Effect of ascorbic acid, ethanol and acetone on adhesion between the treated fiber posts and composite resin cores

Khamverdi Zahra[1], DDS, MS, Talebian Reza[2]*, DDS

[1]Member of Dental Research Center, Department of Operative Dentistry, Dental School, Hamadan University of Medical Sciences, Hamadan, Iran

[2]Dental Private Practice, Kashan, Iran

PURPOSE. The aim of the present study was to assess the effect of ascorbic acid, ethanol and acetone on microtensile bond strength between fiber posts pre-treated with hydrogen peroxide and composite resin cores. **MATERIALS AND METHODS.** Twenty four fiber posts were pre-treated with 24% hydrogen peroxide and divided into 4 groups as follows: G1: no treatment, as control group; G2: treatment with10% ascorbic acid solution for 5 minutes; G3: treatment with 70% ethanol solution for 5 minutes; and G4: treatment with70% acetone solution for 5 minutes. Each fiber post was surrounded by a cylinder-shaped polyglass matrix which was subsequently filled with composite resin. Two sections from each sample were selected for microtensile test at a crosshead with speed of 0.5 mm/min. Statistical analyses were performed using one-way ANOVA and a post hoc Tukey HSD test. Fractured surfaces were observed under a stereomicroscope at $\times 20$ magnification. The fractured surfaces of the specimens were observed and evaluated under a SEM. **RESULTS.** Means of microtensile bond strength values (MPa) and standard deviations in the groups were as follows: G1: 9.70 ± 0.81; G2: 12.62 ± 1.80; G3: 16.60 ± 1.93; and G4: 21.24 ± 1.95. G4 and G1 had the highest and the lowest bond strength values, respectively. A greater bond strength value was seen in G3 compared to G2. There were significant differences between all the groups ($P<.001$). All the failures were of the adhesive mode. **CONCLUSION.** Application of antioxidant agents may increase microtensile bond strength between fiber posts treated with hydrogen peroxide and composite cores. Acetone increased bond strength more than ascorbic acid and ethanol. **[J Adv Prosthodont 2012;4:187-91]**

KEY WORDS: Composite resin core; Fiber post; Antioxidant agents; Acetone; Ethanol; Microtensile bond strength

INTRODUCTION

Fiber posts provide acceptable esthetic, adhesion to dentin and suitable distribution of functional stresses.[1,2] The factors affecting the longevity of a post and core restoration are directly related to core material, post type and bond strength of the post to the core.[3,4] It has been suggested that the post surfaces should undergo special treatments in order to improve retention. A large number of studies have been evaluated various treatment procedures by using chemical and mechanical techniques to improve the bond between quartz fiber posts and core materials and tooth structures.[5-7] It has been reported that mechanical techniques including the use of air-abrasion with silica particles or sandblasting improve the bond efficacy between fiber posts and composite resin cores, but decrease post fitness within the root canal, because particles inflict damage on fibers and post shape modifies.[8-15] Chemical treatments lead to a greater mechanical retention by roughening the post surface.[16] Some of the chemical solutions used for post surface treatments are potassium permanganate, hydrofluoric acid, silane and hydrogen peroxide.[17-19]

Hydrogen peroxide dissolves the resin matrix and exposes the fibers, resulting in an improved adhesion between the post and composite resin.[2] One of the most important problems of hydrogen peroxide use is the accumulation of free oxygen radicals on the micro porosities of post surface due to hydrogen peroxide degradation. These free radicals can interfere with adhesion between the post and the core. Therefore, with the use of agents which can neutralize the effect of free oxygen radicals it might be possible to overcome this problem. A large number of research studies have been performed on antioxidants.[7,20,21]

Corresponding author: Talebian Reza
Center of Advanced Cosmetic & Reconstructive Dentistry, Kashan, 8715134714, Iran
Tel. 98 913 0549415: e-mail, Zagross1807@gmail.com
Received May 25, 2012 / Last Revision July 26, 2012 / Accepted August 6, 2012

*This study was supported by the Dental Research Center and Vice Chancellor of Research, Hamadan University of Medical Sciences.

