

Composite resin shear bond strength on bleached dentin increased by 35% sodium ascorbate application

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ABSTRACT

Background: Restoration of the teeth immediately after bleaching with 35% hydrogen peroxide (H_2O_2) is contraindicated due to the remnant of free radicals that will stay inside enamel and dentin for 1-3 weeks and reduce the adhesion of composite resin. Sodium ascorbate is an antioxidant substance known to bind free radical residues, thereby shortening the delay in restoration. **Purpose:** The purpose of this study was to examine the resin bond strength of bleached dentin influenced by the application of 35% sodium ascorbate.

Methods: Nine premolars were divided into their crown and root sections, with the crown subsequently being cut into four equal parts to obtain 36 samples. These were then divided into four groups, each containing nine samples. Group A (control): samples were bleached using 35% hydrogen peroxide, immersed in an artificial saliva, stored in an incubator at 37°C for seven days and then filled with a composite resin. Group B: samples were also bleached by means of 35% H_2O_2 followed by one application of 0.025 ml 35% sodium ascorbate for 5 minutes and restored with composite resin. Group C: samples were bleached with 35% H_2O_2 , followed by two applications of 0.025 ml 35% sodium ascorbate for 5 minutes, and restored with a composite resin. Group D: dentin was bleached with 35% H_2O_2 followed by three applications of 0.025 ml sodium ascorbate 35% for 5 minutes and restored with a composite resin. The shear bond strength of the composite resin was measured by a universal testing instrument (Zwick, USA). Data was analyzed by means of one-way Anova and LSD. **Results:** The highest mean shear bond strength of composite resin was in group C, while the lowest was in group B. The result of one-way Anova indicated a difference in the shear bond strength of composite resin in the four treatment groups ($p < 0.05$). An LSD test showed there to be a difference in shear bond strength of composite resin between group A and groups C and D or between group B and groups C and D. There was no difference in shear bond strength of composite resin between group A and group B or between group C and group D. **Conclusion:** Application frequency of 35% sodium ascorbate affect on shear bond strength of composite resin restoration in bleached dentin by 35% H_2O_2 .

Keywords: 35% sodium ascorbate; bleached dentin; 35% hydrogen peroxide; shear bond strength

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INTRODUCTION

There are two kinds of bleaching procedure: extracoronal and intracoronal. The materials used for bleaching are sodium perborate, 30–38% hydrogen peroxide (H_2O_2) and 10–35% carbamide peroxide. The bleaching materials release free radicals perhydroxyl ($HOO\bullet$) and oxygen nascent ($O_n/O\bullet$). The free radicals react with the double

bonds of chromogenic molecules in enamel and dentine, dividing into simpler molecules that are less reflective and cause the color of teeth to become brighter. Post-treatment of intracoronal bleaching requires composite resin restoration to fill cavity that serves to prevent tooth-recontamination by bacteria, thereby minimizing root canal failure. Restoration of the tooth immediately after bleaching is contraindicated since post-bleaching procedures often

have peroxide and residues inside the dentin tubule, between the collagen matrix and in the interprismatic enamel, which remain active for a period of time. The trapped ion peroxide and residues can survive until eliminated by pulp microcirculation and then diffuse to external tooth surfaces.¹ The residue of peroxide and oxygen nascent are free radicals which can cause a decrease in adhesion of composite resin and an increase in microleakage.² These molecules will interfere with the propagation of vinyl radical composite resin, causing the early termination of the polymer chain, and will also form polymers with such limited mechanical power that the strength of the bonding declines, resulting in weak adhesion and microleakage.^{3–5} Microleakage can lead to discoloration of marginal restoration and, ultimately, root canal treatment failure. H₂O₂ can alter the surface of the tag resin on composite resins. Resin tags on bleached teeth are fewer in number and shorter than on those that are not bleached. This is probably due to bleaching materials producing mechanical modifications to the inter tubular and peritubular dentine that can lead to biomechanical changes.⁶

Composite resin restoration must be undertaken 1–2 weeks after bleaching is completed because it is expected that free radical residues on the bleached teeth will gradually reduce, resulted in the need for longer treatment. One way to shorten the delay time is through the application of antioxidants.^{7,8} Antioxidants are substances that can bind free radicals, one such recommended antioxidant being sodium ascorbate.⁸

Sodium ascorbate is a sodium salt of L-ascorbic acid, consisting of a white or yellowish, odorless, non-toxic, crystalline powder or solid, that is soluble in water and partially soluble in ethanol. Sodium ascorbate in liquid form has a pH of 6.5–8 and constitutes a biocompatible antioxidant.⁹ Sodium ascorbate will be oxidized to dehydroascorbic acid after contact with On.¹⁰

