

Comparison of the Effect of Hydrogel and a Solution of Sodium Ascorbate on Dentin-composite Bond Strength After Bleaching

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Abstract

Aim: The aim of this study was to compare the effects of solution and different sodium ascorbate hydrogels on dentin-resin composite shear bond strength subsequent to a bleaching procedure with 10% carbamide peroxide.

Methods and Materials: Sixty buccal dentin surfaces obtained from intact human third molars were randomly divided into five groups (n=12). Dentin surfaces received different treatments: (1) no treatment; (2) bleaching (10% carbamide peroxide gel); (3) bleaching + 10% sodium ascorbate solution; (4) bleaching + 10% sodium ascorbate hydrogel, and (5) bleaching + 20% sodium ascorbate hydrogel. Dentin surfaces were bonded with Single Bond™ and restored with a composite (Z100). The samples were tested for shear bond strengths. Data was analyzed using analysis of variance (ANOVA) and Tukey tests.

Results: Significantly higher bond strengths were observed subsequent to treatment with hydrogel and solution forms of sodium ascorbate ($p < 0.05$). No significant differences were demonstrated between different forms of sodium ascorbate preparations. In addition, no significant differences were observed among groups with antioxidant treatment (Groups 3, 4, and 5) and Group 1 (no treatment).

Conclusion: Reduced bond strength to bleached dentin can be amended by the use of sodium ascorbate as an antioxidant.

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Clinical Significance: Both hydrogel and solution forms of sodium ascorbate can significantly improve the reduced bond strength of resin composite to dentin subsequent to a bleaching procedure with 10% carbamide peroxide.

Keywords: Bleaching, bond strength, dentin, hydrogel, sodium ascorbate

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Introduction

Nonvital bleaching techniques are successfully used to return root-filled teeth to a desirable color.¹ Traditionally, 30% hydrogen peroxide solution alone, with heat activation or in combination with sodium perborate is used for nonvital bleaching.² However, external root resorption following nonvital bleaching is an important aspect to be considered.¹ While the causes of this resorption are not fully known, a review of the literature indicates a number of possible causes such as heat application and penetration of hydrogen peroxide through the dentinal tubules into the cervical periodontal ligaments and initiation of a local inflammatory reaction.³ A safer option for nonvital bleaching is the use of an inside/outside bleaching technique. A 10% carbamide peroxide is applied in a tray for a tooth prepared for the traditional walking bleaching technique, and bleaching takes place simultaneously inside and outside the tooth.² It has been reported this technique can be successfully used for bleaching nonvital teeth.^{4,5}

Ten percent carbamide peroxide has been shown to adversely affect the dentin-resin composite bond strength when bonding is performed immediately after bleaching.⁶ Some authors have recommended delays in restorative procedures to avoid clinical problems related to compromised bond strength.^{2,7,8}

Recent investigations have shown a reduction in dentin-resin composite bond strength following bleaching can be reversed with the use of sodium ascorbate solution as an antioxidant.^{9,10} However, application of the solution form of sodium ascorbate requires an extended amount of chair time which may not be clinically acceptable. Patients themselves can place the gel form of sodium ascorbate in the bleaching tray before bonding.¹¹ In the present study two hydrogel

forms of sodium ascorbate were prepared (10% and 20%), and the impact of the solution and hydrogel forms of sodium ascorbate on the dentin-resin composite shear bond strengths subsequent to bleaching was evaluated.

Methods and Materials

Sixty intact extracted human third molars were selected for the purpose of this study. The teeth were extracted and collected over a two-month period. Subsequent to extraction, the teeth were cleaned of any residues and stored in a 1% chloramine solution.