Antioxidants donate one of their electrons and stabilize free radicals.[22] Ascorbic acid has antioxidant properties and acts as a reducing agent.[23-25] Therefore; it is possible that free radicals on the post surface are removed by ascorbic acid. On the other hand, some agents can reduce the adverse effects of free oxygen radicals by removing and evaporating them from the surface; some of these agents include ethanol and acetone.[26,27] Since sufficient and definite data is not available in relation to the effects of these agents on bond of quartz fiber post pre-treated with hydrogen peroxide to resin composite core, the purpose of the present study was to assess and compare the effect of ascorbic acid, acetone and ethanol on the microtensile bond strength between fiber posts treated with hydrogen peroxide and composite resin cores.

MATERIALS AND METHODS

Twenty four N-2 white quartz fiber posts (DT Light-Post Radiopaque, RTD, Grenoble, France) were used in this study. The maximum diameter of each post was 1.8 mm. The posts were immersed in a solution of 24% hydrogen peroxide for 10 minutes at room temperature. Subsequently, the posts underwent a two-minute rinsing procedure with running water. Finally, the posts were dried under a gentle air. The posts were divided into 4 groups (6 in each group) based on antioxidant agents used. Group 1 was considered as the control group (without surface treatment). In Group 2, post surfaces were treated with fresh 10% ascorbic acid solution (Sigma Chemical Co., St. Louis, MO, USA) for 5 minutes. In Group 3, posts surfaces were treated with 70% ethanol solution (Merck KGaA, Germany) for 5 minutes. In Group 4, posts surfaces were treated with 70% acetone solution (Merck KGaA, Germany) for 5 minutes. The solutions were applied by brush on surfaces and refreshed every 1 minute. The post surfaces underwent a one-minute rinsing procedure under running water to remove excess agents used and then were gently air-dried. Subsequently, a core build-up procedure was carried out using a light-cured flowable composite resin (Elite Flow, Bisco, Inc, Shaumburg, IL, USA). The core was built up according to Gorracii's procedure.[28] The posts were placed upright on a glassslab and secured using sticky wax. A cylinder-shaped matrix was fabricated, which measured 10 mm in diameter; the length of the cylinder was the same as that of the non-tapering part of the post, measuring almost 6 mm. Each post was surrounded by the cylinder in a manner in which the post was placed exactly at the center. Flowable composite resin was placed on the post using the incremental technique; each increment had 1 mm thick and was light-cured, separately. A halogen light-curing unit (Degulux, Degussa Dental, Hanau, Germany) was used for the curing procedure. Before removing the matrix, an additional 40-second light-curing step was carried out from the bottom of the cylinder. All the samples were kept in distillated water at 37℃ for a 24-hour period. A blade was used, under water cooling, in a sectioning machine (IsoMet, Buehler LTD., Lake Bluff, IL, USA) to prepare two sticks in a direction along the post long axis, followed by sectioning at right angle to the post long axis. The final sections consisted of the post sandwiched between composite resin core laterally (Fig. 1). The sections measured 1 ± 0.1 mm in diameter as determined by a digital measuring instrument (Mitutoyo CD15, Mitutoyo Co., Kawasaki, Japan). Two sticks were chosen from each post, which were fixed on the two freely gliding portions of a platform mounted on the microtensile test machine (EZ Test, Shimadzu Co., Kyoto, Japan). Failure rate was 0.5 mm/min. This design was used for measuring pure microtensile forces. With dividing the force at failure (N) to the bonding surface area (mm^2) were calculated bond strength in Mpa.

