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The Effect of Hydrogel and Solution of Sodium Ascorbate on Bond Strength in Bleached Enamel

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Clinical Relevance

Both forms of sodium ascorbate (hydrogel and solution) can significantly increase the bond strength of resin composite to enamel after bleaching.

SUMMARY

Compromised bonding to bleached enamel can be reversed with sodium ascorbate as an antioxidant. This study evaluated the effect of hydrogel and solution of sodium ascorbate on enamel-resin composite shear bond strength after bleaching. Sixty buccal enamel surfaces obtained from human, sound third molars were randomly divided into 4 groups (n=15). Enamel surfaces were subjected to different treatments: 1) bleaching (10% carbamide peroxide gel); 2) bleaching + 10% sodium ascorbate solution; 3) bleaching + 10% sodium ascorbate hydrogel and 4) bleaching + 20% sodium ascorbate hydrogel. The specimens were bonded with Single Bond and restored with a composite. The specimens were prepared for shear bond testing. The data was evaluated using ANOVA and Tukey tests. Bond strengths were significantly increased following hydrogel and solution of sodium ascorbate treatments ($p<0.05$). Also, there was no significant difference among the different forms of sodium ascorbate preparations.

INTRODUCTION

The esthetic treatment of anterior teeth is an important aspect of modern dentistry. A common method for treating discolored teeth is to bleach them using a mouthguard. This technique requires the application of a carbamide peroxide gel in a custom-made tray (Ben-Amar & others, 1995). Previous studies have shown that carbamide peroxide beaching agents adversely affect the bond strength of composite to acid-etched enamel when bonding is performed immediately after the bleaching procedure (Titley, Torneck & Ruse, 1992; García-Godoy & others, 1993). It is related to the possible presence of residual peroxide, which interfered with resin attachment and inhibited resin polymerization (Titley & others, 1991; Dishman, Covey & Baughan, 1994). Compromised bonding to carbamide peroxide-bleached enamel can be reversed with 10% sodium ascorbate solution before resin bonding (Lai & others, 2002). Sodium

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ascorbate solution is a neutral, biocompatible antioxidant.

In this study, a hydrogel form of sodium ascorbate was prepared (10% and 20%), and the effect of the solution and hydrogel forms of sodium ascorbate on the enamel-resin composite shear bond strength after bleaching was compared.

METHODS AND MATERIALS

Sixty sound, extracted human third molars were selected for this study. Following extraction, residue on the teeth was removed and washed away, and the teeth were stored in a 1% chloramine solution. All teeth used in this study were extracted in the course of 2 months.

Preparation of Specimens

The roots of all teeth were separated using a water-cooled diamond bur. Self-cured acrylic resin was loaded into a heavy body silicon matrix and the specimens were placed in the acrylic resin in such a way that their buccal surfaces faced up. The samples were kept in cold water until the resin was completely cured, in order to avoid the thermal effects generated by the resin curing process. The buccal surfaces of the teeth were sandblasted with 50 µm alumina according to the previously described method (Lai & others, 2002) to provide bonding surfaces that were devoid of surface aprismatic enamel. The samples were randomly divided into 4 groups, where each group was treated as shown in Table 1.

Bleaching

Bleaching gel (VivaStyle, Ivoclar Vivadent AG, FL-9494 Schaan/Liechtenstein), containing 10% carbamide peroxide, was placed on the surfaces of the samples at 100% relative humidity for 8 hours, according to the previously described methods (Ben-Amar & others, 1995; Lai & others, 2002). Also, other studies reported that home bleaching with 10% carbamide peroxide comprises daily applications of 5 to 8 hours (Haywood, 1992; Haywood & Robinson, 1997). The samples were then rinsed with distilled water.

Preparation of the Solution and Hydrogels

Carbomer (Carbopol 934) was supplied by Noveon (Brussels, Belgium). Sodium ascorbate (L (+) Ascorbic acid sodium salt) was obtained from Fluka (Buchs, Switzerland). All other chemicals were of analytical grade. The solution containing sodium ascorbate (10%) was prepared by dissolving sodium ascorbate in purified water under mixing at room temperature. The carbopol gel (2.5% [wt/wt]) containing sodium ascorbate (10 and 20%) was prepared by dispersing the carbopol resin in purified water containing sodium ascorbate under gentle mixing. The mixture was stirred until thickening occurred and then neutralized by dropwise addition of thriethanolamine until a transparent gel appeared. The quantity of thriethanolamine was adjusted to achieve a gel pH of 7.