Preparation of the Specimens

A water-cooled diamond bur was used to separate the roots of all the teeth. The specimens were placed in self-cured acrylic resin (Triplex, Ivoclar Vivadent AG, FL-9494 Schaan/Liechtenstein) with their buccal surfaces facing upwards. The samples were placed in cold water until the resin was completely cured in order to minimize the thermal influences during the curing process of the resin. The buccal surfaces of the teeth were ground with 180 grit wet silicon carbide paper until dentin surfaces were visible. A light microscope (Olympus, Model CH30RF200, Olympus Optical Co., LTD, Japan) was used to confirm the exposure of dentin. Four hundred and 600 grit wet silicon carbide abrasive papers were used to polish dentin surfaces. The samples were randomly divided into five groups. Each group was treated as shown in Table 1.

Bleaching

A 10% carbamide peroxide bleaching gel (VivaStyle, Ivoclar Vivadent AG) was applied to the dentin surfaces of the embedded teeth at 100% relative humidity for eight hours. The specimens were partially immersed in distilled water at 37°C in a glass laboratory beaker so the

Table 1. Study groups.

Groups	Bleaching Treatment	Antioxidant
1	None	None
2	10% carbamide peroxide gel	None
3	10% carbamide peroxide gel	10% sodium ascorbate solution
4	10% carbamide peroxide gel	10% sodium ascorbate hydrogel
5	10% carbamide peroxide gel	20% sodium ascorbate hydrogel

dentin surfaces coated with bleaching gel did not contact the distilled water. Then the specimens were thoroughly rinsed with distilled water and air dried.

Preparation of the Solution and Hydrogels

Carbomer (Carbopol 934) was obtained from Noveon (Brussels, Belgium). Sodium ascorbate (L (+) ascorbic acid sodium salt) was procured from Fluka (Buchs, Switzerland). All other chemicals were of analytical grade. The solution containing sodium ascorbate (10%) was prepared by a method in which sodium ascorbate was dissolved in purified water by mixing at room temperature (pH=7.5). The carbopol gel (2.5% [wt/wt]), which contained sodium ascorbate (10% and 20%), was prepared by gently mixing and dispersing the carbopol resin in purified water containing sodium ascorbate. The mixture was agitated until it thickened. Then it was neutralized by the dropwise addition of triethanolamine until a transparent gel was produced. Triethanolamine concentration was modified so a gel pH of 7.5 was achieved.

Application of Antioxidant

The samples were immersed in 10% sodium ascorbate solution for three hours (Group 3). Sodium ascorbate was used for at least one-third of the application time of the oxidizing bleaching agent to neutralize the oxidizing effect of carbamide peroxide according to a previously described method.¹¹ Ten percent and 20% sodium ascorbate hydrogels were applied to the surfaces of the samples at 100% relative humidity for three hours in Groups 4 and 5, respectively. Then, the samples were rinsed and submerged in distilled water for ten minutes to dissolve the sodium ascorbate crystals on the bonding surfaces.

Preparation of Resin Composite

Only one composite cylinder was used in each sample. Holes, 3 mm in diameter, were prepared in acetate strips (Hawe Neos Dental, Bioggio, Switzerland) to achieve an adhesive bond to the spaces where the composite cylinder was to be bonded. These acetate strips harbored holes fixed to the surface of the samples (Figure 1).



Figure 1. A sample with acetate strip in place.

Subsequent to an etching procedure with 35% phosphoric acid (3M Scotchbond™ Etchant, 3M Dental Products, St. Paul, MN, USA), the adhesive (Single Bond™, 3M Dental Products) was applied to the open surface on the sample according to the instructions provided by the manufacturer. After strip removal, Teflon® molds containing cylindrical shaped holes of 3 mm in diameter and 6 mm in length were placed on the adhesive-applied surfaces so they completely covered the adhesive (Figure 2).

Three layers of composite resin (Z100, 3M Dental Products) were placed into the hole, and each layer (2 mm) was light-cured for 40 seconds with a conventional quartz halogen light-curing unit (Coltolux 4, Coltene/Whaledent Inc., Mahwah, NJ,

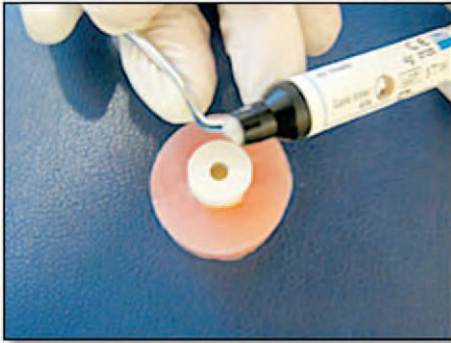


Figure 2. A sample with a Teflon® mold.

