamel.

Materials and methods

Specimen preparation

The sample size was determined using the data from a study by Fernandes et al.[20] A power analysis indicated that 12 teeth per group would result in an 80% chance of obtaining significance at the 0.05 level. Seventy-two bovine incisors without enamel defects were used in this study. The specimens were submerged for 7 days in 0.5% chloramine-T solution for disinfection. The teeth were then washed in tap water and submitted to manual debridement with a periodontal curette to remove organic debris. The enamel surfaces of all the specimens were first flattened using 600-grit aluminum oxide (Al_2O_3) abrasive paper then polished with 1000- and 1200-grit Al_2O_3 abrasive papers to remove irregularities that could interfere with bracket bonding. Finally, specimens were ultrasonically cleaned (Unique Ind e Co Produtos Eletrônicos Ltda) for 10 minutes to completely remove debris.

The specimens were embedded vertically (90 degrees to mold base) in standardized polyethylene molds containing self-curing resin with the crowns exposed. Each buccal crown surface was pumiced with a rubber prophylaxis cup in a low-speed conventional handpiece (KaVo Dental), washed for 10 seconds, and dried with a gentle continuous stream of oil-free compressed air.

The specimens were randomly divided into 6 experimental groups (n = 12): group 1, no bleaching plus bracket bonding (positive control); group 2, bleaching plus bracket bonding (negative control); group 3, bleaching plus 10% SA plus bracket bonding; group 4, bleaching plus 10% GT plus bracket bonding; group 5, no bleaching plus 10% SA plus bracket bonding; and group 6, no bleaching plus 10% GT plus bracket bonding.

Treatment

Group 1 received neither bleaching nor antioxidant treatment, and brackets were bonded to those specimens immediately after preparation.

Table 1. Mean (SD) shear bond strengths (in MPa) for the treatments in the study (n = 12 per group).

Treatment	SA	GT	Control
No bleaching	8.96 (2.24)^{Aa*}	9.19 (2.33)^{Aa*†}	6.91 (2.14)*
Bleaching	5.86 (1.60)^{Ab*}	7.00 (2.69)^{Aa*}	3.63 (1.36)†

Abbreviations: GT, green tea; SA, sodium ascorbate.

No bleaching + SA = group 5; no bleaching + GT = group 6; no bleaching + control = group 1; bleaching + SA = group 3; bleaching + GT = group 4; bleaching + control = group 2.

Means followed by the same superscript uppercase letter are not significantly different within the same row, representing differences between antioxidants ($P < 0.05$; Tukey test).

Means followed by the same superscript lowercase letter are not significantly different within the same column, representing differences within the same antioxidant ($P < 0.05$; Tukey test).

*Statistically significant difference from negative control group ($P < 0.05$; Dunnett test).

†Statistically significant difference from positive control group ($P < 0.05$; Dunnett test).

Specimens in groups 2-4 received bleaching treatment performed to simulate in-office techniques using 35% hydrogen peroxide (HP) (Whiteness HP Maxx, FGM Produtos Odontológicos). The bleaching agent was mixed and applied to the enamel surfaces for 15 minutes at 37°C. The specimens were washed for 30 seconds, and the bleaching agent was applied twice more for 15 minutes each, according to the manufacturer's instructions. Specimens in groups 5 and 6 also received no bleaching treatment. Immediately after bleaching, bracket bonding was performed on the group 2 specimens, as described in the next section.

The respective antioxidant (SA or GT) was then applied to the enamel surface of specimens in groups 3-6. For antioxidant application, individual trays were made using 1-mm-thick flexible polymer in a vacuum plasticizer (Plastivac P7, Bio-Art Equipamentos Odontológicos). Antioxidant gels—consisting of 10% SA (Fragon Produtos para Indústria de Borracha) for groups 3 and 5 and 10% GT (60% catechins and 5% caffeine, Fragon Produtos para Indústria de Borracha) for groups 4 and 6—were applied to the specimens for 1 hour at 37°C. In groups 3 and 4, the gels were applied immediately after bleaching; in groups 5 and 6, the antioxidants were applied immediately after specimen preparation. Bracket bonding was then performed for all antioxidant groups.