Failure patterns of the specimens were evaluated under a stereomicroscope (Nikon Eclips E600, Tokyo, Japan) at a magnification of × 20 and scored as cohesive (fracture within the post

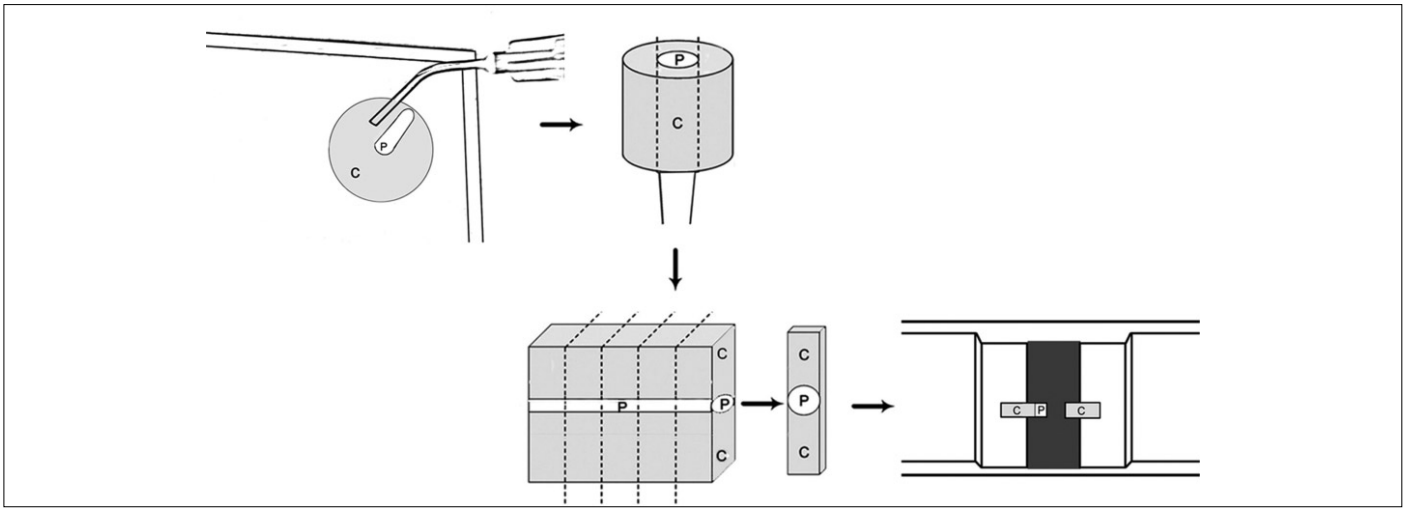

Fig. 1. Schematic design of the specimen, and testing procedure (P = Post and C = Core).

or core material), adhesive (fracture at post/core interface), or mixed (a combination of adhesive-cohesive). Two fractured samples were randomly selected from each group to be sputter-coated with gold-palladium for observation under a SEM (JSM-5310, JEOL, Tokyo, Japan) using different magnifications. One-way ANOVA and a post hoc Tukey test were used for statistical analysis. Statistical significance was defined at α=.05.

RESULTS

Means and standard deviation of microtensile bond strength values of the specimens are presented in Table 1. Results of one-way ANOVA (Table 2) demonstrated significant differences between the groups (P<.001). In addition, paired comparisons of groups using a post hoc Tukey test showed statistically significant differences between all groups (P<.001). Evaluation of fracture patterns under a stereomicroscopic showed adhesive failure in all the specimens. Table 3 indicates modes of failure within different groups. SEM micrographs indicated failure in fiber post-composite resin core interface in all the groups. However, in Group 4, there was more epoxy resin values on fiber post surfaces compared to Group 1 (Figs. 2-4).

Table 1. Means and standard deviation values of the microtensile bond strength of the groups under study

Groups	*n*	Bond strength (MPa) (Mean ± SD)
1	12	9.70 ± 0.81
2	12	12.62 ± 1.80
3	12	16.60 ± 1.93
4	12	21.24 ± 1.95

DISCUSSION

In the present study, the effect of 10% ascorbic acid, 70% ethanol and 70% acetone on microtensile bond strength of fiber post to composite core was evaluated and compared subsequent to treating the post surface with hydrogen peroxide.

