

ORIGINAL ARTICLE

Effect of pine bark extract on bond strength of brackets bonded to bleached human tooth enamel

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Abstract

Aim. The purpose was to investigate the effect of pine bark (proanthocyanidin, natural antioxidant) solution on the shear bond strength (SBS) of metal brackets bonded with composite resin to human enamel after bleaching with hydrogen peroxide (HP). **Materials and methods.** Sixty recently extracted premolars were divided into an experimental group ($n = 45$), which was bleached with 40% HP, and a control group ($n = 15$), which was not bleached. The experimental group was further divided into three sub-groups. Specimens in group IB ($n = 15$) were bonded immediately after bleaching; specimens in group SA ($n = 15$) were bleached, then treated with 10% sodium ascorbate and then bonded; group PB specimens ($n = 15$) were bleached, then treated with 5% pine bark solution and bonded. The specimens were debonded with Universal testing machine. The adhesive remnant index was calculated. **Results.** No significant differences in shear bond strength were noted when the pine bark treated group was compared with the control group and sodium ascorbate group ($p > 0.05$). Treating the bleached enamel surface with 10% sodium ascorbate or 5% pine bark solution reverses the SBS reduction. **Conclusion.** So, as a natural antioxidant and less hazardous, clinicians can choose pine bark solution instead of sodium ascorbate.

Key Words: dental bonding, orthodontics, orthodontic brackets, antioxidant

Introduction

Increasing interest in esthetic dentistry has resulted in the widespread usage of vital bleaching [1]. There are many kinds of bleaching systems and these systems use different concentrations and different application types [2,3]. Vital tooth bleaching is a well accepted and reliable method [4]. One procedure for tooth bleaching carried out by dentists in clinics is by applying a high concentration of hydrogen peroxide (HP) solution [5,6]. Bleaching can be performed before or after fixed orthodontic treatment.

Several studies have shown that if at-home or in-office bleaching is used prior to any adhesive restoration or resin-bonded fixed appliances, the bond strength to tooth significantly decreases because of oxidation of the macromolecules of stains by bleaching [7,8]. Some researchers offered pre-treating enamel with alcohol or antioxidants such as sodium ascorbate, while some used adhesive-containing organic solvents [9,10]. Some researchers thought that the oxidation may be

reversed by applying antioxidants [11,12]. Because the reduction of resin bond strength to bleached enamel has been shown to be temporary, it can be offered to reschedule orthodontic bonding after the last bleaching session [13,14]. The waiting interval after the last bleaching session has been suggested to vary from 24 h to 4 weeks [15,16].

Sodium ascorbate is a non-toxic and biocompatible antioxidant when used as a 10% solution and it can reverse the reduced bond strength of bleached enamel. It was also found that the bond strength after applying sodium ascorbate was similar to the bond strength when bracketing was delayed for 1 week [17,18]. The naturally occurring antioxidants such as grape seed extract contain oligomeric proanthocyanidin complexes (OPCs). The OPCs have free radical scavenging activity, which is shown to be 50-times more potent than sodium ascorbate [19,20]. In the literature, there is a report implying the successful effect of sodium ascorbate, an artificial antioxidant, on bleached teeth, but there are not so many reports on

natural antioxidants [18]. According to our hypothesis the reverse effect of pine bark extract on increasing shear bond strength may be more than the reverse effect of sodium ascorbate.

To the best of our knowledge, to date there are no reports on the effects of OPCs on bleached enamel in orthodontic literature. The primary aim of this study was to determine if the shear bond strength of metal orthodontic brackets, immediately bonded to HP-bleached enamel tissues, increases after application of pine bark extract solution, a natural antioxidant agent. The other aim is to compare the effects of 10% sodium ascorbate vs 5% OPCs on the bond strength of bleached teeth.

Materials and methods

Preparation of specimens

This randomized, controlled laboratory study was carried out in the research center of the Faculty of Dentistry of Selcuk University in Konya, Turkey. Sixty-four sound, consecutive, human maxillary premolars freshly extracted for orthodontic indication were collected. Teeth with hypoplastic areas ($n = 2$), gross irregularities ($n = 1$) or cracks ($n = 1$) were excluded. Following extraction, residue on the teeth was removed and washed under running tap water. The teeth were stored in distilled water and the water was changed weekly to avoid bacterial growth. The 60 teeth samples were randomly divided into four groups of 15 teeth each. The teeth were randomized using an internet-based computer program. A power analysis was established by G*Power software (Ver. 3.0.10; Franz Faul, Universitat Kiel, Germany). A total sample size of 60 teeth would give more than 70% power to detect significant differences with a 0.40 effect size between four groups and at a $p = 0.05$ significance level.

All teeth were mounted vertically in self-cure acrylic, so that the crowns were exposed. Then, the buccal surfaces were cleaned and polished with a rubber cup and slurry with pumice and water, followed by rinsing with a water spray and drying with compressed air.

