Original Article

Surface analysis of glass fiber posts after pretreatment with Er: YAG laser: An SEM study

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Abstract

Introduction: Surface pretreatment of posts is expected to increase the chemical and mechanical bond between the luting composite resin and the post by exposing the surface glass fibers and allowing the silane-coupling agent to directly react with the silicate group of the glass fibers allowing a stronger bond to form between the post and the resin cement. The best method to do this has not been definitively determined. **Aim:** To analyze the surface changes on glass fiber posts after pretreatment with erbium-doped yttrium aluminium garnet (Er: YAG) laser at different settings. **Materials and Methods:** Twenty glass fiber posts (ReforPost, Angelus, Londrina, Brazil) were divided into four groups. Group I: No surface pretreatment was performed Group II: Surface pretreatment of posts with Er: YAG laser at 1 W Group III: Surface pretreatments of posts with Er: YAG laser at 1.5 W Group IV: Surface pretreatment of posts with Er: YAG laser at 2 W. **Results and Conclusion:** Er: YAG laser does not damage the glass fibers at 1.5 W and at the same time clears the epoxy resin coating over the surface of the posts potentially allowing silane coupling agent to chemically interact with exposed glass fibers.

Key words

Erbium-doped: Yttrium aluminium garnet, glass fiber posts, surface treatment

Introduction

Cast posts have been traditionally used as a technical solution for the reconstruction of endodontically treated teeth. However, they have fallen out of favor due to characteristics such as preparation which is far from being conservative, extremely time consuming, requirement of two appointments, the need of a laboratory stage, temporization, probability of corrosion, retention impaired by the lack of adhesion to the remnant tooth, and perhaps the biggest disadvantage of cast posts and cores is in areas that require an esthetic temporary restoration. Temporary posts/crowns are not effective in preventing contamination of the root canal system.[1-4] As an alternate to cast metal post/cores, nonmetallic posts emerged, such as those made from zirconium, ceramics, carbon fiber, quartz fiber, silicon fiber, and most recently glass fiber-based posts.

Since the invention of carbon fiber posts in 1990 by Duret *et al.*, fiber posts have acquired growing importance becoming more and more popular in the restoration of nonvital teeth.[5]

Glass fiber posts have been shown to be quite a viable alternative as they possess characteristics such as an elasticity module similar to that of dentin, biocompatibility, better distribution of masticatory forces, high durability, resistance to corrosion, elimination of the laboratory stage, superior esthetics as they have optical properties that provide greater translucence to the dental core.[1,4,6,7] Another notable aspect is the possibility of using resin cements that

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present dual polymerization, since they may be activated both physically and chemically and positively influence the retention after cementation, as the light polymerizing materials would be placed at too great a depth, in the apical region for polymerization to occur.[8,9]

Considerable attention has been paid to the clinical applications of fiber posts. Reliable bonding can be achieved using composite resin-based cement; when post, luting materials, and dentin achieve good adhesion; thus forming a "monoblock" unit.[10]

Fracture modes reported in earlier studies were adhesive in nature, with failure of the composite resin bond to the post surface.[11,12] Therefore, the challenge is to form an interpenetrating network between the luting composite resin or its adhesive and the glass fibers.[13]

The benefit of applying silane-coupling agents as adhesion promoters has been reported.[14-16] However, the post/composite joint still remains relatively weak. Coupling of conventional epoxy resin-based fiber posts to dental composites is hampered by the absence of chemical union between the epoxy resinous matrix and methacrylate-based resins.[17]

Surface pretreatment of posts is expected to increase the chemical and mechanical bond between the luting composite resin and the post by exposing the surface glass fibers and allowing the silane coupling agent to directly react with the silicate group of the glass fibers allowing a stronger bond to form between the post and the resin cement. The best method to do this has not been definitively determined.

The present study is a scanning electron microscope (SEM) analyses of the surface changes of glass fiber posts after pretreatment using erbium-doped yttrium aluminium garnet (Er: YAG) laser at different power settings.

Aim

To analyze the surface changes on glass fiber posts after pretreatment with Er: YAG laser.

Materials and Methods

Twenty glass fiber posts #2 with a tip diameter of 1.3 mm (ReforPost, Angelus, Londrina, Brazil.) were used for the study. The posts were made of 80% unidirectional glass fibers bound in 20% epoxy resin matrix. The posts were divided into four groups (n = 5) according to the surface pretreatment performed.

