

Effect of ascorbic acid on bond strength between the hydrogen peroxide-treated fiber posts and composite resin cores

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Abstract

Aim: This study evaluated the effect of 10% ascorbic acid on the bond strength between fiber post and composite resin core after applying 24% hydrogen peroxide.

Materials and Methods: Twenty-four hydrogen peroxide-treated fiber posts were divided into 4 groups ($n = 6$). Group 1 was the control group with no treatment. In groups 2-4, post surfaces were treated with 10% v ascorbic acid solution for 10, 30 and 60 minutes, respectively. Cores were built up using flowable composite resin. Two sticks were prepared from each specimen. Microtensile bond strength test was performed for each stick. Failure modes of sticks were evaluated under a stereomicroscope ($\times 20$). Surface morphologies of two fractured sticks from each group were assessed by SEM.

Statistical analysis: Data were analyzed using one-way ANOVA and Tukey HSD tests ($\alpha = 0.05$).

Results: The highest microtensile bond strength was observed in Group 4 (20.55 ± 2.09) and the lowest in Group 1 (10.10 ± 0.55). There were significant differences in microtensile bond strength between all the groups ($P < 0.05$).

Conclusion: It is concluded that ascorbic acid application increased the microtensile bond strength between the hydrogen peroxide treated fiber post and composite resin core. The increase is dependent on the duration of exposure to the antioxidant.

Keywords: Ascorbic acid; composite resin core; fiber post; hydrogen peroxide; microtensile bond strength

INTRODUCTION

Fiber-reinforced posts have been a common choice for restoring endodontically treated teeth.^[1,2] These materials provide good esthetic results, better stress distribution and adhesion to tooth structure.^[3,4]

An important problem in effective bonding of post surface to composite resin core and luting cement is insufficient functional groups of surface structure.^[5] Surface treatments of fiber posts are performed to overcome this problem.^[6,7] Recently, hydrogen peroxide has been used for treatment of post surface.^[8-10]

Hydrogen peroxide etching of quartz fiber post can dissolve epoxy resin and expose fibers. This process enhances micromechanical retention on the surface of fiber post.^[11] According to a study conducted by de

Sousa Menezes *et al.*, application of hydrogen peroxide in different concentrations improves adhesion between fiber post and composite core.^[12] Elseka,^[13] Yenisey,^[14] and Vano^[15] reported that chemical surface treatment of post surface with hydrogen peroxide increases bond strength of quartz fiber post to composite resin core. However, studies have shown that fiber post-composite resin core interface is yet the weakest area. It appears that release of oxygen-free radicals from the entrapped hydrogen peroxide in microporosities of the post-surface is responsible for this problem.

Antioxidants are increasingly used in dentistry.^[16] They have reducing properties and scavenge free radicals.^[17-19] Application of antioxidants might inhibit the process of trapping residual oxygen-free radicals in the rough post surface. Ascorbic acid (vitamin C) is a water-soluble antioxidant present in citrus fruits, potatoes, tomatoes

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and green leafy vegetables. One important property is its ability to act as a reducing agent (electron donor). Ascorbic acid is a reducing agent with a hydrogen potential making it capable of reducing some compounds into molecular oxygen.^[20] This antioxidant is routinely applied in operative dentistry, especially for increasing bond strength after tooth bleaching.^[21-23] Many studies have indicated that application of ascorbic acid and related salts can reverse the compromised bond strength between composite resin and tooth structures after bleaching.^[24,25] Therefore, it is possible that free radicals on the post-surface are removed by ascorbic acid. Due to the lack of sufficient data concerning the role of antioxidants in adhesion of fiber post to composite core, this study was carried out to evaluate the effect of ascorbic acid on bond strength between the hydrogen peroxide-treated fiber post and composite resin core. The null hypothesis was that ascorbic acid has no effect on bond strength of hydrogen peroxide-treated fiber posts to composite resin core.

MATERIALS AND METHODS

In order to prepare 10% w/v ascorbic acid solution, 10 g L-ascorbic acid powder with purity of $\geq 99.0\%$, (Product Number A4403, Sigma — Aldrich, St. Louis, MO, USA) were mixed and diluted with 100 ml distilled water in a standard flask. Twenty-four N-2 white quartz fiber posts (DT. Light-Post™, RTD, St. Egreve, France) were selected. All the posts were immersed in 24% hydrogen peroxide solution for 10 minutes at room temperature, rinsed with distilled water for two minutes and gently air-dried. Then, the treated posts were divided into 4 groups ($n = 6$) based upon the duration of ascorbic acid used as follows: Group 1: control group (no application of ascorbic acid); Groups 2 to 4: Immersion in 10% ascorbic acid solution for 10, 30 and 60 minutes, respectively. Post surfaces were rinsed under running water for 1 minute and then gently air-dried. Core build-up was performed according to Goracci's method.^[26] Each post was positioned upright on a glass slide in the center of a cylindrical polyglass matrix with a diameter of 10 mm and a height of 6 mm. It was fixed with sticky wax. A light-cured flowable composite resin (Elite Flow, Bisco Inc., Schaumburg, IL, USA) was applied around the post in 1-mm-thick increments and each layer was separately cured using a halogen light-curing unit (Degulux, Degussa Dental, Hanau, Germany) for 40 seconds with an intensity of 450 mW/cm². The thickness of each increment was measured with a periodontal probe. The mold was separated from the glass slide and an additional 40-second curing was performed from the bottom of the cylinder to ensure optimal polymerization of the core material. Then, all the prepared samples were stored in deionized water at 37°C for 24 hours. Each sample was sectioned by a water-cooled blade of a sectioning machine (IsoMet, Buehler

