

## Effect of Surface Conditioning and Resin Cements on the Adhesion of Fiber Posts

Renato Roberto<sup>1\*</sup>, Mohamed Ghazy<sup>2</sup>, Omar El-Mowafy<sup>3</sup> and Igor J Pesun<sup>4</sup>

<sup>1</sup>Associate Professor, Department of Comprehensive Care, School of Dental Medicine, Case Western Reserve University, Cleveland, Ohio, USA

<sup>2</sup>Associate Professor, Department of Conservative Dentistry and Fixed Prosthodontics, Faculty of Dentistry, University of Mansoura, Mansoura, Egypt

<sup>3</sup>Professor, Department of Clinical Sciences, Faculty of Dentistry, University of Toronto, Toronto, ON, Canada

<sup>4</sup>Associate Professor & Head, Department of Restorative Dentistry, Faculty of Dentistry, University of Manitoba Winnipeg, MB, Canada

\*Corresponding author: Renato Roberto, DDS, MSc, PhD, Associate Professor, Department of Comprehensive Care, School of Dental Medicine, Case Western Reserve University, Cleveland, Ohio, USA

Received Date: July 30, 2013, Accepted Date: September 20, 2013, Published Date: September 22, 2013

Citation: Renato Roberto (2013) Effect of Surface Conditioning and Resin Cements on the Adhesion of Fiber Posts. J Dent Oral Health 1: 1-5

### Abstract

**Purpose:** This study evaluated the influence of surface treatments on the microtensile bond strength between a glass fiber post surface and resin cements.

**Methods:** Forty-five posts (Reforpost, Angelus, Londrina, PR- Brazil) were assigned to three groups with different surface treatment: Group 1: No treatment and silane application only (G1); Group 2: immersion in 96% ethyl alcohol for 10 minutes followed by silane application (G2); Group 3: immersion in 24% H<sub>2</sub>O<sub>2</sub> for 10 minutes followed by silane application (G3). Each group was divided into 3 subgroups according to the resin cement used: UniCem/3MESPE (UN); BisCem/Bisco (BC); and Panavia F/Kuraray (PN). Posts were placed in a square-shaped matrix, in which it was held in place by the resin cement and subsequently photo-cured. Blocks were obtained, serially cut into sticks and then loaded onto a micro-tensile testing machine.

**Results:** ANOVA indicated significant differences among surface treatments ( $p < 0.05$ ) and resin cements ( $p < 0.05$ ). The Tukey test revealed that the group G3 had greater bond strength than group G2 without a statistical difference ( $p > 0.05$ ). Group G1 had lower bond strength values ( $p < 0.05$ ). The values for group BC and group PN were significantly higher than group UN ( $p < 0.05$ ). The type of surface treatment and resin cement influenced the microtensile bond strength.

**Hypothesis:** The use of different surface treatment can improve the chemical-mechanical interaction between fiber posts and resin cements, thus improving the performance of clinical application of these materials in endodontic treated teeth.

**Clinical Significance:** Within the parameters of this study, the bonding capability of conventional and self-adhesive resin cements to fiber posts were affected by different post surface pre-treatments. Post surfaces treated with 24% H<sub>2</sub>O<sub>2</sub> or 96% ethyl alcohol showed significantly stronger bond interactions to resin cements than only silane application.

### Introduction

The use of restorative fiber posts for the restoration of endodontically treated teeth is currently a common practice in dental offices due to good mechanical properties of the fiber posts when compared to traditional metal cast posts [1-3]. Some common advantages for these posts are: better aesthetic for the final restoration when used in combination with full ceramic crowns; and one single visit to the dental office for both post and core, once there is no additional laboratory step involved. It has been mentioned that fiber posts can also increase the transmission of light within the root canal, thereby increasing the degree of conversion of monomers to polymers (resin cements) and also eliminating the problem of curing deeper areas of the root when using resin cements [4]. Others have also mentioned that fiber posts provide their modulus of

elasticity and diametral tensile strength similar to the dentin, therefore, diminishing the risk of root fracture. Clinical studies have been proving the high success rates of restored teeth with fiber posts without the occurrence of root fractures [5-9].