The results of the present study demonstrated that bond strength in groups 2, 3, 4 was significantly different from that of the control group. Higher bond strength in the ascorbic acid group compared to the control group might be attributed to the antioxidant effect of this agent, inhibiting the effect of residual free oxygen radicals derived from hydrogen peroxide degradation on post surfaces. Ascorbic acid plays a role as a reducing agent.[22-25] Electron transfer from ascorbate to free oxygen radicals can result in the formation of semi-dehydroascorbate, which is a more stable material.

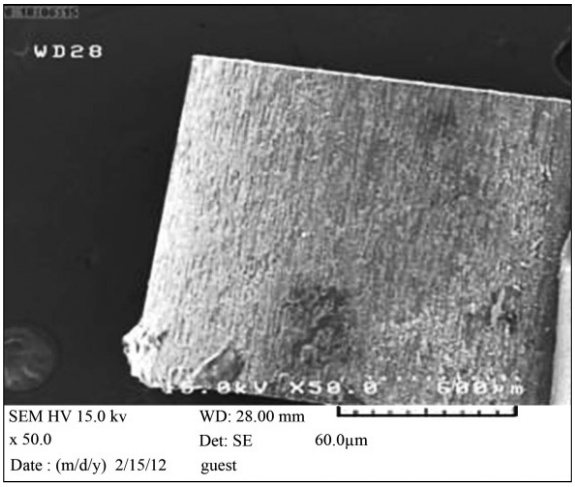

Fig. 2. SEM view of the fractured surface showing adhesive failure on post surface.

Table 2. Results of one-way ANOVA

	Sum of squares	Df	Mean square	F	Sig.
Between Groups	902.608	3	300.869	104.705	0.0001
Within Groups	126.434	44	2.874		
Total	4029.042	47			

Table 3. Failure modes within tested groups

Groups	*n*	Adhesive failure	Cohesive failure	Mixed failure
1	12	12 (100%)	0	0
2	12	12 (100%)	0	0
3	12	12 (100%)	0	0
4	12	12 (100%)	0	0
Total	48	48 (100%)	0	0

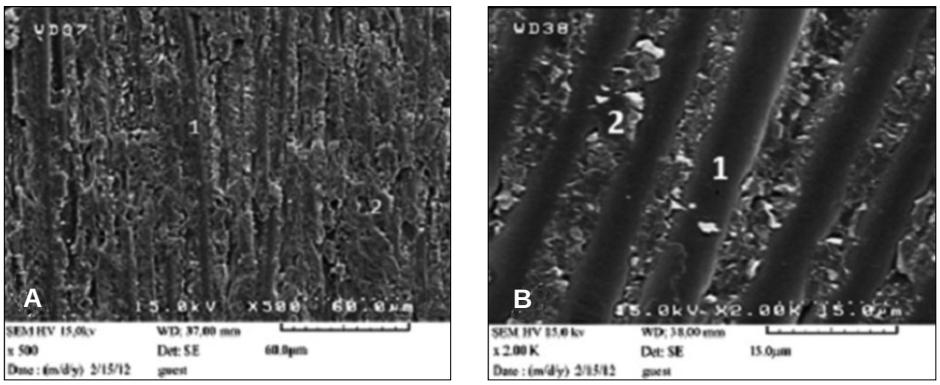

Fig. 3. SEM views of the fractured surface showing adhesive failure on post surface in the control group (G1). Complete exposure of quartz fibers (1) and presence of epoxy resin (2) between fibers is observed. A (× 500) view is magnified in B (× 2,000).