Application of Antioxidant

The samples in Group 2 were immersed in 10% sodium ascorbate solution for 3 hours to neutralize the oxidizing effect of carbamide peroxide according to the method described by Lai and others (2002). They reported that compromised bonding in bleached enamel could be effectively reversed with sodium ascorbate when it was used for at least 1/3 of the time of application of the oxidizing bleaching agent. Ten percent and 20% sodium ascorbate hydrogels were placed on the surfaces of the samples at 100% relative humidity for 3 hours in Groups 3 and 4, respectively. The samples were then rinsed and immersed in distilled water for 10 minutes to dissolve the sodium ascorbate crystals that were deposited on the bonding surfaces.

Preparation of Resin Composite

Only 1 composite cylinder was applied to each sample. Holes 3 mm in diameter were cut in Mylar strip bands to ensure that the adhesive adhered to the spaces where the composite cylinder was bonded; these Mylar strip bands contained holes that were fixed to the surface of the sample. After etching with phosphoric acid, adhesive (Single Bond, 3M, Dental Products, St Paul, MN, USA) was applied to the open surface on the sample according to the manufacturer's recommendations. After the band was removed, transparent molds containing cylindrical shaped holes 3 mm in diameter and 6 mm in length were placed on the adhesive-applied surfaces so that they covered the entire adhesive. Resin composite (Z100; 3M Dental Products) was placed into the hole in 2 layers; each layer was light cured for 40 seconds with a conventional quartz halogen LC unit (Astralis 7, Ivoclar Vivadent). Additional light curing was done from the underside of the cylinder. After removing the transparent molds, the samples in the matrix were removed from the container and placed in distilled water. They were then kept in distilled water at 37°C for 24 hours. Shear bond strengths of the samples were analyzed in a universal testing machine, Model 1195 (Instron Limited, Bucks, England). The machine was set with a crosshead speed of 1-mm/minute. The data was directly converted into a

Table 1: *Study Groups*

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

computer and shear bond strength in MPa was calculated. The data was analyzed by ANOVA (1-way analysis of variance) and Tukey test.

RESULTS

Figure 1 summarizes the results of the shear bond strength tests. The analysis of variance indicated a statistically significant difference among the groups ($p<0.05$) due to the sample treatment. Therefore, the data was further analyzed by Tukey test. The Tukey test indicated that the shear bond strengths of all groups with antioxidant treatments were significantly higher than Group 1 (without antioxidant treatment), and there was no significant differences in shear bond strength among 3 groups with antioxidant treatments.

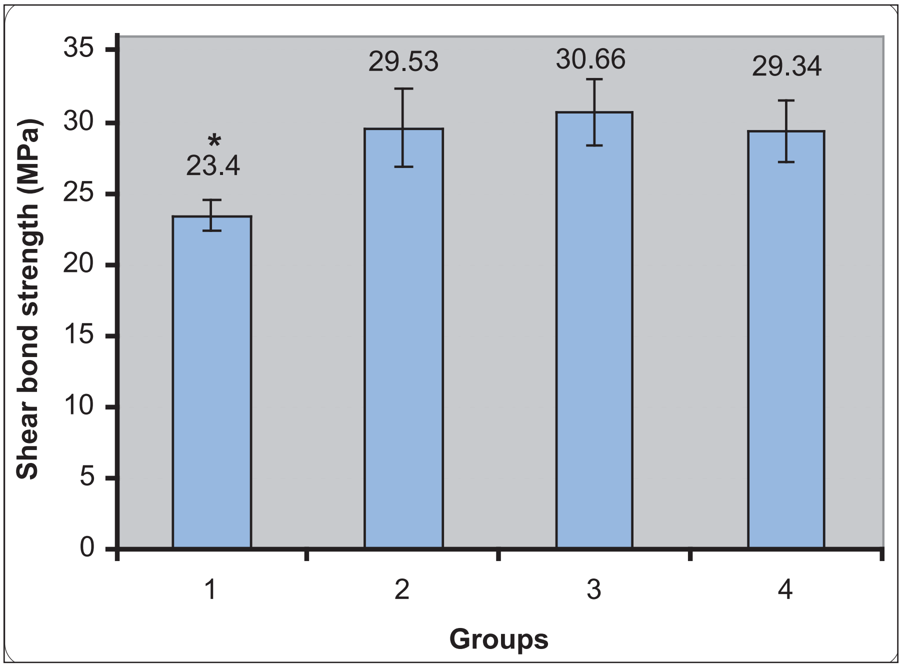

Figure 1. *Mean shear bond strength in study groups (n=15 $\alpha=0.05$, *statistically significant [$p<0.05$]).*

