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INFLUENCE OF SELF-ETCH ADHESIVE AND LASER IRRADIATION ON THE SHEAR BOND STRENGTH OF FIBER POSTS TO ROOT DENTIN

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ABSTRACT

Introduction: Fiber posts and cores are usually used for the restoration of endodontically treated teeth with extensive coronal destruction. The most common cause of failure of fiber posts is debonding at the adhesive resin- dentin interface due to bond deficiency. **Aim of the study:** The purpose of this In-vitro study was to evaluate the effect of different dentin surface treatments including self- etch adhesive system, Er,Cr:YSGG laser irradiation and self- etch adhesive system after Er,Cr:YSGG laser irradiation on the push out bond strength of fiber posts to radicular dentin. **Materials and Methods:** The coronal portions of fifteen maxillary central incisors were cut till CEJ, the roots were endodontically treated and posts spaces were prepared. The roots were divided according to the dentin surface treatment method used into three groups (n= 5): group A: Optibond XTR self- etching adhesive system. Group B: Er,Cr:YSGG laser irradiation with output power of 2W, a repetition rate of 20Hz and water / air flow (80/60%). Group C: Er,Cr:YSGG laser irradiation with output power of 2W, a repetition rate of 20Hz and water / air flow (80/60%) followed by self- etching adhesive system (Optibond XTR). Dentoclic glass fiber posts were cemented, then each root was sectioned horizontally into three sections. Push out test was performed using a universal testing machine at a crosshead speed of 0.5 mm/min until failure. **Results:** There was a significant difference in the mean push out bond strength among different groups (p<0.001). The highest push out bond strength value was found in group A followed by group C, while the lowest bond strength value was found in group B. **Conclusion:** Optibond XTR self-etch adhesive system seemed to be an effective approach for fiber posts cementation.

INTRODUCTION

Endodontically treated teeth with extensive coronal destruction usually require post and core systems [1]. Fiber posts are the most common type of posts used nowadays because they have superior esthetics, a modulus of elasticity comparable to that of dentin and good biocompatibility [2, 3].

Debonding is the most common cause of failure of fiber post restorations [4]. Debonding usually happens at the dentin- cement interface, as it is the weakest point. Many factors affect the quality of the dentin- cement interface such as the direction and the number of dentinal tubules, irrigation solutions, dentin conditioning method and type of adhesive system [5].

Different adhesive systems are used for treatment of radicular dentin before fiber posts cementation such as total etch systems, self-etch systems and self-adhesive resin cements. Total etching of dentin surface causes removal of smear layer, opening of dentinal tubules and exposure collagen fibrils to be infiltrated by resin cements, which leads to formation of micromechanical retention between fiber posts and dentin surface by formation of hybrid layer and resin tags. However, the total etch systems had shown to be very technique sensitive because of their multiple steps and poor moisture control. Self-etch adhesive systems form hybrid layer and resin tags by partial dissolution and partial demineralization of the smear layer as their acidity is less aggressive than the acidity of total etch acids. Self-etch adhesive systems seem to be a more successful approach as they do not require etching by a separate etchant and do not require rinsing. The self-adhesive resin cements contain acidic monomers that demineralize and decalcify the dentin surface with no need for previous dentin surface treatment. They are single step and do not require any previous dentin surface treatment, but their penetration into the thick smear layer is debatable because they have weak acidic monomers. However, the clinical performance of these three different adhesive systems mainly depends on the adhesive brand not on the bonding approaches and the efficacy of these systems is inconsistent [6-8].

Zicari *et al*.[9] evaluated the sealing abilities and the bond strength of different adhesive systems (self-etch adhesive systems, total etch adhesive systems and self-adhesive resin cements) used for cementation of fiber posts, they found that self-etching adhesive systems showed higher bond strength compared to total etch systems and self-adhesive resin cements. Also, Naeem, Zohdy and Salah [10] evaluated the influence of different radicular dentin pretreatment methods on the bond strength of glass fiber posts (total etch light cured adhesive, total etch dual cured adhesive, self-etch light cured adhesive and self-etch dual cured adhesive), they concluded that pretreatment of radicular dentin with self-etch dual cured adhesive before cementation of fiber posts offered the highest bond strength.

