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Article *in* Journal of Conservative Dentistry · October 2011

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ISSN: 0972-0707

Journal of Conservative Dentistry

Volume 14 Issue 4 Oct - Dec 2011

Official Publication of
Federation of Operative Dentistry of India

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Original Article

Effect of storage time on microtensile bond strength between quartz fiber post and composite core after different post surface treatments

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Abstract

Aim: The aim was to evaluate the influence of water storage on fiber post-resin composite adhesion after different postsurface treatments.

Materials and Methods: Forty-two fiber posts were used. Half of them were treated by hydrogen-peroxide and the other half were sandblasted. The adhesive (Single Bond, 3M, USA) was applied on the post. Core was built-up using flowable composite (Ælite Flow, Bisco, USA). The specimens were divided into eight groups. Group 1 was treated with H_2O_2. Groups 2–4 were treated with H2O2 but stored for 3, 6, and 9 months, respectively. Groups 5–8 were sandblasted and stored for 0, 3, 6, and 9 months. μTBS was measured and data analyzed using one-way ANOVA and Tukey HSD. The fractured surfaces were evaluated by a stereomicroscope. The morphology of interfaces was assessed under SEM. H_2O_2-treated groups showed higher bond-strength.

Results: The effect of "surface-treatment method" and "storage-time" was significant ($P<0.0001$), but there was no significant difference for their interaction effect ($P=0.05$). Water aging significantly decreased μTBS.

Conclusions: Water aging significantly decreased microtensile bond strength regardless of the type of post surface treatment.

Keywords: Composite resins; dental bonding; post and core technique; tensile strength

INTRODUCTION

Restoration of endodontically treated teeth is still one of the most important problems in dentistry. The posts are necessary for adequate retention of core, when significant coronal tissues are lost. Nowadays, fiber posts are increasingly used for this purpose.[1-4]

Long-term success of a post/core restoration depends on different factors including: the material selected for core buildup, type of post, and quality of the core adhesion to the post.[5,6]

In order to enhance the retention between different structures, surface treatments of posts are recommended. Many studies have been performed on chemical and mechanical treatment procedures for better bonding of fiber posts to core and dental tissues.[7-9]

Previous studies demonstrated that mechanical treatment techniques such as sandblasting or air abrasion with silica increase bond strength between the fiber post and composite resin substrate. These treatments may modify the post shape and consequently decrease its fitness within the root canals.[10-16] Chemical treatments are performed to roughen the post surface, leading to greater mechanical retention.[17] Hydrofluoric acid, potassium permanganate, silane and hydrogen peroxide are the chemical solutions used for surface treatments.[18-20]

It has been reported that hydrogen peroxide has the ability to dissolve the resin matrix, breaking epoxy resin bonds and exposing the fibers. Therefore, it can provide stronger adhesion between post surface and resin composite.[21]

A few experimental studies have shown the long-term effect of these treatments on bond strength of post to composite core.[22,23] On the other hand, there are several factors in the oral cavity such as functional loading, thermo cycling,

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Date of submission: 20.02.2011
Review completed: 28.05.2011
Date of acceptance: 07.07.2011

Access this article online

Quick Response Code:

Website: www.jcd.org.in

DOI: 10.4103/0972-0707.87198

oral fluids (commonly water) that penetrate within the interfaces and can affect the retention between composite and fiber post.[23] Providing the similar conditions of the oral environment in the laboratory may help in achieving actual results.[22]

Water as the main element in the oral cavity can interfere with long-term durability of the bond. For this reason, water storage is considered as an *in vitro* accelerated aging test.[22,23] Due to the lack of definitive information concerning the role of different post treatments in long-term storage, the present study was carried out to evaluate the effect of two different surface treatments on the microtensile bond strength of quartz fiber posts to composite core in long-term storage time. The null hypotheses were that storage duration and post surface treatment had no effect on bond strength of fiber posts to resin core.