LTD., Lake Bluff, IL, USA). First, two sections were made parallel to the long axis of the post, followed by sections perpendicular to the long axis of the post. The final sections contained the posts in the center and composite resin cores on both ends and had a diameter of 1 ± 0.1 mm, measured by a digital caliper (Mitutoyo CD15, Mitutoyo Co., Kawasaki, Japan). Two sticks were selected from each post. Each stick was glued to the two free-sliding components of a jig mounted on the microtensile tester (EZ Test, Shimadzu Co., Kyoto, Japan). This setup was designed to apply purely tensile forces. The sticks were loaded at a crosshead speed of 0.5 mm/min until failure. Bond strength was expressed in MPa, by dividing the load at failure point (N) by the bonding surface area (mm²). $N = 6$, may not be eligible for parametric analysis. Please consult a statistician using SPSS 16.0 version (Statistical Package, SPSS Inc., Chicago, IL, USA). Statistical significance was set at $\alpha = 0.05$.

Failure modes of the samples were observed under a stereomicroscope (Nikon Eclipse E600, Tokyo, Japan) at $\times 20$ magnification and scored as cohesive failure (failure in the post or the core material), adhesive failure (failure at the interface of post and core material), or mixed failure (adhesive-cohesive failure). Two fractured sticks of each group were randomly selected for evaluation of the morphology of fractured surfaces under a scanning electron microscope (SEM). The specimens were cleaned for 5 minutes in distilled water. Then they were immersed in 95% ethanol and gently air-dried. Each specimen was gold sputter-coated (Polaron Range SC7620, Quorum Technology, Newhaven, UK) and placed in a scanning electron microscope unit (JSM-5310, JEOL, Tokyo, Japan) and assessed under 300, 500 and 2000 magnifications.

RESULTS

Means and standard deviations of microtensile bond strengths of the tested groups are summarized in Table 1. Groups 1 and 4 exhibited the lowest and highest bond strength values, respectively. One-way ANOVA demonstrated significant differences between the study groups ($P < 0.05$) [Table 1]. Paired comparisons of groups showed significant differences between Groups 1 and 2, 2 and 3, 3 and 4 ($P < 0.05$). Stereomicroscopic evaluation revealed that all the failures in Groups 1, 2 and 3 were adhesive failures, but 3 samples in Group 4 showed mixed failures [Figure 1: C₁].

The SEM evaluation demonstrated the exposed fibers in adhesively failed samples [Figure 1: A_{1,2}, B_{1,2}] and different values of epoxy resin on fiber posts in mixed failures [Figure 1: C₂].

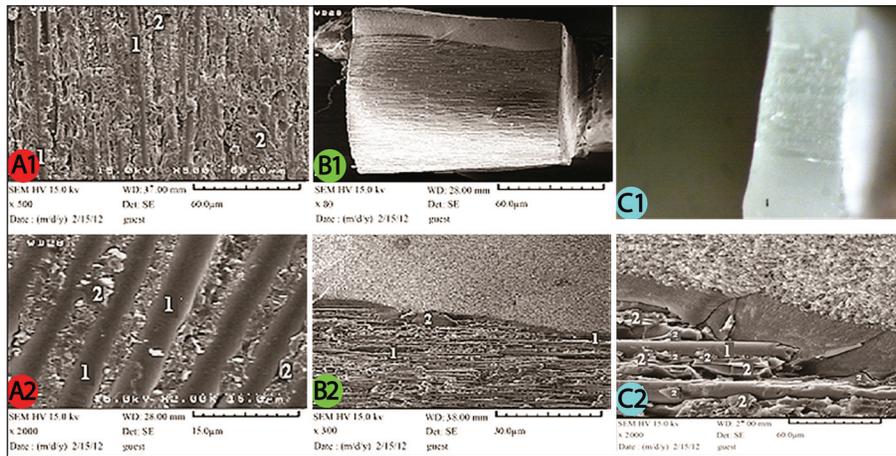


Figure 1: Microscopic views of the fractured surfaces showing adhesive failure on post surface in G1 [A1: (×500), A2: (×2000)] and G4 [B1: (×80), B2: (×300)]and mixed failure in G4 [C1: (×20), C2: (×2000)]. Exposure of quartz fibers (1) and presence of epoxy resins (2) between fibers are observed