Recently, laser technology has shown to be relatively safe and easily applied in different fields of dentistry. The Erbium lasers or hard tissue lasers (Er:YAG and Er,Cr:YSGG) are highly absorbed by dental tissues. They can cause changes in the solubility, permeability and morphology of the microstructure of the radicular dentin. Besides, they can remove smear layer and debris from root canals, open the dentinal tubules and increase the surface roughness which promote formation of mechanical retention by penetration of resin cement into the opened dentinal tubules and micro irregularities. So, Erbium lasers can be used as an alternative to the conventional dentin surface conditioning methods with the aim of enhancing the retention of the fiber posts [11, 12].

Nagase *et al*.[13] evaluated the effect of Er,Cr:YSGG and Nd:YAG laser on fiber post retention, they found that Nd:YAG laser had a negative effect on fiber posts retention as it cause melting of the dentinal walls while Er,Cr:YSGG laser did not affect the retention of fiber posts. In addition to, Borges *et al*. [14] observed the effect of Er:Cr:YSGG and diode laser irradiation on the bond strength of fiber posts to radicular dentin and they concluded that Er:Cr:YSGG laser irradiation of root dentin can improve the retention of the fiber posts.

This in vitro study evaluated the shear bond strength of fiber posts to radicular dentin treated by self- etch adhesive system, Er,Cr:YSGG laser irradiation and self- etch adhesive system after Er,Cr:YSGG laser irradiation.

MATERIALS AND METHODS

This study was approved by the research ethical committee of Faculty of Dentistry- Suez Canal University (n.2018/118). The coronal portions of fifteen sound human maxillary central incisors were cut till CEJ using a low speed cutting disc, then the roots were endodontically treated. The working length was established 1 mm shorter of the apical foramen. The root canals were instrumented in crown down technique and obturated by lateral condensation technique. Then the roots were stored in saline for one week at 37°C before post space preparation. The post spaces were prepared about 10 mm in length leaving 3-5 mm gutta-percha as an apical seal.

The roots were divided into three groups (each group consists of five roots) according to the dentin surface treatment method used: **Group A**: Root canal dentin was treated with self- etch adhesive system (OptiBond XTR, Kerr) according to the manufacturer's instructions. The self- etch primer was applied to the root canal dentin walls using a disposable micro brush followed by OptiBond XTR adhesive. The excess adhesive was removed by using an absorbent paper points and then was light cured for 10 seconds according to the manufacturer's instructions where the light was directed to the cervical area of the root to resemble the clinical situation. **Group B**: Root canal dentin was treated by Er,Cr:YSGG laser (Biolase Technology, Sam Clemente, CA) which emits photons at a wavelength of 2780 nm. The output power of 2W, a repetition rate of 20 Hz, pulse duration of 60Ms (H mode), water / air flow (80/60%) and radial fiber tip (RFT 200 micron) were used. The fiber tip was inserted into the apical part of root canal and then pulled from apical to coronal direction four times with a rate of 2mm/sec and a 20 second break between each cycle. Then the root canals were dried by using air and paper points. **Group C**: Root canal dentin was irradiated by Er,Cr:YSGG laser irradiation with the same parameters used in group B and then treated with self- etch adhesive system (OptiBond XTR, Kerr) as described in group A.

Dentoclic glass fiber posts (Itena, Paris, France) were cemented using NX3 Nexus dual-cure resin cement (Kerr, Orange, CA, USA). The cement was applied inside the root canals with a lentulo spiral rotating in anti-clockwise motion. Fiber posts were inserted into the root canals to full depth and the excess cement was cleaned with a disposable brush. The cement was light cured and the light directed to the cervical area of the root.

Each root was sectioned horizontally perpendicular to the long axis of the tooth into three sections (cervical, middle and apical) with 2 mm thickness of each root section.

