

Effect of 10% sodium ascorbate applied for different time periods on shear bond strength of composite to bleached enamel.

Efecto del 10% de ascorbato de sodio aplicado durante diferentes períodos de tiempo sobre la resistencia al cizallamiento del material compuesto al esmalte blanqueado.

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Abstract: Aims: Residual peroxide on the enamel surface and in the interprismatic spaces decreases the shear bond strength (SBS) of composite to bleached enamel. Evidence shows that 10% sodium ascorbate can efficiently neutralize the singlet oxygen generated by the bleaching agents. This study aimed to assess the effect of duration of application of sodium ascorbate on SBS of composite to bleached enamel. Materials and Methods: This in vitro experimental study was conducted on 30 sound human third molars, which were randomly divided into three groups (n=10). In group 1, the teeth were bleached for 45 minutes and were then subjected to immediate bonding and restoration with composite resin. In groups 2 and 3, the teeth were bleached, immersed in 10% sodium ascorbate solution for 5 (group 2) and 10 (group 3) minutes and were then bonded and restored with composite, and the SBS was then measured. Results: The highest SBS (14.02±8.6MPa) was noted in group 3 (immersion in 10% sodium ascorbate for 10 minutes before bonding). The lowest SBS was noted in group 1 (immediate bonding after bleaching) ($p<0.05$). The difference in SBS of groups 1 and 2 was not significant ($p=0.4$). Conclusion: Application of 10% sodium ascorbate for 10 minutes increases the SBS of composite to bleached enamel.

Keywords: Dental bonding; bleaching agents; antioxidants; ascorbic acid; composite resins; dental enamel.

Resumen: Objetivos: el peróxido residual en la superficie del esmalte dental y en los espacios interprismáticos disminuye la resistencia al cizallamiento (RAC) de la resina compuesta al esmalte dental blanqueado. La evidencia muestra que el 10% de ascorbato de sodio puede neutralizar eficientemente el oxígeno singlete generado por los agentes blanqueadores. Este estudio tuvo como objetivo evaluar el efecto de la duración de la aplicación de ascorbato de sodio en la RAC de la resina compuesta al esmalte dental blanqueado. Materiales y Metodos: Este estudio experimental in vitro se realizó en 30 terceros molares humanos sanos, que se dividieron aleatoriamente en tres grupos (n=10). En el grupo 1, los dientes se blanquearon durante 45 minutos y luego se sometieron a una unión y restauración inmediata con resina compuesta. En los grupos 2 y 3, los dientes se blanquearon, se sumergieron en una solución de ascorbato de sodio al 10% durante 5 (grupo 2) y 10 (grupo 3) minutos y luego se unieron y restauraron con resina compuesta; luego se midió la RAC. Resultados: La RAC más alta (14,02 ± 8,6 MPa) se observó en el grupo 3 (inmersión en ascorbato de sodio al 10% durante 10 minutos antes de la unión). El valor de RAC más bajo se observó en el grupo 1 (unión inmediata después del blanqueo) ($p<0,05$). La diferencia en RAC de los grupos 1 y 2 no fue significativa ($p=0,40$). Conclusión: la aplicación de ascorbato de sodio al 10% durante 10 minutos aumenta la RAC de la resina compuesta al esmalte dental blanqueado.

Palabras Clave: Recubrimiento dental adhesivo; blanqueadores; antioxidantes; ácido ascórbico; resinas compuestas; esmalte dental.

INTRODUCTION.

Tooth whitening is a major request from many dental patients. Bleaching is the most conservative method to achieve this goal.¹ Tooth bleaching lightens the tooth color without damaging its mechanical structure. This modality has become increasingly popular in recent years due to the increasing demand for dental esthetics.^{1,2}

Tooth bleaching is more conservative than other modalities such as porcelain fused to metal or full-porcelain crowns and porcelain and composite veneers.³ Also, combining the bleaching treatment with restorative procedures is a common practice in esthetic dentistry to achieve a more favorable color match.⁴ For instance, in severe tooth discolorations, tooth bleaching needs to be performed before the veneering procedures to obtain more favorable esthetic results.⁵

Therefore, due to clinical requirements, the effect of bleaching treatment before and after restorative procedures has been a topic of research.³

Many researchers have reported a significant reduction in shear bond strength (SBS) of composite to bleached enamel, which is believed to be due to the presence of residual peroxide on the enamel surface and in the interprismatic spaces.⁶⁻⁹ Thus, evidence shows that restorative procedures should not be performed immediately after the bleaching treatment due to increased microleakage and decreased bond strength of resin materials.^{10,11}