Controversy persists regarding the concentration, frequency and duration of sodium ascorbate applications necessary to reduce the residual bleaching material. The most widely used concentration in various studies is 10% sodium ascorbate.¹¹ Previous research has shown that up to ten minutes' application of 10% sodium ascorbate is effective in increasing the shear bond of composite resin in bleached teeth by 15–35% carbamide peroxide.^{12–14} Carbamide peroxide is the material commonly used for extra coronal bleaching on vital teeth. In intracoronal bleaching, the most commonly used material is 35% H₂O₂. Briso *et al.*⁶ showed that 10% sodium ascorbate increases the tensile strength of composite resin attachment in enamel bleached using 10% carbamide peroxide, but proves ineffective on enamel and dentine bleached by means of 35% hydrogen peroxide. Similar results were demonstrated by Turkmen *et al.*,¹⁵ 10% sodium ascorbate was ineffective in raising the shear bond strength of composite resins on teeth bleached using 35% and 38% H₂O₂. The higher concentrations of H₂O₂ would leave more free radical residue and, therefore, require antioxidants at

higher concentrations. Freire *et al.*¹⁶ confirm the amount of sodium ascorbate required to reduce H₂O₂ depends on the concentration of hydrogen peroxide used. Freire *et al.*¹⁷ and Murad *et al.*¹⁸ also argued that longer time applications do not prove effective. According to Freire *et al.*¹⁷ sodium ascorbate can rapidly lose its antioxidant power. Consequently, repeated applications are more effective than extending the application time. The aim of this study was to investigate the effectiveness of 35% sodium ascorbate to improve the shear bond strength of composite resin on dentin that bleached by 35% H₂O₂.

MATERIALS AND METHODS

Nine premolars free of caries and cracks were stored in a 10% saline buffer for a period of two months prior to the study. Nine premolars were separated into their crown and root sections, with the crown subsequently being cut into four equal parts to obtain 36 samples. The samples were divided into four groups consisting of nine parts each was embedded in 2 × 2 × 2 cm self-cured acrylic. The samples were bleached using 0.025 ml of 35% H₂O₂ (Opalescence Endo, Ultradent Products, South Jordan, USA). Each sample was subsequently placed in a sterile plastic box and stored for 120 hours in an incubator at 37°C. The samples were washed with 5ml of distilled water before being dried for 10 seconds using a water syringe. Bleaching was repeated twice. All of the 36 samples were divided into four groups: A, B, C, and D. Group A (control) was soaked in artificial saliva and stored in an incubator at 37°C for seven days, before a restoration procedure was undertaken. Group B was administered with 0.025 ml of 35% sodium ascorbate (Sigma Eldrich, Singapura) for five minutes washed with 5 ml of distilled water by means of a syringe and dried for ten seconds, before undergoing a restoration procedure. 0.025 ml of 35% sodium ascorbate was applied by group C with the same procedure being repeated twice, prior to a restoration procedure. Group D was administered with 0.025 ml of 35% sodium ascorbate with the same procedure being repeated three times, followed by a restoration procedure. The restoration procedures applied to each sample were completed with a composite resin restoration (Z 350, 3M Espe, USA). A bonding agent (Tetric N-Bond Universal, Ivoclar Vivadent) was applied to each dentin surface of the sample and cured for ten seconds. A mould was mounted in the sample and filled with composite resin before being cured for 20 seconds. The samples were immersed in artificial saliva (Faculty of Mathematics and Science, Department of Chemistry Universitas Gadjah Mada) and stored in an incubator at 37°C for 24 hours. A shear bond strength test was performed on each sample using a universal testing instrument (Zwick, USA) at the Instrument Laboratory of the Faculty of Engineering, Universitas Gadjah Mada data was analyzed by means of one-way Anova and LSD.

RESULTS

The highest mean shear bond strength of composite resin in dentin bleached by 35% H₂O₂ was that of group C, while the lowest was in group B (Table 1). A one-way Anova test showed there to be difference in the shear bond strength of the composite resin in the four treatment groups (Table 2). An LSD test was subsequently conducted to quantify the difference between each group, the results of which can be seen in Table 3. An LSD test showed that there was a difference in shear bond strength of composite resin between group A (control) and groups C and D, and between group B and groups C and D. In contrast, no difference in shear bond strength of composite resin between group A (control) and group B, or between groups C and D existed.

DISCUSSION

Composite resin restoration is contra indication performed immediately after intracoronal bleaching, due to the presence of free radical residues that will affect the bond strength of the composite resin.¹⁹ The present study used 35% H₂O₂ because this material is often used in intracoronal bleaching techniques.²⁰ Sodium ascorbate is an antioxidant reputed to capture free radicals. The frequency of 35% sodium ascorbate application that was performed (once, twice and three times) refers to the study by Freire which indicates that to remove all remaining free radicals, sodium ascorbate must be applied more than once.¹⁷

As an antioxidant, sodium ascorbate will provide one electron to bind to free radicals, becoming another more stable form of water and ascorbyl free radicals (AFR). The AFR pair produces one molecule of dehydroascorbic acid and one ascorbate. Dehydroascorbic acid reacts with

oxidants of reactive oxygen compounds such as hydroxyl radicals.^{5,8}

A one-way Anova test confirmed that there was a significant difference ($p < 0.05$) of shear bond strength of composite resin on dentine bleached with 35% H₂O₂ which was applied at different frequencies with 35% sodium ascorbate. This is in accordance with the research of Freire *et al.*¹⁶ that showed the amount of sodium ascorbate required is directly proportional to the number of free radicals released by the bleaching materials. This study used 35% H₂O₂, a compound which it could be assumed released numerous free radicals. The higher the numbers of free radicals are released by bleaching materials, the more likely a greater residual post-bleaching. To capture the remaining free radicals requires more sodium ascorbate.¹⁶