Push out test was applied using a computer-controlled universal testing machine. A customized metallic base was made with a central hole where the diameter of the central hole was slightly larger than the diameter of the post. Each root section was fixed on the metallic base with the coronal side of the root section facing the metallic base. Then the post segment was loaded with a stainless-steel cylindrical plunger tip. Compressive load was applied from apical to cervical direction at a crosshead speed of 0.5 mm/min until failure. The force at which failure occurred was recorded in Newton (N) and then push out bond strength was calculated in Mpa by dividing the maximum failure load by the bonded area of the post segment.

Microscopic analysis

Three new root samples were prepared with the same treatment protocols used in the three tested groups and then viewed under scanning electron microscope (SEM) at 5000´ magnification to visualize the effect of different dentin surface treatments on the radicular dentin surface.

Statistical analysis

The push out bond strength results were tabulated and statistically analyzed. Two-way ANOVA was used to study the effect of different tested variables.

RESULTS

Effect of different dentin surface treatments on the mean push out bond strength:

There was a significant difference in the mean push-out bond strength in the three tested groups ($p<0.001$). Group A showed the highest push out bond strength value followed by group C, while group B showed the lowest push out bond strength value as shown in Table (1). All results were represented in graph 1.

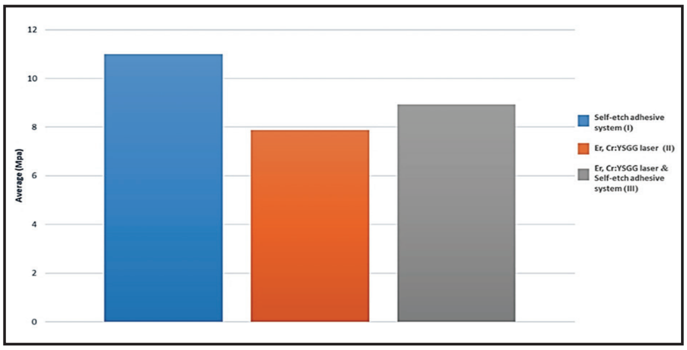
Scanning electron microscope results

SEM image of the radicular dentin surface before any dentin surface treatment showed a dense smear layer covering the dentin surface, blocked dentinal tubules orifices and a lot of debris (Fig. 1a). In group A, the radicular dentin surface showed widely opened and clean dentinal tubules, demineralized intertubular dentin, distinct visible peritubular dentin and thin homogenous smear layer (Fig. 1b). In group B, the radicular dentin surface showed removal of the smear layer but without complete removal of the debris, narrow openings of the dentinal tubules, melting areas of the dentin surface and presence of many cracks and fissures (Fig. 2a). In group C, the radicular dentin surface showed widely opened dentinal tubules, less amount of debris, demineralized intertubular and peritubular dentin with some remnants of the smear layer (Fig. 2b).

Table (1): *Mean and standard deviation (SD) of push-out bond strength (Mpa) of different groups*

Root section	Dentine surface treatment (mean±SD)			p-value
	Self-etch adhesive system (A)	Er,Cr:YSGG laser (B)	Er,Cr:YSGG laser & Self-etch adhesive system (C)	
Coronal	12.65 ± 0.87^{Aa}	9.12 ± 0.53^{Ca}	10.12 ± 0.52^{Ba}	**<0.001***
Middle	11.17 ± 0.41^{Ab}	8.03 ± 0.56^{Cb}	9.20 ± 0.56^{Bb}	**<0.001***
Apical	9.15 ± 0.35^{Ac}	6.47 ± 0.49^{Cc}	7.45 ± 0.27^{Bc}	**<0.001***
Mean±SD	10.99 ± 1.58^{A}	7.87 ± 1.23^{C}	8.92 ± 1.22^{B}	**<0.001***

Different upper and lower case superscript letters indicate a statistically significant difference within the same horizontal row and vertical column respectively; significant (p ≤ 0.05) ns; non-significant (p>0.05).*



Graph (1): Bar chart showing mean push-out bond strength (Mpa) of different groups.