Glass fiber posts are basically composed of glass fibers, inorganic filler, and a resin matrix covering the whole thing. They are usually cemented inside the root canal with a conventional or a self-adhesive resin cement to increase their retention and improve the mechanical performance of restored teeth once the resin cement is able to dissipate the stress when tooth is in normal function [10-12]. Monticelli et al. [13] have also suggested the use of silane coupling agents in coating application on the post surface before using the resin cement in order to promote adhesion between the post surface and the polymeric

molecules of the resin material. However, in many cases interfacial failure has been attributed to chemical incompatibility between the post surface and the resin cement. As mentioned before, the core (fiber post/resin cement) is responsible to dissipate the stress when the tooth is in normal function and the durability of a composite core restoration depends on the formation of a strong bond between the composite resin and the residual dentin, as well as the composite resin and the fiber post, enabling sufficient resistance to the interface stress under functional loading [13].

Chemical surface treatments are well known methods of improving the general adhesion properties of a material, thereby enhancing chemical and micromechanical union between different components. As an example, the chemical surface treatment of the enamel and dentin before applying the resin adhesive. The adhesion of a composite resin to the surface of a fiber post is not an exception. There is no chemical interaction between methacrylate-based composite resin and the epoxy resin matrix present on the surface of fiber posts [14,15]. Recent studies have demonstrate that in order to improve the bond strength between the post surface epoxy resin and the composite resin cement, many surface pre-treatments for posts are available using different chemical agents[2,5,9,14-18]. The idea is simple: chemical treatment is aimed to roughening the post surface, thus enhancing the mechanical interlocking between the post and the composite resin cement. Several chemical solutions have been used for post surface treatment, however, the hydrogen peroxide has been shown to significantly increase the bond strength between fiber posts and flowable composite resin materials used for core build-up [9].

The present study was aimed to evaluate the fiber post surface treatment on the microtensile bond strength between glass fiber posts and composite resin cements. The changes in post-surface characteristics following the different pre-treatments were also observed using Scanning Electron Microscopy (SEM).

## Materials and Methods

Forth-five fiber posts (Reforpost, Angelus, Londrina, PR, Brazil) with a maximum diameter of 1.5 mm and 20 mm length were used in this study. The posts are composed of longitudinal oriented fibers covered with epoxy resin and one steel filament inside the post. Three different superficial chemical surface treatment were performed as follows:

Group 1 (G1) consisted of only one application of a single layer of silane (Silane Component, Bisco, Schaumburg, IL, USA) for 60 seconds followed by gentle air drying for the equivalent time.

Group 2 (G2) consisted of three successive steps: a) immersion of the fiber post in a 96% ethyl alcohol solution for 10 minutes; b) extensive rinsing with tap water for one minute and; c) application of a single layer of silane for 60 seconds followed by gentle air drying for the equivalent time.

Group 3 (G3) the treatment also followed three successive steps: a) immersion of the fiber post in a 24% hydrogen peroxide solution for 10 minutes; b) extensive rinsing with tap water

for 1 minute and; c) application of a single layer of silane for 60 seconds followed by gentle air drying for the equivalent time.

Conventional resin cement (Panavia F - Kuraray, Tokyo, Japan) and two self-adhesive resin cements were used in this study (UniCem [3MESPE]- St Paul, MN, USA; BisCem [Bisco] - Schaumburg, IL, USA). The composite resin cements (conventional and self-adhesive) were mixed according to the manufacturer instructions.

Each fiber post was positioned into the central part of a square shaped cavity made in a silicon matrix with the following dimensions: 10mm (L) x 15mm (H) x 1.5mm (W). The silicon matrix was subsequently filled completely with composite resin cement. The excess of composite resin cement was removed and a plastic Mylar strip placed on top of it. Subsequently, a glass slide was placed onto the matrix and light-curing was performed through the square area using a halogen light (Spectrum 800 Light Cure Unit, Dentsply DeTrey, Konstanz, Germany) with an output of 600 mW/cm<sup>2</sup> for 40 seconds. This resulted in a cured block of uniform thickness, with the post in the center and the resin cement on both sides. Using a sand paper (400um grip) each block was then serially polished to obtain a more uniform thickness of 1.5mm.