The free radicals resulting from the breakdown of H₂O₂ are highly electrophilic and unstable because they lack electron pairs. As a result, the free radicals will try to locate pairs of electrons in order to become more stable.⁹ If, in bleached teeth, free radical residue still exists, then the restoration with composite is applied to the surface enabling free radicals to react with the composite resin monomer. The polymerization of the composite resin at the propagation stage will be disrupted resulting in early polymerization. Inadequate polymerization produces polymers with low mechanical strength which, in turn, will result in low bonding to the tooth structure.⁸

The occurrence of shear bond strength may also be due to a loss of calcium or changes in the organic structure affecting tooth structure and leading to a decrease in bonding strength.²¹ The magnitude of changes that occur in tooth structure is related to the amount of free radicals released by bleaching materials. Examination using an electron microscope on the post-bleaching teeth showed that the resin tags are short and irregular while, on some surfaces, they are not even present at all.^{1,16} Freire *et al.* also highlighted granular and porous features with bubbles on the surface between the resin and bleached enamel. These bubbles can block the infiltration of the bonding material into the tooth structure.¹⁶

An LSD test showed that there was a significant difference in shear bond strength of composite resin between group A (control) and groups C and D, as well as between group B and groups C and D. The shear bond strength of composite resin in groups A and B is lower than in groups C and D. These results could probably be attributed to the fact that in groups A and B the remaining free radical residue was greater than in groups C and D.

Table 1. The mean shear bond strength of composite resin (N/mm²) in dentin bleached by 35% H₂O₂ and with 35% sodium ascorbate applied

Group	Mean ± SD	Samples
A	10.68 ± 2.63	9
B	9.11 ± 2.14	9
C	13.40 ± 1.54	9
D	13.34 ± 3.05	9

Table 2. One-way Anova of shear bond strength in dentin bleached with 35% H₂O₂ and with 35% sodium ascorbate applied

Variable	Sum of squares	df	Mean square	F	Sig
Between Groups	119.913	3	39.971	6.884	0,001*
Within Groups	185.807	32	5.806		
Total	305.720	35			

* $< 0,05$ = significance.

Table 3. LSD test of shear bond strength in dentin bleached by 35% H₂O₂ and with 35% sodium ascorbate applied

Group	A	B	C	D
A	–	0.177	0.023*	0.025*
B	–	–	0.001*	0.001*
C	–	–	–	0.961
D	–	–	–	–

Note: * < 0,05 = significance; A (control) = soaked in saliva for 1 week; B = one application of 35% sodium ascorbate; C = two s application of 35% sodium ascorbate; D = three applications of 35% sodium ascorbate.

This finding is in accordance with the study of Freire *et al.* which shows that to remove all residual free radicals after bleaching with 35% H₂O₂, the application of 35% sodium ascorbate should be carried out more than once.¹⁷

The remaining free radicals will result in early termination. Consequently, the mechanical properties of the composite resin in the group soaked in saliva for one week and receiving a one-off application of 35% sodium ascorbate are lower when compared to the mechanical properties of the composite resin in the group receiving two or three applications of 35% sodium ascorbate. More free radical residue will also result in greater loss of calcium and changes in the structure of more organic tissues, including collagen. To achieve a strong bond with dentin, collagen is required to create a dentin hybrid layer on a resin composite.¹⁹ Hydrogen peroxide can lead to denaturation of collagen so that no effective hybrid layer is formed resulting in weakly-formed bonds. The lower mechanical properties of the composite resin and the greater denaturation of collagen will result in lower shear strength.²²

An LSD test showed no significant difference in shear bond strength between groups C and D. This result was probably due to free radical residue being attached when 35% sodium ascorbate is applied twice to dentin. When the application is propagated three times, it proves unsuccessful. The application of 35% sodium ascorbate more than once leaves no free radical. Therefore, complete composite resin polymerization can take place.¹⁷

This study showed that the application of 35% sodium ascorbate can improve the shear bond strength of composite resin on teeth bleached with 35% H₂O₂. Therefore, with composite resin restoration after bleaching a one-week delay is unnecessary. The shear bond strength of composite resin is higher if teeth bleached with 35% H₂O₂ had 35% sodium ascorbate applied to them more than once. This study used sodium ascorbate in gel form due to the consideration greater ease and control of application. The selection of gel form was also based on the research of Awdah *et al.* which states that bleached teeth treated with sodium ascorbate gel form or solution showed the same shear bond strength. The gel form has a high viscosity, is easier to apply and can be applied to the tooth surface for a greater duration compared to a solution form.²³ In conclusion application frequency of 35% sodium ascorbate

affects on shear bond strength of composite resin restoration on bleached dentin by 35% H₂O₂.

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