MATERIALS AND METHODS

Forty-eight white quartz fiber posts (DT Light-Post radiopaque, RTD, Grenoble, France) with maximum 1.8 mm diameter were selected. Twenty-four posts were immersed in 24% hydrogen peroxide solution for 10 min at room temperature and then rinsed under running water for 2 min and gently air dried. The remaining posts were sandblasted with 110 μm aluminum oxide particles (Rocatector Delta, 3M, ESPE, Seefeld, Germany) for 5 s at 0.28 MPa from a 1 cm distance. A light cured fifth generation adhesive (Single Bond, 3M ESPE, Ltd, USA) was used on all the posts according to the manufacturer's instructions. Core build up was, then, performed using a light cured flowable composite (Ælite Flow, Bisco, Inc, Shaumburg, IL, USA). Each post was positioned upright on a glass slab and fixed with a drop of sticky wax. A cylindrical matrix was made with 10 mm in diameter and the length was equal to the nontapered portion of the post (6 mm). It was placed around the post and adjusted so that the post was positioned exactly at the center. Flowable composite was applied on the post in 1 mm thickness increments and each layer was cured separately using a halogen light curing unit (Degulux, Degussa Dental, Hanau, Germany). To ensure optimal polymerization of the core material an additional 40 s curing was performed from the bottom of the cylinder before removing the matrix. Hydrogen peroxide treated samples were divided into four groups (six in each group). Group 1 was not stored and Groups 2, 3, and 4 were stored in deionized water at 37°C for 3, 6, and 9 months, respectively. Groups 5, 6, 7, and 8 included the sandblasted samples in the same manner. Then, by means of a water-cooled blade of a sectioning machine (IsoMet, Buehler LTD., Lake Bluff, IL, USA), first two sections parallel to the long axis of the post and then sections perpendicular to the long axis of the post were done, resulting in sections containing the post in the center and composite cores on both ends. The final sections had 1±0.1 mm diameter measured by a digital caliper (Mitutoyo CD15, Mitutoyo Co., Kawasaki, Japan). Two sticks were selected from each post. After the specific storage time, 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 set-up was designed to apply pure tensile forces to the post-core interface. The specimens 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) to the bonding surface area (mm).

Failure modes of the samples were assessed using a stereomicroscope (Nikon Eclips E600, Tokyo, Japan) at 20× magnification and recorded as cohesive failure (failure in post or core material), adhesive failure (failure at the interface of post and core material), and mixed failure (adhesive–cohesive failure). Two randomly selected fractured sticks of each group were sputter coated with gold-palladium and assessed with scanning electron microscope (JSM-5310, JEOL, Tokyo, Japan) at 500 and 1000 magnifications. Data were analyzed using two-way ANOVA and Tukey HSD test. Statistical significance was set at $\alpha = 0.05$.

RESULTS

Mean and standard deviations of microtensile bond strength of the groups tested are given in Table 1. Two-way ANOVA indicated that the main effect of surface treatment and storage duration were significant ($P=0.0001$). The interaction of surface treatment and storage duration was not significant ($P=0.054$). Variance analysis demonstrated that significant differences existed among all groups treated with hydrogen peroxide (Group 1–4). Also, all sandblasted groups had significant differences except Group 6 with Group 7 and Group 7 with Group 8. In addition, paired comparisons of sandblasted groups and hydrogen-peroxide-treated groups showed that there were no significant differences between Group 4 with Groups 7 and 8.

The mean microtensile bond strength of groups tested had significant differences with each other except Group 4 with 7 and 8, Group 6 with Group 7 and Group 7 with 8.

Table 1: Means and standard deviations of microtensile bond strength of tested groups

Storage duration	Surface treatment Sandblasting	Hydrogen peroxide
	Mean±SD (MPa)	Mean±SD (MPa)
No storage (G1and5)	26.79 ± 3.91	30.26 ± 3.63
3 month storage (G2 and6)	15.37 ± 3.19	21.78 ± 3.32
6 month storage (G3and7)	12.52 ± 3.43	17.86 ± 3.16
9 month storage (G 4and8)	10.68 ± 4.54	11.7 ± 3.04