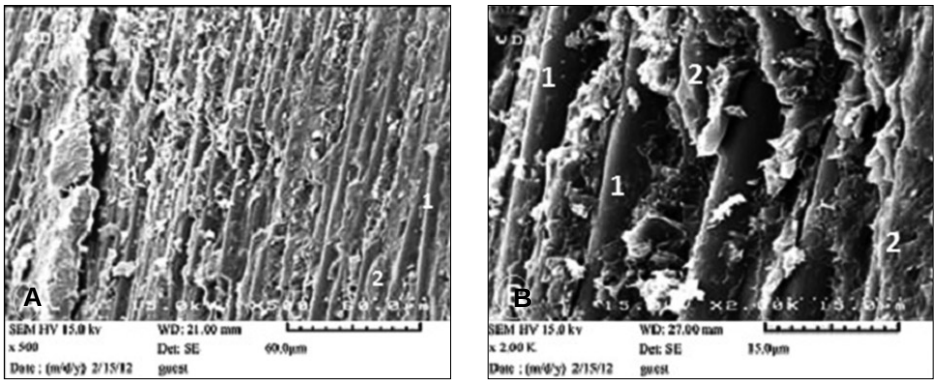

Fig. 4. SEM views of the fractured surface showing adhesive failure in the acetone group (G4). The exposed quartz fibers (1) and more epoxy resin (2) values are observed on fiber post surface. A (× 500) view is magnified in B (× 2,000).

Generally, three major mechanisms of action are considered for antioxidant materials: Breaking or scavenging of chains, catalyzing of molecules of oxidant substrate, and preventing Fenton reactions and sequestering transition metal ions.[29] Ascorbic acid had a function similar to the first group. However, this finding of the study supports the results of previous studies which have shown that ascorbic acid and related salts reverse the reduced bond strength after bleaching.[30-32]

Higher bond strength in G3 and G4 compared to the other two groups is probably attributed to higher surface wetting compared to their effects on removing surface free oxygen radicals. A recent study showed that dentin surfaces treated with acetone or ethanol become dehydrated and, therefore, might provide a suitable substrate for an adhesive procedure with hydrophilic self-etch adhesives, including one-bottle self-etch ones.[31]

This result is consistent with the results of a study by Hashimoto *et al*.[33] Similar studies have been performed in this field on tooth structure, but there is no evidence available for application of antioxidants on fiber posts. The results showed that acetone can increase bond strength even more than ethanol, which might be attributed to more evaporating power of acetone in comparison to other materials used. Previous studies have shown differences in the capacity of either experimental solvents or commercial formulations to evaporate. Nihi *et al*. reported that the acetone-based materials presented a greater evaporation capacity compared to ethanol-based products.[22] Adhesive fracture was the predominant pattern in all the groups in stereomicroscopic assessment, indicating that post core interface still is the weakest area. SEM observations confirmed stereomicroscopic results. Although, SEM views showed that in Group 4, there were more epoxy resin values on fiber post surfaces compared to Group 1, which might explain the better adhesion of fiber post to composite resin core in Group 4. However, it is necessary that more accurate techniques were applied for observation of post-composite resin interface. It is obvious that reinforcement of the adhesion of post to resin is required for better services of restorations. The use of microtensile test for bond strength measurement is advised because of its reliable results for specimens with a surface area of 1 mm^2. It seems that flowable composite resins, due to their low viscosity, are a good choice for core build-up because they provide a more homogenous penetration and void-free surface for bonding. In order to better simulate the oral cavity conditions, it is suggested that fatigue tests be carried out along with the use of antioxidants. In addition, in

the present study, one fiber post type and composite resin material were evaluated; it is suggested that future studies evaluate other fiber post types and composite resin core materials. Clinical trials on bond strength are yet to be carried out.

CONCLUSION

Within the limitations of the present study, it is concluded that application of ascorbic acid, ethanol and acetone can increase microtensile bond strength between fiber posts treated with hydrogen peroxide and composite resin cores. The use of acetone resulted in a higher increase in bond strength than the other materials used.

ACKNOWLEDGEMENTS

The authors would like to thank the Dental Research Center and Vice Chancellor of Research, Hamadan University of Medical Sciences, for supporting this study.

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