USA). A built-in curing radiometer confirmed a light intensity of at least 400 mw/cm² before the start of each experimental session. The samples were kept in distilled water for 24 hours at 37°C after the Teflon® molds were removed.

Testing and Data Analysis

Shear bond strengths of the samples were analyzed in a universal testing machine (Instron Limited, Model 1195, Bucks, England). The machine was adjusted at a crosshead speed of 1 mm/minute. Data was directly transferred into a computer, and shear bond strengths in MPa were calculated. Data was analyzed using a two-factor analysis of variance (ANOVA) and the Tukey test at a significance level of $p < 0.05$.

Results

The mean shear bond strength values and standard deviations in MPa are shown in Table 2. The ANOVA indicated a statistically significant difference among the groups as a result of differences in sample treatment procedures ($P < 0.0001$). Therefore, data was further analyzed by using the Tukey test which indicated a statistically significant decrease in bond

strength compared to Group 1 [no treatment] when bonding was performed immediately after bleaching (Group 2) ($p = 0.001$). In addition, shear bond strengths in all groups with antioxidant treatments were significantly higher than in Group 2 without antioxidant treatment ($p < 0.05$), and there were no significant differences in shear bond strengths among the three groups with antioxidant treatments ($p > 0.05$). Furthermore, there was no significant difference among groups with antioxidant treatment (Groups 3, 4, and 5) and Group 1 with no treatment ($p > 0.05$).

Discussion

Reduced bond strength following nonvital bleaching with 10% carbamide peroxide threatens the success rate of both the bleaching procedure and endodontic treatment.² A shear bond strength test is the common procedure used for the evaluation of the bonding efficacy of dental materials.¹² This method was used in the present study to compare the impact of different treatment modalities on dentin-resin composite shear bond strength subsequent to a bleaching procedure.

A significant limitation in the present study was the use of the superficial dentin to evaluate the effect of bleaching and antioxidant agents on dentin, according to a previously described method.⁹ Dentin moisture and regional structural differences are important factors that can affect the bond strength to dentin.¹³ Therefore, further research on the bond strength to dentinal walls of the pulp chamber is warranted using special methods such as a microtensile bond test, which allows testing various regions of dentin.

The results of the present study demonstrated bleaching with 10% carbamide peroxide has

Table 2. Shear bond strengths (MPa) for the different groups.

Group	n	Mean*	SD
1 (no treatment)	12	23.03 ^a	2.14
2 (bleaching)	12	16.72 ^b	2.68
3 (bleaching + 10% sodium ascorbate solution)	12	21.89 ^a	4.51
4 (bleaching + 10% sodium ascorbate hydrogel)	12	22.83 ^a	4.72
5 (bleaching + 20% sodium ascorbate hydrogel)	12	21.30 ^a	3.70

Note: * Values with the same letter are not significantly different at $p < 0.05$.

a deleterious effect on dentin-resin composite bond strength when the bonding procedure is performed immediately after bleaching. These findings are consistent with the results of previous studies.^{6,7} It has been suggested the decrease in bond strength might be attributed to the accumulation of oxygen in dentin, since dentin acts as an oxygen reservoir.^{7,14} The release of oxygen might interfere with resin infiltration into etched dentin or polymerization of resins that cure via a free-radical mechanism.^{9,15,16} Therefore, composite restorations should be delayed after a bleaching procedure. Some authors have suggested delays in restorative procedures in order to avoid reduced bond strength following bleaching.^{2,7} This interval has been suggested to vary from 24 hours to four weeks.⁸

According to the results of some studies, the use of alcohol-based bonding agents can decrease the adverse effect of bleaching agents on composite bond strength when restorative work is to be completed immediately after bleaching.^{17,18} On the contrary, Shinohara et al.¹⁹ reported the use of water/alcohol and acetone-based adhesive systems does not reverse the effects of bleaching procedures on bond strength. In addition, the results of the present study demonstrated the use of Single Bond™ (water/ethanol-based adhesive system) does not reverse the adverse effects of the bleaching agent.