Table 1: Means and standard deviation of microtensile bond strength and the results of one-way ANOVA

Groups	N	Bond Strength (MPa) (Mean ± SD)		Sum of squares	Df	Mean square	F	P*
1	6	10.10±0.55	Between Groups	715.657	3	238.552	129.985	.000
2	6	12.64±0.95	Within Groups	80.750	44	1.835		
3	6	14.87±1.31	Total	796.407	47			
4	6	20.55±2.09						

*Groups labeled with the same letter superscripts are significantly different ($P < 0.05$)

DISCUSSION

Adhesion of post to root canal dentin and also composite resin core play an important role in the longevity of restoration.^[1,2,14,27] Many studies have evaluated the effects of surface treatments on adhesion of fiber-reinforced posts to cores.^[10-15] Applying hydrogen peroxide on quartz fiber post is a conservative procedure for the enforcing of post-core interface. Previous studies have shown several advantages of this procedure for treatment of quartz fiber-post surfaces.^[11,15] The presence of oxygen-free radicals could compromise bond of post — core interface. Thus, the present study was carried out to evaluate the effect of ascorbic acid as an antioxidant agent for improving the bond strength between the hydrogen peroxide- treated fiber post and composite resin core.

The findings of this study indicated that use of ascorbic acid enhanced microtensile bond strength of quartz fiber post to composite resin core compared with control group, when the post surface was treated with hydrogen peroxide. This considerable increase might be attributed to the antioxidative effect of ascorbic acid. Ascorbic acid is an accessible non-enzymatic antioxidant agent, which has exogenous source. As mentioned in the introduction, the main property of ascorbic acid is its ability for transmission of electron to oxygen-free radicals and providing a stable form of the material. Therefore, it acts as a reducing agent and has an inhibitory effect on hydrogen peroxide-derived oxygen-free

radicals.^[19] The results of the present study are consistent with those of a study conducted by Khamverdi *et al.*,^[28] which showed that antioxidant agents increase adhesion of post and core. In addition, Weston *et al.*,^[29] showed that the considerable reduction in resin-dentin bond strength, which resulted from the use of 5.25% NaOCl irrigations, can be reversed by 10% sodium ascorbate treatment.

Another finding of this study showed significant differences between bond strength values of the ascorbic acid-treated groups and the increase was directly proportional to the duration of ascorbic acid application, which might be due to greater effects of ascorbic acid regarding its antioxidant properties, resulting from an increase in fiber post surface exposure time to this agent. Since, there were no studies to determine the minimum application time of ascorbic acid on fiber post surface; duration of 10 minutes was selected based on study results of Türkün *et al.*,^[30] and Kaya *et al.*^[31]

Kaya *et al.*,^[32] have used longer times of 60, 120, 240 and 480 minutes. Selection of a 60-minute duration in the present study was based on the study done by Kaya.

However, a 10-minute application of the antioxidant in this study resulted in a significant increase in bond strength; this duration is applicable in clinical situations. In the present study, maximum exposure time was 60 minutes. Longer exposure time might be clinically difficult to apply.

Evaluation of sample fracture modes in groups revealed that the majority of fractures were adhesive. Observation of 3 mixed fracture modes within group 4 might be an indication of bond strength reinforcement between the post and core. The SEM assessment was performed to confirm stereomicroscopic findings.

Previous studies reported a 10% ascorbic acid salt that can compensate the reduced bond strength of dentin to composite resin after bleaching.^[21,25] However, only one study had utilized this solution on the post surfaces.^[28] Ten percent solution was applied in the present study, as it is suggested to be the minimum effective concentration.^[21,25,29] The microtensile bond strength test was performed according to previous studies, which have proved as a standard test for bond strength testing in small sections.^[13,26] Flowable composite resins have a good penetration property into surface porosities after application of hydrogen peroxide. In addition, they are easily handled.

The solution form accelerates onset of action and is recommended for shorter clinical time of application.^[32] Limitation of this form used is its difficult manipulation in clinical cases. It should be utilized several times prior to the bonding procedure. It is recommended that other forms of this material, for example, hydrogel form, which are clinically more acceptable, be prepared and compared with the solution form.

In the present study, thermocycling was not carried out and this was another limitation of the study. For more similarities to the oral conditions, future studies with thermocycling are recommended. In addition, one antioxidant was used. Application and comparison of other new antioxidants in future investigations appears to be useful.

CONCLUSION

Within the limits of this study, it can be concluded that:

1. Application of ascorbic acid can increase microtensile bond strength between the hydrogen peroxide-treated fiber posts and composite resin cores.
2. The increase is dependent on the duration of exposure to the antioxidant.

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