After storing the specimens in distilled water for 24 hours, each block was fixed with wax onto acrylic blocks and mounted on the holding device of a slow-speed diamond saw (Isomet Buehler, Lake County, IL, USA) to be serially sectioned to obtain 5 sticks with dimensions of approximately 10mm(L) x 3.0mm(H) x 1.5mm(W), (Figure 1). Each stick was attached to the grips of a special device designed for the microtensile bond strength test using cyanoacrylate glue (Zapit, Dental Ventures of America, Anaheim Hills, CA, USA) and stressed to failure with a  $\mu$ TBS testing machine (BISCO).

**Figure 1:** Making Fiber post/ resin cement sticks for the Micro Tensile Bond Strength test.

Means and standard deviations were calculated, and the data was analyzed by analysis of variance (ANOVA) using a factorial design in which post surface treatment and resin cement acted as the independent variables. Multiple comparisons of means were performed by the post hoc statistical test. SPSS 15.0 software was used for statistical analysis.

Additional posts were also made for SEM analysis. Two extra posts of each group were randomly selected for SEM examination of the superficial aspect of the post following surface pretreatment. The posts were observed longitudinally. Each post was mounted on a metallic stub, platinum-sputtered (Polaron SL 515 machine, Watford, Herts, U.K.) and observed under a scanning electron microscope (Hitachi S2500, Tokyo, Japan) at different magnifications (35X, 500X, 1000X and 2000X).

## Results

Statistical analysis (one-way ANOVA) revealed that both the post surface treatment and the type of resin cement had a significant influence on microtensile bond strength ( $p < 0.05$ ). (Table 1) and (Graph 1). Regarding the post surface treatment, the bond strength achieved of G3 had significantly higher values than G1 ( $p < 0.05$ ), and higher, however, with no statistical difference than G2 ( $p > 0.05$ ). The G1 group showed the lowest strength values and the difference was statistically significant compared to G1 and G2 ( $p < 0.05$ ).

**Graph 1:** Mean bond strength values (MPa $\pm$ SD) of investigated resin cements and different surface treatment.

Material	Treatment			
	Control	ethyl Alcohol	H <sub>2</sub> O <sub>2</sub>	
UniCem	6,80 $\pm$ 1,72 <sub>c</sub>	11,08 $\pm$ 2,71 <sub>ab</sub>	14,00 $\pm$ 1,77 <sub>a</sub>	
BisCem	10,96 $\pm$ 1,35 <sub>a</sub>	12,03 $\pm$ 3,46 <sub>a</sub>	14,31 $\pm$ 2,89 <sub>a</sub>	
Panavia F	10,38 $\pm$ 1,86 <sub>bc</sub>	15,35 $\pm$ 3,10 <sub>a</sub>	13,37 $\pm$ 2,15 <sub>ab</sub>	

\*Interactions between lines of different resin cements are represented by symbols; interactions between rows of different treatments per resin cement are represented by letters.

**Table 1:** Mean bond strength values (MPa $\pm$ SD) of investigated resin cements and different surface treatment.

For the resin cements used in this study, a statistical significance was observed between the different groups. The resin cements Panavia F and BisCem, demonstrated higher values of bond strength with no statistical difference ( $p > 0.05$ ). The UniCem resin cement showed the lowest values of bond strength ( $p < 0.05$ ).

### SEM analysis

SEM evaluation revealed that the post surface morphology was modified following treatment with alcohol and hydrogen peroxide. Both surface treatments produced similar changes in the ultrastructure of the post surface. At a lower magnification (35x) without treatment, the complete coverage of the fibers by

the epoxy resin was evident. After exposure to 96% ethyl alcohol for 10 minutes or 24% hydrogen peroxide solution for 10 minutes, a uniform distribution of micro-spaces was apparent among the exposed fibers (Figure 2 and 3).

**Figure 2:** SEM photograph of surface of glass-fiber post, silane application (control group), at different magnification (A:35, B:500, C:1000 and D:2000X).

**Figure 3:** SEM photograph of surface of glass-fiber post, 96% ethyl alcohol group, at different magnification (A:35, B:500, C:1000 and D:2000X).

**Figure 4:** SEM photograph of surface of glass-fiber post, H<sub>2</sub>O<sub>2</sub> group, at different magnification (A:35, B:500, C:1000 and D:2000X).