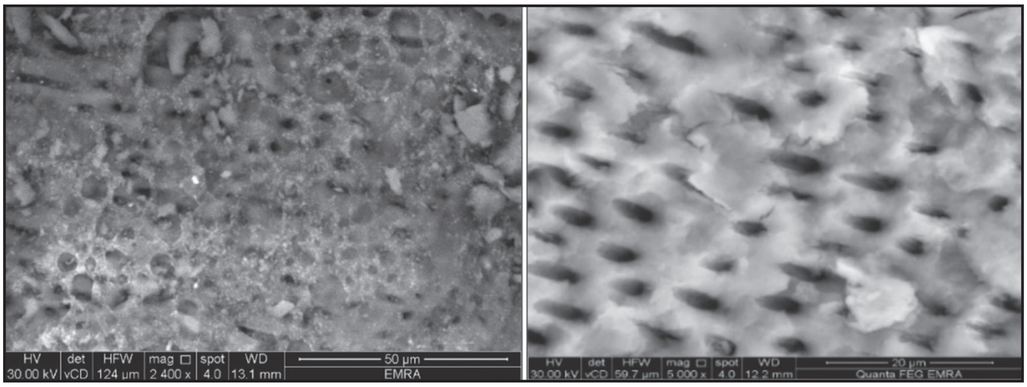


Fig. (1 a) SEM image showing root dentin surface before any dentin surface treatment.
Fig. (1 b) SEM image showing root dentin surface after treatment with self-etch adhesive system.

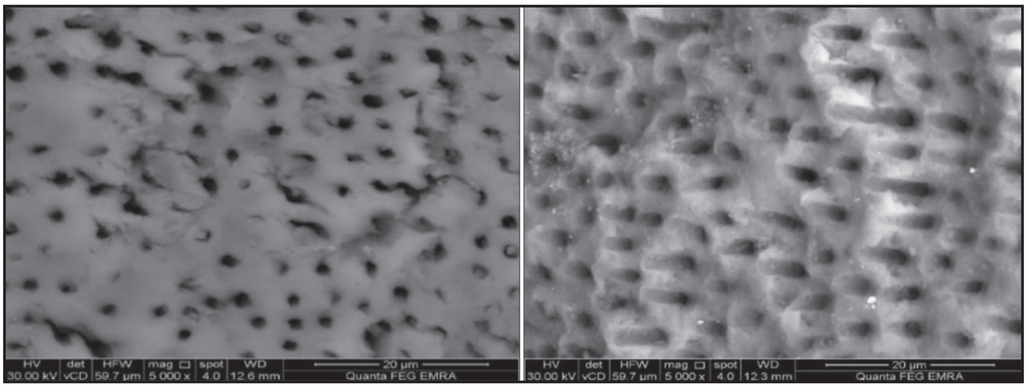


Fig. (2 a) SEM image showing root dentin surface after treatment with Er,Cr:YSGG laser irradiation.
Fig. (2 b) SEM image showing root dentin surface after treatment with Er,Cr:YSGG laser irradiation and self-etch adhesive system.

DISCUSSION

Adhesion of fiber posts to radicular dentin is challenging so, several dentin surface treatment methods are used to increase the bond strength of fiber posts to radicular dentin [3, 15]. Group A that was treated with self-etch adhesive system showed higher bond strength values compared to Er,Cr:YSGG laser irradiation groups.