Specimens were prepared for bracket bonding according to one of the following procedures (Table I):

- *Control Group (C)*, 15 premolars were separated as the control group. The teeth were not bleached.
- *Immediately Bonded Group (IB)*, a commercially available 40% HP bleaching gel (Opalescence Xtra Boost; Ultradent Products, South Jordan, UT) was activated with a syringe-to-syringe mixing process. A 1-mm thick layer of the bleaching gel was applied on the labial surface of each tooth. The gel was removed 20 min after application. This gel contains HP, which is chemically activated when mixed and does not need light activation. Immediately after bleaching, all teeth were bonded with brackets.

Table I. Groups and treatment methods before bonding.

	Treatment method
Group C	Not bleached before bonding
Group IB	Bonded immediately after bleaching
Group SA	Treated with 10% sodium ascorbate after bleaching
Group PB	Treated with 5% pine bark solution after bleaching

- *Sodium Ascorbate Group (SA)*, specimens in this group were bleached with the same procedure described for group IB. Then, the buccal surfaces of the teeth were treated with 10% sodium ascorbate and bonded with brackets.
- *Pine Bark Group (PB)*, specimens were bleached; then buccal surfaces were treated with 5% pine bark solution. Then, teeth were bonded with brackets (Table I).

Standard edgewise-premolar stainless steel brackets (G&H Wire Company, Greenwood, IN) with a base surface area of 10 mm² were bonded to the teeth (bracket base dimensions were provided by G&H). A 37% phosphoric acid gel (3M Unitek) was applied to the buccal surface of each tooth for 15 s. Then, the teeth were rinsed with water and dried until the buccal surfaces appeared to be chalky white. Transbond sealant (3M Unitek) was applied on the etched surface. The adhesive (Transbond XT; 3M Unitek) was then cured with a visible curing light unit (Elipar S10; 3M ESPE, Seefeld, Germany) for 20 s.

Application of antioxidants

Group SA specimens were treated as described by a previous study [18]. The 10% sodium ascorbate was prepared as follows: 10 g of sodium ascorbate (S.D. Fine CHEM Limited, Mumbai, India) was dissolved in 100 mL of distilled water. Then 10 mL of this solution was dripped on the enamel surfaces after bleaching and agitated with a sterile brush. After 10 min, it was washed and dried. Then, the brackets were bonded.

Group PB specimens were treated as follows: 5 g of pine bark extract in the form of powder (Cactus Botanicals, Long Beach, CA) was collected and dissolved in 100 mL of distilled water to make a 5% pine bark solution. The labial surfaces of the specimens were treated with (agitated with sterile brush) 5% pine bark solution for 10 min and rinsed. Then, the brackets were bonded.

Mechanical tests

The shear bond strengths were measured with a universal testing machine (Instron Corp., Canton, MA) at a cross-head speed of 1 mm/min, using a

Table II. Descriptive statistics of shear bond strengths in MPa and comparison of the groups.

	<i>n</i>	Min	Max	Mean ± SD	Comparison*
Group C	15	3.25	15.74	9.91 ± 4.08	A
Group IB	15	2.67	9.19	6.43 ± 2.12	B
Group SA	15	3.43	33.07	15.5 ± 8.76	A
Group PB	15	5.32	29.6	13.76 ± 7.58	A

* Mann-Whitney U-test with Bonferroni correction, $p < 0.0167$, groups with different letters are significantly different from each other.

SD, Standard deviation.

100 g load cell. Incisal-to-cervical shear force was applied close to the tooth-bracket interface. The load at failure was recorded. The data for the applied load were standardized by dividing the force to failure with the entire surface area of the bracket base and expressed in MPa.

Residual adhesive

A stereomicroscope (Olympus Co, Tokyo, Japan) at $\times 16$ magnification was used to determine the enamel surfaces and bracket bases. The adhesive remnant index (ARI) was used to classify failure patterns observed in specimens [21]. The scoring criteria of the index were as follows: a score of 0 was assigned when no adhesive was left on the tooth surface; (1) less than half of the adhesive left on the tooth surface; (2) when half of the adhesive or more was left on tooth surface; and (3) when all of the adhesive was left on the tooth surface or failure between adhesive and bracket base [21].

Statistical analysis

The shear bond strength data of the groups were subjected to a test of normality, Kolmogorov-Smirnov test. Non-normal distributions were observed, so a non-parametric test (Kruskal-Wallis) was used to determine the significance between the groups. Mann-Whitney U-test with Bonferroni correction was performed to determine the differences between the groups. The pre-determined level of significance ($p < 0.05$) was re-set as $p < 0.0167$ after Bonferroni correction. The ARI scores were evaluated by means of chi-square analysis. All statistical analyses were processed with the Statistical Package for the Social Sciences software system (SPSS 13, SPSS, Chicago, IL).

Results

Descriptive statistics of shear bond strengths in MPa and comparison of the groups are shown in Table II. The Kruskal-Wallis test revealed that there were significant differences between the four groups

Table III. Comparison of adhesive remnant indices of groups.

	<i>n</i>	1	2	3
Group C	15	2	7	6
Group IB	15	6	4	5
Group SA	15	4	8	3
Group PB	15	5	5	5

ARI scores: 1 = less than half of the adhesive left on the tooth surface, 2 = half of the adhesive or more left on the tooth surface, 3 = all adhesive left on the tooth surface.