Bracket bonding

Enamel surfaces in all groups were polished with oil- and fluoride-free fine pumice and water using rubber cups and a low-speed handpiece; specimens were then washed and dried with an oil-free compressed air syringe. A single operator bonded standard stainless steel brackets (Gemini Roth, 3M ESPE) on all specimens in groups 1-6 using a conventional adhesive system (Transbond XT, 3M ESPE) according to the manufacturer's guidelines. After proper positioning, the brackets were subjected to a 450-g force, as verified with a tensiometer (Ormco Corporation).[20] Excess bonding resin was then removed with an exploratory probe. The adhesive was light cured (Radii Cal LED, SDI [North America] Inc) for 40 seconds (10 seconds each on the mesial, distal, gingival, and occlusal margins) at a 1200-mW/cm^2 intensity. The specimens were kept in distilled deionized water at 37°C until SBS analysis.

Shear bond strength analysis

After 24 hours, each specimen was loaded into a universal testing machine (DL 2000, EMIC Equipamentos e Sistemas de Ensaio Ltda). The knife-edged shearing blade was positioned parallel to the labial surface and bracket interface to allow transmission of the force in the occlusogingival direction. The machine was regulated at a crosshead speed of 0.5 mm/min and a load cell of 50 kgf. Failure load values (Newtons) were recorded and converted to megapascals by dividing the failure load by the surface area of the bracket base.

Adhesive remnant index

Immediately after bracket debonding, the enamel surface of each specimen was examined under 10× magnification with a stereoscopic loupe (Bel Photonics do Brasil Ltda) to determine the amount of residual adhesive. Adhesive remnant index (ARI) scores at the failure sites were recorded according to the classification of Artun & Bergland: score 0, no adhesive left on the tooth; score 1, less than half of the adhesive left on the tooth; score 2, more than half of the adhesive left on the tooth; and score 3, all of the adhesive left on the tooth.[21]

Statistical analysis

According to the Kolmogorov-Smirnov test of normality, SBS data from all groups were normally distributed. These data were therefore subjected to a 2-way analysis of variance (ANOVA) followed by Tukey multiple comparison test. The factors considered were bleaching vs no bleaching and SA vs GT antioxidant. The Dunnett test was used to compare the experimental groups with the negative and positive control groups. The ARI scores were compared with the Kruskal-Wallis test followed by the Dunn test. Results were considered statistically significant at $P < 0.05$.

Results

Table 1 shows the means and standard deviations of the SBS measurements. The ANOVA revealed no significant difference between antioxidants evaluated ($P = 0.484$) but significant effects with bleaching ($P < 0.0001$ vs no bleaching). The Dunnett test showed significant differences in SBS values between the negative control group (group 2) and all other groups. The SBS of the positive control group (group 1) differed significantly from those of groups 3-5 ($P < 0.0001$).

The analysis of the ARIs (Table 2) showed that group 1 was significantly different from group 4 ($P = 0.001$). Furthermore, group 1 presented a higher percentage of score 1 failure sites than did the other groups, which showed more score 0 failure sites.

Discussion

The present study demonstrated the ability of the antioxidants GT and SA to restore the SBS of bleached enamel to metallic brackets immediately after bleaching with 35% HP. Thus, the study hypothesis was accepted.

Several studies have examined interactions between bleaching agents, such as carbamide peroxide and HP, and the SBS of composite resin to enamel. Reduced SBS has been documented in teeth treated with 35% HP and immediately bonded with light-cured composite.[22,23] Several authors have also reported a significant reduction in the SBS of brackets bonded to enamel immediately after bleaching.[9,24]

In the present study, a significant reduction in SBS was observed in specimens treated with a simulated office bleaching technique and immediately subjected to bracket bonding. These results are in agreement with those of Patusco et al, who showed that bleaching with 35% HP significantly reduced the SBS and the amount of resin remaining on the tooth surfaces after bracket debonding, as can be seen in the negative control bleached group (group 2).[25] Similarly, Uysal et al used a 35% HP agent immediately or 30 days before bonding and found that bleaching significantly reduced the amount of resin remaining on tooth surfaces after debonding.[7] The percentages of sites assigned an ARI of score 0 were higher in the bleached groups, indicating a poor interaction of the tooth structure with the bonding system.[7]

Contrary to the results of the present study, Bishara et al and Uysal et al reported that bleaching with 10% hydrogen carbamide or 35% HP did not affect the SBS of orthodontic brackets to enamel.[7,26,27] The reduction of SBS after bleaching may be attributed to changes in the roughness and structure (such as organic content, calcium loss, and reduced microhardness) of enamel surfaces or the presence of residual oxygen from the bleaching agent, which either interferes with the resin infiltration of bleached enamel or inhibits resin polymerization.[4,28] Thus, the postponement of orthodontic bracket bonding for 2-3 weeks may be beneficial and prudent.[7,26]

Table 2. Frequency distribution (%) of adhesive remnant index (ARI) scores of the groups in the study (n = 12 per group).