Recent studies have demonstrated a decrease in dentin-resin composite bond strength subsequent to a bleaching procedure is reversed with the use of 10% sodium ascorbate antioxidant solution.^{9,10} The antioxidant ability of sodium ascorbate helps neutralize and reverse the oxidizing effects of the bleaching agent.^{10,11} In addition, it is possible by restoring the altered redox potential of the oxidized bonding substrate sodium ascorbate allows free-radical polymerization of the adhesive to proceed without premature termination, reversing the compromised bond strength.¹⁰ In the present study two different concentrations (10% and 20%) of sodium ascorbate hydrogel were prepared. Perhaps 10% sodium ascorbate hydrogel might not be as effective as 10% sodium ascorbate solution because the additives within the hydrogel may reduce the efficacy of the material (that is, decreased diffusivity of ascorbate). As a result, the 20% sodium

ascorbate hydrogel was also prepared. According to the results of the present study, the shear bond strength of composite restorations after antioxidant application subsequent to a bleaching procedure was higher than composite restorations placed immediately after bleaching without antioxidant treatment. In addition, there were no significant differences between Group 1 (no treatment) and Groups 3, 4, and 5 with antioxidant treatment. Therefore, it is suggested sodium ascorbate may reverse the oxidative effects of the bleaching agent. These results are consistent with those of Turkun and Turkun² who reported the treatment of access cavities and pulp chambers with 10% sodium ascorbate solution following bleaching restores the sealing ability of resin composites. Furthermore, the results of the present study coincide with the results of other studies reporting decreases in dentin bond strengths being reversed subsequent to treatment with 10% sodium ascorbate solution.^{9,10} Moreover, there were no statistically significant differences among different forms of sodium ascorbate. Therefore, it is suggested sodium ascorbate hydrogel might be as effective as the solution form of sodium ascorbate when similar concentrations are used. In addition, 10% sodium ascorbate hydrogel might be as effective as 20% sodium ascorbate hydrogel in neutralizing the oxidizing effects of the bleaching agent and increasing the bond strength.

Ascorbic acid and its salts are well-known antioxidants and are capable of reducing a variety of oxidative compounds, especially free radicals.² Since ascorbic acid (Vitamin C) and its salts are non-toxic and widely used in the food industry as antioxidants, it is unlikely their intraoral use will result in any adverse biological effects or clinical hazards.^{9-11,20}

According to this study, the use of sodium ascorbate hydrogel for three hours could neutralize the oxidizing effects of bleaching agents and increase the dentin bond strength. Further studies are required to determine the minimal time necessary for the treatment of access cavities with sodium ascorbate hydrogel after nonvital bleaching. Using this method, the need for delays to achieve the normal dentin bond strength can be eliminated. In addition, hydrogel is easy to apply and is less expensive for patients compared to the application of sodium ascorbate solution by the

dentist because of the shorter chair time needed. Manipulation of sodium ascorbate solution is more difficult compared to hydrogel, and the solution should be used several times prior to bonding. As a result, a hydrogel formulation can decrease the cost and duration of a restorative procedure.

In the present study the teeth were bleached for eight hours, consistent with a previous study.¹¹ Other studies should evaluate longer periods of bleaching to further simulate clinical situations. Moreover, failure mode and scanning electron

microscope (SEM) evaluations of dentin-resin composite interface should be carried out in future studies.

Conclusion

1. Bleaching with 10% carbamide peroxide adversely affected the dentin-resin composite bond strength when the bonding procedure was performed immediately after bleaching.
2. Different kinds of sodium ascorbate treatments (10% solution form, 10% hydrogel and 20% hydrogel forms) following bleaching reversed the reduced dentin bond strength.

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