Group I:	No surface pretreatment was performed
Group II:	Surface pretreatment of posts with Er: YAG laser at 1 W (100 mJ and 10 Hz)
Group III:	Surface pretreatment of posts with Er: YAG laser at 1.5 W (150 mJ and 10 Hz)
Group IV:	Surface pretreatment of posts with Er: YAG laser at 2 W (200 mJ and 10 Hz).

The surface pretreatment of posts in all the groups were carried out in non-contact mode for 60 s, that is, 15 s per side and the post was rotated four times through 90°.

The posts were then cleaned in deionized water for 10 min, and dried with an oil-free air stream in order to remove any surface residues. Since posts of group 1 were not pretreated, they were not subject to cleaning.

Each glass fiber post was then subjected to an SEM analysis in order to assess the surface changes on the fiber posts. The SEM images were analyzed to see the amount of epoxy resin coating cleared from the surface of the posts and whether or not there is any substantial damage that is caused to the glass fibers of the posts.

Results

The posts of Group 1 [Figure 1] showed a uniform layer of epoxy resin coating on the surface with no exposed glass fibers. The posts of Group 2 [Figure 2] showed partial removal of the epoxy resin coating with no damage to the individual glass fibers. The posts in Group 3 [Figure 3] showed complete removal of epoxy resin coating with no damage to the glass fibers of the posts. In Group 4 [Figure 4] the posts showed discontinuous and broken glass fibers. The posts here also showed melting of fibers in certain areas.

Discussion

Glass fiber-reinforced resin post systems were introduced in 1992.[18] These posts are composed of unidirectional glass fibers embedded in a resin matrix. Matrix polymers are commonly epoxy polymers with a high degree of monomer conversion and a highly crosslinked structure.[19] However, a major drawback