	ARI score					
Group	0	1	2	3	Dunn test[a]	*P* value[b]
1	2 (16.7)	6 (50.0)	1 (8.3)	3 (25.0)	A	
2	9 (75.0)	2 (16.7)	1 (8.3)	0 (0.0)	AB	
3	9 (75.0)	2 (16.7)	0 (0.0)	1 (8.3)	AB	
4	9 (75.0)	3 (25.0)	0 (0.0)	0 (0.0)	B	0.001
5	7 (58.3)	3 (25.0)	1 (8.3)	1 (8.3)	AB	
6	6 (50.0)	1 (8.3)	3 (25.0)	2 (16.7)	AB	

Groups: 1, no treatment + bracket bonding (positive control); 2, bleaching + bracket bonding (negative control); 3, bleaching + 10% sodium ascorbate (SA) + bracket bonding; 4, bleaching + 10% green tea (GT) + bracket bonding; 5, no bleaching + 10% SA + bracket bonding; 6, no bleaching + 10% GT + bracket bonding.

[a]Groups with different letters are significantly different ($P < 0.01$; Dunn test).

[b]Kruskal-Wallis test.

The use of antioxidants to eliminate residual oxygen in the enamel structure immediately after bleaching, thereby enabling immediate realization of the adhesive procedure, has been studied.[3,9-11,18,29] SA (10%) has been examined most commonly, but a recent study found that 10% GT, a more powerful antioxidant, satisfactorily restored the SBS of adhesive restorations.[3,9,18,29] In the present study, GT and SA had significant effects on SBS after bleaching. These results corroborate those of previous studies, which found that 10% SA restored the SBS of bleached enamel to composite.[3,8,29] Lai et al suggested that antioxidants inverted the incorporation of peroxide ions and that SA allows free radical polymerization of the adhesive resin without premature interruption, thereby restoring the redox and binding potential of the substrate, thus reestablishing the affected ability to bond.[3]

GT gel is made from the leaves and buds of the shrub *Camellia sinensis,* which is rich in phenolic compounds and flavonoids.[30] The antioxidant actions of such phenolic compounds have been examined. Berger et al reported that a 60-minute application of 10% GT gel immediately after bleaching restored composite bonding strength to bleached enamel.[18] A similar effect—increased SBS vs no bleaching and negative control—was observed in the current study. Furthermore, the effects of GT were similar to those of SA, as reported previously.[18]

Kimyai et al evaluated the application of SA hydrogel or solution for 10 minutes or 3 hours.[9] The results of the 3-hour applications were similar to those of the 60-minute application of 10% SA gel obtained in the present study. Other studies have reported that the treatment of bleached enamel surfaces with SA solution for 10 minutes effectively restores SBS.[2,8] These conflicting results may be attributable to methodological differences among studies, such as in antioxidant application technique. Bulut et al stirred the SA solution on the enamel surface during the 10-minute application time, which may have enhanced the antioxidant effect on bleached enamel.[2,8] In the present study, a small amount of SA or GT gel was placed on the enamel surface, and then the specimens were placed in individual trays to simulate in-office practices.

Khamverdi et al found that a 10-minute application of EGCG significantly increased the SBS of composite resin to bleached enamel.[19] As EGCG is the most active and abundant catechin in GT, the authors of the current study speculate that it is the main component responsible for the capture of free radicals produced by bleaching.[30] In the present study, the GT used contained 60% catechins and no standardized EGCG content. In theory, if the EGCG content were standardized, the application time needed for successful results would be less than the 60 minutes used in this study.

Conclusion

Within the limitations of the present study, treatment with GT satisfactorily restored shear bonding strength in bleached enamel. However, additional clinical and laboratory studies are required before GT can be used in daily clinical practice.

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