## Discussion

Nowadays, restorative procedures are based on a variety number of steps using a variety number of different materials in order to achieve a desired result: good longevity for the restoration. However, incompatibility between materials is still a common problem in dental practice. The use of fiber posts in combination with resin cements in endodontic treated teeth should be strong enough to support the occlusal stress and the mechanical load of the post and core/crown restoration [14,19-22]. Lack of proper adhesion between the fiber post surface and the resin cement as well as the resin cement and the intra-coronal dentin are clearly the most challenging aspects and clinical failures are common outcomes. Methods to improve the adhesion between the post surface and the resin material used for cementation haven't been extensively investigated, and dentists are still looking for a simple protocol using common chemical solutions available in the dental office able to create a better adhesion between the fiber post surface and the resin cement.

One simple method was demonstrated by Monticelli et al. [16] to improve this adhesion. It consisted of the use of 24% Hydrogen Peroxide applied for 10 min on the post surface followed by a silane compound application. The use of a silane compound is indicated to increase the bond strength between the cement and the exposed fibers.

Some authors explain that the coupling action of silane involves the formation of covalent bonds from the reaction of the organo-functional group and the hydrolyzed alkoxy group,

respectively, with the resin matrix and the mineral substrate (glass or silica) of the composite material [13,16]. Thus, with the removal of the superficial layer of epoxy resin via chemical treatment, additional exposed glass fibers, in terms of surface area, are available to be in contact with the silane molecules. The increased chemical union between the silanized glass fibers and the methacrylate-based resin material would significantly improve the interfacial bond strength [17].

Other authors also demonstrated that the epoxy resin covering the fibers can be selectively dissolved by the action of an oxidizing solution [9,13,17,23]. The use of an oxidizing solution as a chemical pre-treatment (i.e. the hydrogen peroxide and the ethyl alcohol) can easily break the epoxy bonds. Removing the epoxy resin is not the only desired function of a chemical treatment. The fibers should also be selective dissolved in the surface in order to provide an irregular pattern of micro-spaces, in other words, providing better micro-adhesion to the silane coupling agent. This may increase the surface area and facilitate the penetration of the composite into the microretention of the etched post surface [9]. Our SEM investigation illustrated that the both pattern of dissolution in the post surface are the same when using 96% ethyl alcohol or 24% hydrogen peroxide over the epoxy resin. Our results were similar to those obtained by Vano et al. [2] in which the exposed fibers did not appear to be damaged by the action of hydrogen peroxide, and no defects or fractures were evident on the surface.

Even though some scientific papers have reported different techniques to etch the post surface, some authors are also mentioning the use of more aggressive procedures, such as the use of a gel of hydrofluoric acid [7] and air blasting technique with zirconia or silica oxide [9,23]. However, these techniques can deeply affect the integrity of the fiber post and microscopic analysis has revealed an uneven removal of the epoxy resin matrix and extensive damage to the quartz fibers. Monticelli et al. [16] suggested that hydrogen peroxide, on the contrary, is a considerably milder technique because the exposed quartz fibers remain smooth and leave the underlying epoxy resin matrix intact after the etching procedures.

Two different resin cement materials were evaluated in this study: regular resin cement, which is commonly employed for this purpose, and two self-adhesive resin cements. Although it has been reported that resin cements have good mechanical properties and adaptation to the post surface [24], it can be seen from the interfacial strength results that one self-adhesive resin cement investigated did not differ significantly from the regular resin cement. It can be speculated that, because of its etching capability, the self-adhesive resin cement was able to penetrate optimally within the post surface irregularities, taking the greatest advantage of the increase in surface area available for bonding following the post surface treatment, within the thick zone of denuded glass fibers. This could enable the self-adhesive resin cement to achieve a bond with the post that was as solid as other resin cements.

In the present study, differences in bond strength between the post surface treatments might be explained by the diverse composition and properties of resin cements. Nevertheless, further

long-term clinical studies should be conducted to evaluate the survival rate of fiber posts with this kind of treatment under clinical conditions.

In conclusion, the post surface pre-treatment with ethyl alcohol and hydrogen peroxide significantly increased the bond strength between silanized glass fiber posts and resin cements. The bond strength was also significantly affected by the type of resin cement used.

## Acknowledgements

The materials investigated in this experiment were generous gifts from Bisco (USA), 3MESPE (USA), Kuraray (Japan) and Angelus (Brazil).

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