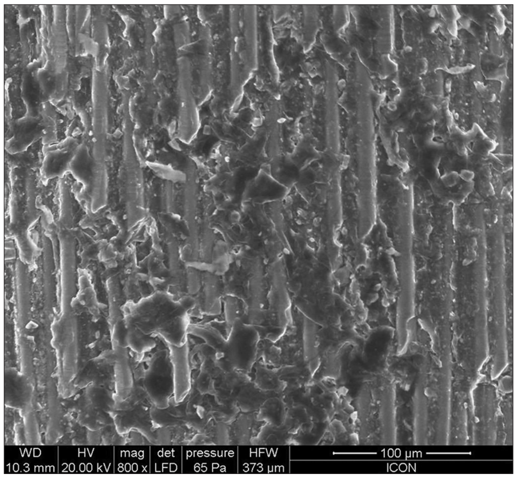

Figure 1: Scanning electron microscope image of Group I at ×800 magnification

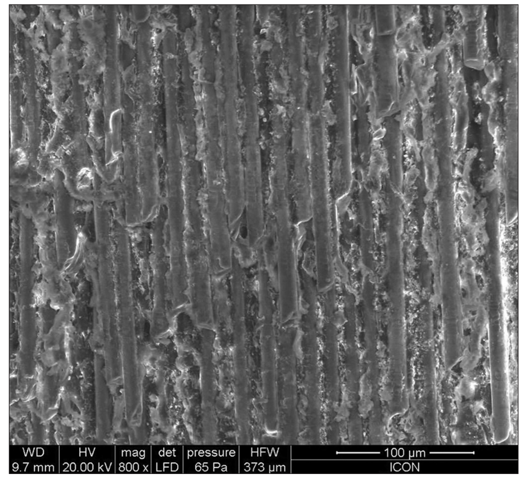

Figure 2: SEM image of Group II at ×800 magnification

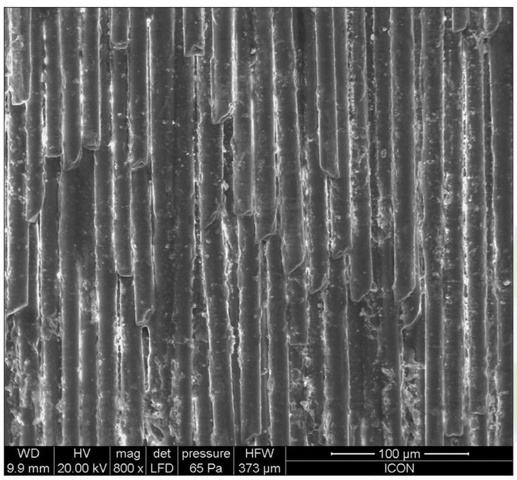

Figure 3: SEM image of Group III at ×800 magnification

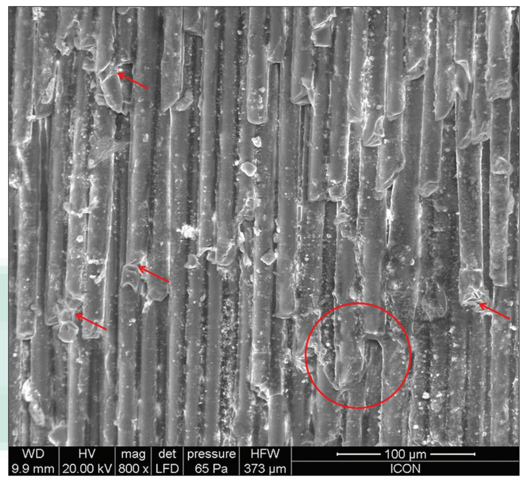

Figure 4: SEM image of Group IV at ×800 magnification (arrows showing damaged/broken areas of glass fibers, circle showing melted area of glass fibers)

of fiber posts is that they are insufficient on bonding performance, which may lead to clinical failure.[20,21]

Although comparative studies showing the advantages of various types of surface pretreatment methods on fiber post exist,[15,17,22] there has been no consensus in the literature regarding the best surface pretreatment method for optimum bonding.

Silane coupling agents are applied to fiber-reinforced composite posts to improve the adhesion at the fiber-resin matrix interface and to modify the catalytic properties and the wettability of the fiber surfaces.[16] Silane molecules react with water to form three silanol groups (Si-OH) from the corresponding methoxy groups ($Si\text{-}O\text{-}CH_3$). The reactive molecules are able to connect organic and inorganic material by reacting with the inorganic silicate of fiber-reinforced concrete (FRC) and polymerizing with the methacrylate groups of the adhesive resin.[22] Sahafi *et al.*, found that silane did not increase the bond strength of ParaPost Cement to ParaPost Fiber White.[21] This they explained on the basis of the inefficiency of silane forming a weak or absent bond of the silane functional group to the epoxy resin, a nonsilicate-based material, which cover the surface of the fiber posts.

Previously, hydrofluoric acid has been used for the surface pretreatment; but with little success. The technique produced substantial damages to the glass fibers and affected the integrity of the post.[22] This is due to the extremely corrosive effect of hydrofluoric acid on the glass phase of a ceramic matrix.[23,24] These findings were confirmed by Vano *et al.*,[25] when hydrofluoric acid was used for conditioning methacrylate-based fiber posts.

The SEM analysis of posts surface pretreated at power setting of 1 W did not show clearing of the epoxy resin coat (magnification ×800). The fibers did not appear to be adversely affected at these settings. The images showed the surface appearing similar to untreated posts [Figure 2].

The SEM analysis of the posts surface pretreated at power setting of 1.5 W showed that all the surface glass fibers of the posts were exposed (magnification ×800). There was no damage to the individual glass fibers observed. The surface also appeared to be clear of any leftover debris in between the fibers. This type of a surface appeared perfectly conducive for bonding after the application of silane coupling agent [Figure 3].

Treating the surface of posts at power settings of 2 W visibly charred the surface of the glass fiber posts. The post appeared brownish in color. The SEM analysis revealed an epoxy resin free surface but with discontinuous and broken glass fibers, that had also undergone melting in certain areas, thus the damage to the posts was confirmed [Figure 4].

Any surface treatment carried out on the post is likely to cause changes in the mechanical properties of the posts. In the present study the flexural strength of the surface treated posts should have been compared with the posts that were provided by the manufacturer, especially in the light of the fact that previous studies have reported damaged fibers when hydrofluoric acid was used. Further studies involving the bond strength of the fiber posts cemented with dual cure resin need to be carried out to verify to what extent does surface pretreatment enhances the bond strength.

Conclusion

Within the limitations of the study, the best method for surface treating the posts is by using Er: YAG laser at 1.5 W, since it does not damage the glass fibers but at the same time clears the epoxy resin coating over the surface of the posts potentially allowing silane coupling agent to chemically interact with exposed glass fibers.

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