However, this effect is temporary and is absent at 1 to 3 weeks after the treatment. Therefore, delaying the bonding for a couple of days after the bleaching treatment procedures is often suggested in order to obtain adequate bond strength.¹² However, in many cases, delay in restoration of teeth after the bleaching treatment can cause fatigue and discourage the patients to continue their treatments. Moreover, many patients demand completion of treatment in fewer treatment sessions. Therefore, performing bonded restorations immediately after the bleaching treatment can save time and cost for both patients and clinicians.¹²⁻¹⁸

Evidence shows that 10% ascorbic acid or 10% sodium ascorbate can efficiently neutralize the singlet oxygen produced by the bleaching agents.

Ascorbic acid and its salts such as sodium ascorbate are not toxic, and are extensively used in the food industry as an antioxidant. Thus, their application does not seem to

have biologically or clinically adverse effects on the enamel. Given that sodium ascorbate is effective for reinforcement of SBS of composite to bleached enamel, knowledge about the required duration of application of sodium ascorbate on the enamel surface would be helpful.¹⁹⁻²¹

Evidence shows that the minimum time required for the application of 10% sodium ascorbate to eliminate the bonding problem after enamel bleaching is 60 minutes. In another study, a period of 10 minutes was reported to be suitable for enhancement of bonding after bleaching.^{22,23} Duration of application of 10% sodium ascorbate is still a matter of debate. Another study reported that 5 minutes was required to completely eliminate the effect of hydrogen peroxide and enhance the bond strength of composite to the enamel.²⁴

Due to the existing controversy regarding the duration of application of sodium ascorbate, this study aimed to find the time required for the application of 10% sodium ascorbate to enhance the bond strength. The required times reported in some previous studies are too long and are not applicable in a clinical setting.

On the other hand, there is controversy regarding the 5- and 10- minute time periods. Thus, this study aimed to assess the effect of 5- and 10- minute application periods of 10% sodium ascorbate *versus* no application on SBS of composite to bleached enamel.

If the difference in bond strength following the application of sodium ascorbate for 5- and 10- minutes is not clinically and statistically significant, we can save time and achieve acceptable bond strength.

MATERIALS AND METHODS.

This *in vitro* experimental study was conducted on 30 extracted human third molars. The teeth were sound on visual inspection and had no cracks, fracture, wear, previous restorations, congenital anomalies or structural defects. The teeth were immersed in 0.2% thymol solution for three weeks. The teeth were subjected to scaling and cleaned with a prophylaxis powder and rubber cup one week before the experiment.

The teeth were then stored in distilled water at room temperature and were randomly divided into three groups of 10. The buccal surface of the teeth was polished using 240, 400 and 600-grit silicon carbide abrasive papers under

running water to obtain a smooth surface without exposing the dentin. Then, 38% hydrogen peroxide gel was applied on the samples according to the manufacturer's instructions and activated by light curing. Next, 10% sodium ascorbate was prepared by adding 10g of sodium ascorbate to 90ml distilled water. The groups were prepared as follows:

Group 1 (control): In this group, 38% hydrogen peroxide gel was applied on the tooth crowns and was then rinsed under running water according to the manufacturer's instructions. The buccal surface was then etched with 37% phosphoric acid for 15 seconds and rinsed with water for 30 seconds. It was then dried with an air blast to obtain a chalky white appearance.

Next, two layers of Single Bond were applied on the surface according to the manufacturer's instructions and light-cured for 20 seconds using a light-curing unit with a light intensity of 400mW/cm². Next, a transparent plastic mold measuring 3 mm in diameter and 4mm in height was placed on the enamel surface, and A2 shade of Z100 composite was applied into the mold in three increments. Each increment was light-cured for 40sec.

Group 2: In this group, similar to the control group, bleaching was performed and the samples were then immersed in 10% sodium ascorbate solution for 5 minutes. Bonding process was then performed as in group 1.

Group 3: In this group, similar to the control group, bleaching was performed and the samples were then immersed in 10% sodium ascorbate solution for 10 minutes.

Bonding process was then performed as in group 1.

All samples were immersed in distilled water at 37°C for 24hrs and were then mounted in acrylic resin in a manner that the dental surface was at the same level as the acrylic surface and the composite cylinder was jutting out of the acrylic resin.

The SBS was measured using a universal testing machine. Shear load was applied by the 1 mm blade of the machine onto the composite-tooth interface parallel to the occlusal surface of the tooth at a crosshead speed of 2mm/minute until fracture.