($p = 0.000$). According to Mann-Whitney tests with Bonferroni correction, statistically significant differences were seen between group IB and the other groups (group C, group SA and group PB, $p = 0.014$, $p = 0.000$, $p = 0.001$, respectively).

Tooth surface and bracket base examination after de-bonding indicated that resin can adhere to the base or to the tooth surface. The ARI examination was used to assess the amount of resin left on the tooth surfaces (Table III). Chi-square analysis of the ARI scores revealed that there is no difference between groups ($p = 0.570$). Totally, there was a high frequency of ARI score of 2, which indicated that some amount of adhesive was left on the tooth and bracket base.

Discussion

Based on the results of this randomized and controlled study, the bleaching process decreased the shear bond strength of brackets. This reduction was reversed by treating enamel surfaces with 10% sodium ascorbate solution and 5% pine bark extract solution. There was no significant difference between Group PB and Group SA.

Vital tooth bleaching is one of the commonly used effective treatment modalities to treat discolored teeth. Some studies have shown that reduction in bond strength of composite post-bleaching is due to residual oxygen and the residual oxygen is released from the bleaching product and inhibits the polymerization of resin [16,22]. In a similar study, it was found that, between bleached enamel and resin, there were fragmented and poorly refined resin tags when compared to the unbleached groups [23]. Loss of calcium, decrease in micro hardness and changes in organic substance added to bleaching's effects [24].

During bleaching with HP, hydrogen radicals are substituted by peroxide ions, resulting in the formation of peroxide-apatite. After storing for 2 weeks, peroxide decomposes and substituted hydroxyl radicals re-enter the apatite lattice, resulting in annihilation of the structural changes caused by the unification of peroxide ions [25]. The inclusion of peroxide ions may be reversed by the use of antioxidants [8].

Sodium ascorbate and its salts can be used as antioxidants and are capable of reducing oxidative compounds, especially free radicals [17,26]. Sodium ascorbate allows free radical polymerization of the resin to proceed without early terminations, so ascorbate can reverse the compromised bonding [27,28]. In another *in vitro* bond strength related study, it was reported that treatment of the bleached enamel surface with 10% sodium ascorbate or 5% seed extract solution (proanthocyanidin) increases the reduced bond strength [29]. In our study, the use of sodium ascorbate (group 2) as an antioxidant reversed the negative effects of HP. So this is shown by an increase in shear bond strength when compared with the control group; in which no antioxidant was applied. Our results are concordant with similar studies performed by several researchers [8,17,18].

The reversal of reduced bond strength can be made by using sodium ascorbate. As viable alternatives to sodium ascorbate, the researches on OPCs are rare and should be increased. In our study, the use of OPCs as antioxidants before bonding on bleached enamel was preferred and performed. Additionally, research [30] reported that a minimum bond strength of 8 MPa is enough for most orthodontic clinical usages. In our study, all bond strength values, except for Group IB, were greater than this minimum requirement.

Proanthocyanidins are found in natural sources such as grape seed extract, pine bark extract and cranberries [19]. Because OPCs are naturally occurring plant metabolites, they have been proven to be safe as antioxidants in dietary supplements and clinical usages [19,31]. OPC products have been reported to show anti-viral, anti-bacterial, anti-allergic and anti-inflammatory properties. There are also material safety analyses about the extracts including OPCs and sodium ascorbate. According to these analyses, the level of health hazard for sodium ascorbate is higher than OPCs. Additionally sodium ascorbate is mutagenic for mammalian somatic cells, while OPCs have no mutagenic effect when their material safety data are examined (www.sciencelab.com).

Some *in vitro* research proved that antioxidant potential and the free radical scavenging ability of OPCs are greater than vitamins C and E [19,20]. It is also reported that treatment of the bleached enamel surface with 5% proanthocyanidin reverses the reduced bond strength and the use of proanthocyanidin yields an ideal enamel bond strength when a restoration is to be completed immediately after bleaching [29]. Some naturally occurring antioxidants such as pine bark and grape seed extract have OPCs that have free radical scavenging activity, which is shown to be 50-times more potent than sodium ascorbate [19]. So it can be concluded that, when preparing solutions, a researcher can use a lower concentration of grape seed or pine bark extract than sodium ascorbate.

Our study also had some limitations: For each type of antioxidant, only one concentration was demonstrated. Further studies are needed to evaluate the differences between different concentration/types of OPCs and sodium ascorbate. To raise the power of the study, the sample size of each group can be increased.

Conclusion

With the limitations of the study; the conclusions are as follows; vital bleaching with HP adversely affected the shear bond strength of orthodontic brackets when bracketing was applied immediately after bleaching. Treatment of bleached enamel with 5% pine bark solution (proanthocyanidin) reverses the reduced bond strength as 10% sodium ascorbate does. So, using proanthocyanidins can be beneficial for bonding success immediately after bleaching and can be an alternative to delayed bonding. The use of pine bark extracts as an antioxidant yields almost the same bond strengths when compared with 10% sodium ascorbate.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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