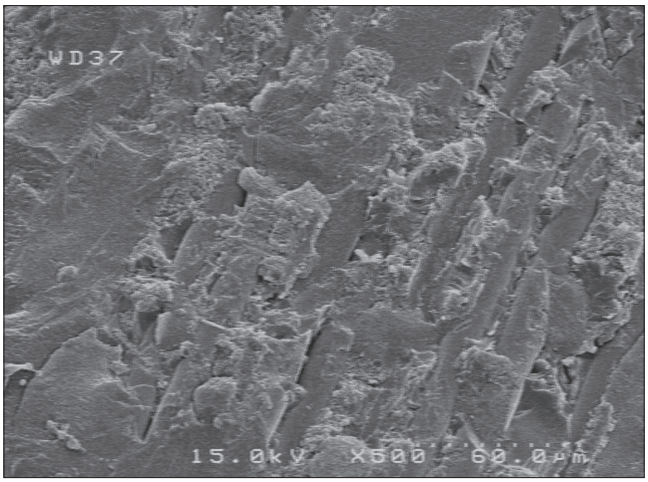

Figure 1: Sandblasted post without storage

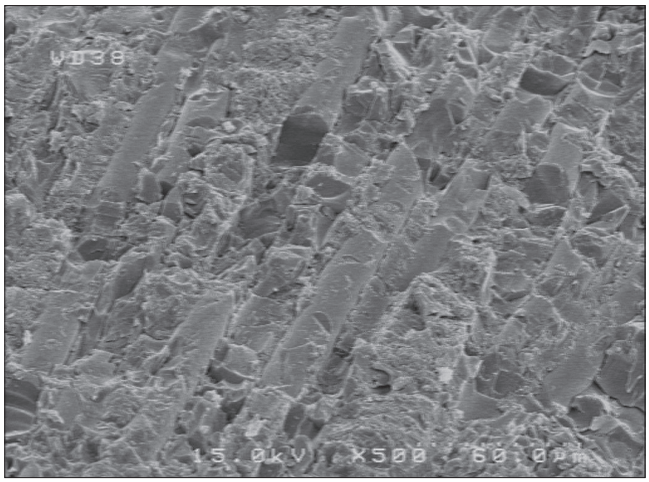

Figure 2: Sandblasted post after 9 months water storage

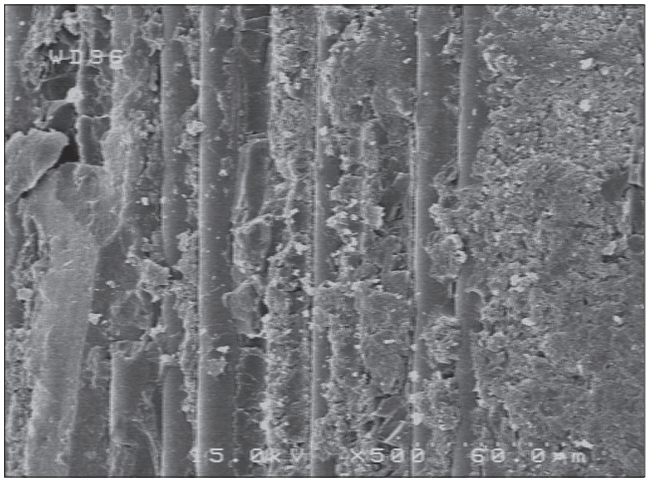

Figure 3: H_2O_2 treated post without storage

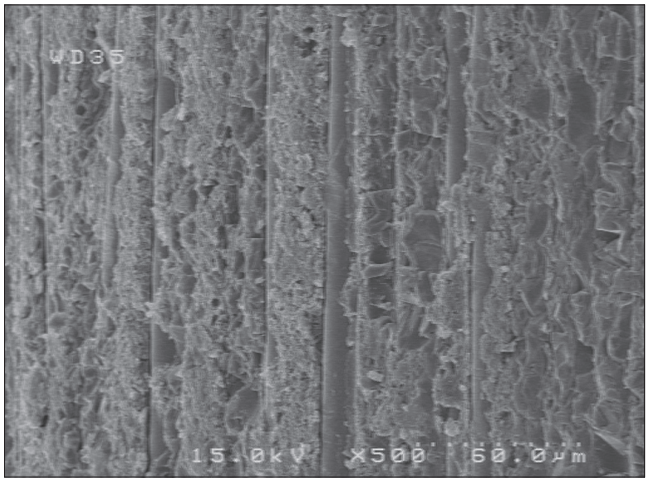

Figure 4: H_2O_2 treated post after 9 months water storage

Stereomicroscopic evaluation revealed that all failures occurred as adhesive failure. No cohesive or mixed failures were observed. Assessment of SEM images in the sandblasted groups showed that fibrils were destroyed and some of the fibrils were completely broken. But in groups treated with H_2O_2, fibrils were relatively intact and just the epoxy resin between fibrils was eliminated. Voids and disintegrates were observed in stored groups [Figures 1–4].