Statistical analysis

Data were analyzed using ANOVA. In case of significant differences, t-test was applied for pairwise comparisons.

RESULTS.

Table 1 shows the SBS of the three groups. As shown, the lowest SBS (4.41±3.68 MPa) was noted for group 1 (control) while the highest SBS was noted for group 3 (14 MPa). ANOVA showed a significant difference in SBS of the groups ($p<0.05$). According to the t-test, the difference between the control group and group 2 was not significant ($p=0.4$). But the difference between group 3 and groups 1 and 2 was statistically significant ($p<0.05$).

The mean SBS was high in all groups and the highest coefficient of variation belonged to group 1 (control group, 83%) while the lowest coefficient of variation belonged to group 2 (58%).

Table 1. Mean shear bond strength in the three groups.

Group	Mean shear bond strength (MPa)	Coefficient of variation
Group 1 (control)	4.41±3.68	83
Group 2 (5 minutes)	5.93±3.43	58
Group 3 (10 minutes)	14.02±8.60	61
p-value	$p<0.05$	

DISCUSSION.

This *in vitro*, experimental study aimed to assess the effect of 10% sodium ascorbate applied for 5 and 10 minutes on SBS of composite to bleached enamel. The results showed a significant difference in SBS among the groups ($p<0.05$).

The highest bond strength was noted in group 3 (10

minutes of exposure, 14MPa). According to the t-test, no significant difference was noted in SBS of groups 1 and 2 ($p=0.4$).

In this study, 38% hydrogen peroxide gel was used for bleaching. This product is widely used by dental clinicians in Iran for tooth bleaching. Duration of application of 38% hydrogen peroxide gel in our

study was 45 minutes according to the manufacturer's instructions and clinical experience.²⁵ Also, 1 g of 10% sodium ascorbate (sodium-L-ascorbate) was mixed with 9ml of distilled water to obtain a 10% concentration. Evidence shows that 10% sodium ascorbate yields more favorable results than 20%.²⁶

Since duration of application of sodium ascorbate after dental bleaching is still a matter of debate, this study aimed to compare the effect of 5 and 10 minutes application of 10% sodium ascorbate on SBS of composite to bleached enamel. The results were also compared with the no-intervention control group. The results showed the highest SBS in group 3 (exposure for 10 minutes). For proper bonding to the enamel, 15 to 20MPa bond strength is often required. ANOVA showed a significant difference in SBS of the three groups in our study ($p < 0.05$).

Immediately after bleaching of teeth with 35% hydrogen peroxide, composite bond strength to the enamel showed a significant reduction and decreased to 4.41 MPa, which was in line with the results of a previous study.²⁷

The current results showed that restoration of teeth immediately after bleaching would significantly decrease the SBS of composite to the enamel. This finding was in agreement with the results of previous studies.¹⁶⁻¹⁸

Previously, it was believed that low bond strength of composite to bleached enamel was due to changes in enamel structure and its increased porosity (similar to the appearance of over-etched enamel) and loss of enamel prisms. However, the majority of researchers now believe that the adverse effects of bleaching on bond strength are related to the gradual release of oxygen species from the bleaching agent and subsequent inhibition of resin polymerization.²⁸⁻³¹

Titley *et al.*,⁹ reported in their electron microscopic study that large parts of the enamel surface were resin-free at the resin-bleached enamel interface and the exiting resin tags were short, brittle and indistinctive.

However, despite the adverse effects of bleaching, postponing the bonding procedure to after the application of sodium ascorbate gel in our study increased the SBS of composite to bleached enamel. This indicated the positive efficacy of sodium ascorbate gel for elimination and neutralization of the residual bleaching agent and the resultant oxides. This finding was in agreement with the

results of Turkun *et al.*,²³ Previous studies showed that the organic matrix in the subsurface enamel changes as a result of the oxidizing effect of hydrogen peroxide; however, these structural changes are not permanent. Also, it is believed that peroxide ions temporarily replace the hydroxyl radicals in the apatite network. It is believed that this phenomenon can be neutralized by using an antioxidant.²¹

On the other hand, ascorbic acid, as a well-known antioxidant, can decrease oxidizing agents, especially free radicals. Previous studies have shown the potentially protective effects of ascorbic acid against hydrogen peroxide in the clinical setting.

The current results, similar to previous studies²¹⁻²³ confirmed the efficacy of this compound for neutralization of adverse effects of bleaching. However, the ability of this compound to completely neutralize such adverse effects is still questioned and seems to be dependent on the duration of application of this compound as well as the type, duration of use and concentration of the bleaching agent.