DISCUSSION

Reduction in bond strength due to bleaching with carbamide peroxide has been evaluated *in vitro* (Stokes & others, 1992; García-Godoy & others, 1993; Ben-Amar & others, 1995), and it is likely to be caused by a delayed release of oxygen that could either interfere with resin infiltration into etched enamel or inhibit polymerization of resins that cure via a free-radical mechanism (Rueggeberg & Margeson, 1990; Lai & others, 2001). It has been reported that it takes 2 to 3 weeks for the enamel to return to conditions that lead to normal bond strength (Cavalli & others, 2001; Lai & others, 2002). Similarly, pretreatment of bleached enamel with alcohol and the use of adhesives containing organic solvents can result in the complete reversal of the reduced enamel bonds (Barghi & Godwin, 1994; Sung & others, 1999). Also, compromised bonding to acid-etched bleached enamel was reversed with a 10% sodium ascorbate solution (Lai & others, 2002). The antioxidant ability of sodium ascorbate helped to neutralize and reverse the oxidizing effects of bleaching agents (Lai & others, 2001, 2002). Also, it is possible that, 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 and, hence, reverse the compromised bonding (Lai & others, 2001). However, application of the solution form of sodium ascorbate involves a long period of time, which may not be clinically acceptable. Patients, themselves, can place the gel form of sodium ascorbate in the bleaching tray before bonding (Lai & others, 2002).

In this study, sodium ascorbate hydrogel was prepared in 2 concentrations (10% & 20%). It was speculated that 10% sodium ascorbate hydrogel might not be effective as sodium ascorbate solution, because the additives within the hydrogel may reduce the efficacy of the material (that is, decreased diffusivity of ascorbate), so, the 20% hydrogel of sodium ascorbate was also formulated.

According to the results of this study, the shear bond strength of composite restorations applied after antioxidant application following bleaching was higher than composite restorations applied immediately after bleaching, without antioxidant treatment. Thus, it is proposed that sodium ascorbate may remove the oxidative effect of the bleaching agent. Also, there was no statistically significant difference among the different forms of sodium ascorbate; therefore, it is suggested that sodium ascorbate hydrogel might be effective at the same level as the solution form of sodium ascorbate and, also, 10% sodium ascorbate hydrogel might be as effective as 20% sodium ascorbate hydrogel in neutralizing the oxidizing effects of bleaching agents and increasing bond strengths. Ascorbic acid and its sodium salt are potent antioxidants capable of quenching reactive free radicals in biological systems (Kaya & Turkun, 2003). Since ascorbic acid and its salts are non-toxic and widely used in the food industry as antioxidants, it is unlikely that their intra-oral use will cause any adverse biological effect or clinical hazard (Lai & others, 2001, 2002; Kaya & Turkun, 2003).

The initial reduction in enamel bond strengths after bleaching is clinically significant, because many patients require the replacement of existing esthetic restorations after bleaching treatment (Miguel & others, 2004). According to this study, bleaching patients could place the sodium ascorbate hydrogel in the bleaching tray for 3 hours before the bonding procedure to neutralize the oxidizing effects of the bleaching agent and increase the enamel bond strength. By using this method, the need to wait 2 to 3 weeks to reach the normal enamel bond strength could be eliminated. Also, this method is easy to perform, and it will be less expensive for the patient compared to application of the sodium ascorbate solution by the dentist in the clinic, because of its shorter chair time. In the latter method, the manipulation of sodium ascorbate solution is more difficult than hydrogel, and the solution should be used several times prior to the bonding procedure. Therefore, using this method could decrease the cost and duration of the procedure.

CONCLUSIONS

In the samples where antioxidant was applied after the bleaching process, shear bond strength in enamel was significantly increased.

This study revealed no significant difference in shear bond strength among different forms of sodium ascorbate (solution, 10% hydrogel & 20% hydrogel) used before the bleaching process.

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