DISCUSSION

This study evaluated the effect of different post surface treatment methods and storage duration on microtensile bond strength between quartz fiber post and resin composite core. Since FRC posts contain epoxy resins or methyl methacrylate, it seems that water uptake by diffusion can cause some changes in post-core adhesion;[22] while metallic posts do not undergo such changes. DT Light quartz fiber posts contain 60% quartz fibers embedding in the epoxy resin matrix. Some studies reported that adhesion of these posts was improved after treatment with H_2O_2 and silane.[23]

Use of flowable composites as core materials is recommended in some studies because of ease of manipulation, structural homogeneity, and good adaptation due to its low viscosity. In addition, its lower filler content has an advantage to perform as a stress absorber that results in higher bond strength.[24-27] This study demonstrated that water storage decreased bond strength values regardless of the surface treatment method. Water storage decreases bond strength values through a degradation effect on adhesion properties. This result can be attributed to water sorption potential of composite core and consequently, production of hydrated swollen layers and dimensional changes in composite bulk. Therefore, water sorption can generate stresses in the interface of post and core.[22]

On the other hand, the presence of hydrophilic monomers in the adhesive layer is one of the possible reasons for results obtained. The hydrophilic compositions such

as HEMA play important role in water uptake.[28] Vichi revealed that exposure to water forms microcracks in HEMA containing polymer networks depending on the concentration of HEMA. However, results of this study are in agreement with Vichi's study.[22]

Additionally, Epoxy resin existing between fibrils can undergo degradation and dislodgement because of its resinous nature, and this may be the reason for decreased bond strength in the stored groups.

The previous studies have reported that effective factors on microtensile strength are the type of composite, water storage, surface treatment on fiber post, aging, and application of adhesive bonding.[21,29]

In this study, storage duration and condition, type of composite and type of the adhesive system were similar in all the groups.

The other finding of this study was that bond strength values of hydrogen-peroxide-treated posts were higher than the sandblasted posts.

Recent studies, also confirmed that treatment with hydrogen peroxide increases bond strength of glass and quartz fiber posts to resin composite.[17-20] Yenisey found that the surface treatment of fiber posts with hydrogen peroxide had greater shear bond strength in comparison with application of methylene chloride and silane.[30] Vano *et al*. and Monticelli *et al*. reported similar results for improving bond strength of hydrogen-peroxide-treated fiber posts.[9,24]

Equilibrium in absorption of water after 6 months is reason for lack of difference between Group 6 with Group 7 and Group 7 with Group 8 in the sandblasted groups. There were no significant differences between Group 4 with Groups 7 and 8. It means that material saturation and hydrolytic equilibrium in sandblasted groups occurred rapidly in comparison with the hydrogen-peroxide-treated groups. This might be due to the presence of greater amount of epoxy resin in the posts treated with hydrogen peroxide. Since hydrogen peroxide method is more conservative than sandblasting, so the greater content of resin remains after treatment.[9] Paired comparison of the sandblasted groups indicated that bond strength values was not different between Groups 7 and 8, but in the hydrogen peroxide groups decreasing of bond strength continued from Groups 1 to 4.

One possible explanation is that the amount of water absorption increases until material saturation and hydrolytically stability achieved.[12]

Finally, there were significant differences between the bond strength values of hydrogen peroxide and sandblasted groups. After 6 and 9 months, the presence of higher number of voids and discontinuities between fiber and the resin material could be a reason for this result.

SEM observations confirmed all the results and revealed that voids can have negative effects on adhesion. Adhesive area is the weakest area in adhesion of fiber post to composite.

Considering the fact that post-core complex is not directly exposed to oral fluids *in vivo*, and water exposure usually occurs after leakage; the times assessed could be attributed to longer times *in vivo*.

In this study, water storage was assessed without thermal and load cycling. For more similarities to the oral conditions, it is recommended to perform fatigue test in combination with water storage. In addition, in this study, one type of fiber post and adhesive were evaluated, future studies on other types of fiber post and adhesive systems are recommended.

CONCLUSIONS

Within the limitations of this study, it was concluded that

1. Water aging significantly decreased microtensile bond strength regardless of the type of the post surface treatment;
2. Duration of water storage was effective in reducing microtensile bond strength in both treatment groups, although bond strength after 9 months storage was not significantly different between sandblasted and H_2O_2-treated groups.

ACKNOWLEDGMENTS

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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How to cite this article: Khamverdi Z, Abbasi S, Habibi E, Kasraei S, Azarsina M, Ebadi S. Effect of storage time on microtensile bond strength between quartz fiber post and composite core after different post surface treatments. J Conserv Dent 2011;14:361-5.

Source of Support: Nil, **Conflict of Interest:** None declared.