Bakhtar *et al.*,²³ evaluated the efficacy of application of 10% sodium ascorbate for 2, 10 and 30 minutes on SBS of composite to enamel bleached with 35% carbamide peroxide. The results revealed that the SBS of composite to enamel significantly decreased after bleaching with 35% carbamide peroxide, and application of 10% sodium ascorbate significantly increased the bond strength to bleached enamel.

No significant difference was noted in the use of 10% sodium ascorbate for different periods of time. It seems that carbamide peroxide is eliminated faster and by a shorter application time of sodium ascorbate compared to hydrogen peroxide,

Tabatabaee *et al.*,¹³ assessed the effect of application of sodium ascorbate for 5 and 10 minutes on SBS of composite to dentin of bleached teeth. The results demonstrated that bleaching agents significantly decreased the bond strength of composite to dentin, and application of sodium ascorbate could not improve the bond strength. Such inefficacy may be due to differences in the anatomical structure of dentin compared to enamel, allowing penetration of higher amounts of free oxygen radicals and peroxide into the interprismatic spaces.

Lima *et al.*,³⁴ evaluated the bond strength of composite

to bleached bovine enamel and dentin following the application of 10% sodium ascorbate for one minute. The results showed that bleaching agents decreased the bond strength to enamel but had no effect on the underlying layers of enamel and dentin.

Application of 10% sodium ascorbate for one minute increased the bond strength of composite to bleached enamel, but this clinical increase was not statistically significant; this finding may be due to the short duration of application of sodium ascorbate and use of bovine teeth, which are different from human teeth in terms of structure and interprismatic spaces.

Friere *et al.*,²⁴ indicated the direct correlation of the amount of hydrogen peroxide and sodium ascorbate. They also reported that application of sodium ascorbate for 5 minutes was effective for the neutralization of hydrogen peroxide, and prolongation of its application time over 5 minutes did not increase its efficacy.

Many studies have evaluated the effect of duration of application of sodium ascorbate on SBS of composite to bleached enamel. Some studies failed to show a significant improvement in SBS following the application of sodium ascorbate;²⁶ however, most studies confirmed that sodium ascorbate improved the SBS of composite to bleached enamel. If sodium ascorbate is not applied, the bonding procedure must be postponed for 1 to 3 weeks after the bleaching treatment to prevent clinical problems related to low bond strength.¹³⁻¹⁸

Evidence shows that immersion of bleached teeth in distilled water or artificial saliva for 7 days increases the bond strength of composite to enamel. Also, removal of the superficial layer of enamel after bleaching can help in achieving a stronger bond.²⁶

Previous studies have indicated that 10% ascorbic acid and 10% sodium ascorbate are highly efficient for neutralization of singlet oxygen produced by the activity of bleaching agents. Ascorbic acid and its salts such as sodium ascorbate are not toxic, and are extensively used in the food industry as an antioxidant.

Thus, their application does not seem to have biologically or clinically adverse effects on the enamel. Given that sodium ascorbate is effective for reinforcement of SBS of composite to bleached enamel, knowledge about the required duration of application of sodium ascorbate

on the enamel would be helpful.¹⁹⁻²¹

Duration of application of sodium ascorbate after bleaching is still a matter of debate. A previous study showed that the minimum required time for the application of 10% sodium ascorbate to eliminate the problems related to low bond strength after tooth bleaching was 60 minutes.

Another study reported that 10 minutes would suffice for the application of sodium ascorbate to improve the bond strength after tooth bleaching.^{22,23} Another study reported that 5 minutes is necessarily required to completely eliminate the effect of hydrogen peroxide and increase the bond strength of composite.²⁴

Gomes Torres *et al.*,³⁵ evaluated the efficacy of antioxidants for neutralization of the adverse effects of bleaching agents and confirmed that the effective duration of application of sodium ascorbate is one-third of the duration of application of bleaching agent.

As projections we suggest to evaluate the efficacy of 10% sodium ascorbate applied for more than 5 minutes and less than 10 minutes; to evaluate the efficacy of different sodium ascorbate gels; and to ascertain the appropriate application time of 10% sodium ascorbate on dentin.

CONCLUSION.

Within the limitations of this *in vitro* study, we conclude that application of 10% sodium ascorbate increased the SBS of composite to bleached enamel. The highest SBS was noted following the application of 10% sodium ascorbate for 10 minutes. Use of 10% sodium ascorbate for 5 minutes also improved the SBS of composite to bleached enamel but the difference in SBS was not significantly different from the control group.

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