Self-etch adhesive system might cause partial demineralization of the smear layer. This demineralization could open the dentinal tubules and allow the exposure of collagen fibrils. Optibond XTR self-etch adhesive system consists of two bottles: self-etch primer and adhesive. The Optibond XTR self-etch primer has 2.4 pH until it is dispensed and acetone evaporates, then the pH of the primer is reduced to 1.6 which might lead to an increase of the concentration of glycerol phosphate dimethacrylate monomers, thus creating a better etching effect. Then the resin monomers of the Optibond XTR self-etch adhesive penetrate into the network of demineralized collagen fibrils and opened dentinal tubules forming micromechanical retention by formation of hybrid layer and resin tags. Since self-etch adhesive systems partially demineralizes the dentin surfaces so they leave some hydroxyapatite crystals on the collagen fibrils which can form an additional chemical bond with the resin cements[16,17]. It was reported that self-etch systems are the option of choice as they have simple application and good adhesive capabilities[18]. Martinbo *et al.*[19] reported that self-etch adhesives are capable of etching the dentin surface as they modify the smear layer well and form a quality hybrid layer. In addition to Kirsch *et al.* [20] who found that Optibond XTR and Futurabond U self-etch adhesives gave the best retention for fiber posts.

In this study Er,Cr:YSGG laser was chosen as it has wavelength 2790 nm so it's highly absorbed by water and hydroxyapatite crystals. Er,Cr:YSGG laser irradiation cause thermomechanical ablation of the dentinal tissue by vaporization of the heated water which causes an expansion followed by microexplosions that lead to ejection of both organic and inorganic components of the dentin surface[21-24]. The irradiated dentin surface mainly delivers its bond strength from the mechanical retention provided by penetration of the resin cement into the opened dentinal tubules forming resin tags [25]. Breschi *et al.*[16] and Chu *et al.*[26] reported that resin tags are contributing minimally at the bond strength to radicular dentin and they are of less importance at dentin bonding. Since radicular dentin has few amounts of dentinal tubules available for the formation of resin tags, this could explain the lower values of the bond strength of the laser irradiated dentin compared to other groups.

In addition, laser irradiation of dentin surface might lead to formation of denatured and fused collagen fibrils which might restrict the diffusion of the resin cements into the intertubular dentin [13, 27, 28] that might compromise bond strength of fiber posts to laser irradiated dentin. Moreover, the thermal heat and microexplosions caused by laser irradiation could promote the formation of micro fissures and microcracks in the dentin surface which were poorly infiltrated by the resin cement [27, 29]. It had been reported by Alonaizan *et al.* [30] that the thermal heat of Er,Cr:YSGG laser irradiation to radicular dentin could lead to a decrease in the bond strength at different root levels.

These findings were in agreement with Kirmali *et al.*[31] and Ghavami *et al.*[32] who concluded that Er,Cr:YSGG laser irradiation of root canal dentin did not enhance the retention of fiber posts.

Irradiation of radicular dentin with Er,Cr:YSGG laser irradiation followed by treatment with Optibond XTR self-etch adhesive system increased the push out bond strength compared to the use of Er,Cr:YSGG laser irradiation alone. Er,Cr:YSGG laser irradiation with power setting more than 1.5W might cause thermal changes to the dentin surface and did not effectively remove the smear layer but it could act as a source of smear layer formation due to the structural changes that happened to the superficial layer of irradiated dentin [33]. Besides remnants of denatured and fused collagen fibrils was found at the basal part of the laser irradiated dentin surface [28] so, the self-etch adhesive system could demineralize and infiltrate into the remaining smear layer and collagen fibrils forming hybrid layer which might enhance the bond strength.

In addition, the use of self-etch adhesive system after laser irradiation might cause some opening of the partial melted and occluded dentinal tubules. Besides, it might cause an enlargement of the diameter of the opened dentinal tubules. This might promote better diffusion and penetration of the resin cement and could enhance the bond strength compared to the use of Er,Cr:YSGG laser irradiation alone [27, 33].

CONCLUSION

Within the limitations and conditions of this in vitro study, it could be concluded that:

1. Pretreatment of radicular dentin with Optibond XTR self-etch adhesive system showed higher

bond strength values compared to irradiation of radicular dentin by Er,Cr:YSGG laser irradiation.

2. Pretreatment of radicular dentin with Optibond XTR self-etch adhesive system after Er,Cr:YSGG laser irradiation could enhance the bond strength of fiber posts to root dentin compared to the using of Er,Cr:YSGG laser irradiation alone.

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