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Effect of Er,Cr:YSGG laser treatment on push-out bond strength of fiber posts to root canal dentin

(Effect of laser treatment on push-out bond strength of fiber posts)

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ABSTRACT

Aims: The aim of this study was to evaluate the effect of Er,Cr: YSGG laser treatment on push-out bond strength of fiber glass posts from root canal dentin.

Materials and Method: forty freshly extracted human central incisors were decoronated, instrumented and obturated. Standardized post space was prepared in each root, then randomly divided into four groups (n = 10) according to the use of the laser for the root canal and glass fiber post surface treatment. Group 1: the root canal was treated with laser, Group 2: the surface of fiber posts received by this group was treated with laser, Group 3: both the fiber posts and the root canal were subjected to laser treatment, and Group 4: the control group (without laser treatment) . The post were luted with Bis Cem resin cement. Each root was sectioned perpendicularly to its long axis to create 2mm coronal, middle and apical segment. A push-out test was performed to measure bond strengths, and the fracture modes were evaluated using a stereomicroscope. The bond strength data were recorded and expressed in MPa, then analyzed statistically.

Result: the result of this study showed that when both the fiber posts and the root canal were subjected to laser treatment (group 3), The highest mean of bond strength was obtained and the less mean of bond strength was seen in group the control group , and there was no significance different between group 1(when laser used for root canal treatment) and group 2(when laser used for post treatment). The bond strength values of coronal root segments were the highest and there were no significance difference between the middle and apical segments of the root in push-out bond strength of fiber post to root canal dentin.

Conclusions: The use of laser for treatment of the glass fiber posts and the root canal enhance bond strength of glass fiber post to radicular dentine.

Key words: bond strength, laser treatment, glass fiber pos.

INTRODUCTION

One of the most important problems in dentistry is the restoration of root-filled teeth. Posts and cores are frequently used in endodontically-treated teeth with excessive loss of coronal tooth structure. In such cases cementation of a post inside the root canal provide retention for final restoration.[(1,2)]

Fiber posts, as an alternative to cast posts and cores and metal dowels, were introduced in early 1990 to restore endodontically treated teeth with an excessive loss of tooth structure. The major advantage of fiber posts is their similar elastic modulus to dentine, producing a stress field similar to that of natural teeth. whereas metal posts exhibit high stress concentrations at the post-dentine interface.[(3,4)]

Other advantages of fiber posts include enabling cementation procedure to carried out without friction with root canal walls, and reduce risk of root canal fractures. In addition to that several study shown that fiber posts distributed occlusal stresses more evenly in the root dentine resulting in fewer and more favorable root fractures, which where often reparable.[(5,6)]

Fiber posts cemented adhesively. Debonding is the most common kind of failure in fiber posts restoration. Thus selecting an appropriate adhesive system for bonding posts is important for the success of fiber post restorations. Achieving a chemical and mechanical bond between the luting agent material and the root canal dentine as well as between fiber post and luting agent material is required. This is important for retention and micromechanical leakage along the root canal or fiber post material.[7,8,9]

In an attempt to maximize resin bonding to FRC posts, several surface treatments were suggested. These procedures can be divided into three categories:(1) silanization and/or adhesive application, (2) acid etching, sandblasting, and silica coating, and (3) alternative etching techniques (i.e., treatments that combine both a micromechanical and chemical component). [9] Due to improvements in lasers used in dentistry, laser treatment is considered an alternative method to other surface treatment methods because of its optical penetration depth. [10,11]

The purpose of this study was to investigate the effects Er, Cr: YSGG laser on push-out bond strength of glass fiber posts cemented to root canal dentine using dual cure self adhesive resin cement.

MATERIALS AND METHODS

Tooth preparation

Forty extracted non-carious maxillary central incisors human teeth were used in this study. Before the experiment, root surfaces of all specimens were cleaned mechanically and ultrasonically and stored in distilled water at 37C° until used . The crowns of the teeth were resected at the cemento-enamel junction using wheel diamond saw (KG Sorensen SP, Barazil) under water irrigation to make all canal 14 mm in length.

Then the roots were accessed and the canal lengths were measured by inserting a size # 15 k-file (MANI, INC,JAPAN) in to each root canal until the tip of the file was visible at the apical foramen. The working length was established 1mm short of the apex. All the root canals were prepared at the predetrrmined working length using ProTaper (NiTi) instrument to size F3 with contra-angle rotary hand piece (Endo-Mat DT,INC, JAPAN). The speed of rotation was maintained at 250rpm and torque 3Nm, 2ml of 2.5% sodium hypochlorite (NaOCl) was used between each file size. ProTaper files were used accoding to manufacturers' recommendations (each set of ProTaper file was used for 5 teeth). After preparation procedure was complete, the teeth were irrigated with 3ml of 2.5% NaOCl, and finally the canals were dried with paper points (Dentsply,Maillefer, Swizerland). Prepared root canals were obturated with gatta-percha cones and resin based sealer (Tgadeal, Technical, and General LTD London) according to the lateral condensations technique. Roots were coronally and apically sealed with soft wax and stored at 37C° and 100% humidity for a period of 7 days .

Post space preparation

Nine mm of gatta-percha would be removed from each root canal obturation to prepare the post space to receive glass fiber post(Dentcolic, Itena, Parias,France) with a diameter of 1.4mm using Peeso reamers (Dentsply, swiss made, Ballaigres) size 1-3coupled with slow speed hand piece leaving 5mm of gatta -percha to preserve the apical seal. Then a rubber stopper was placed on the spreader to verify depth of the instrument within the canal. The surface of fiber post cleaned with 70% ethanol and dried with compressed air according to manufacturer instructions.

Then the roots were divided into four groups (n=10) according to the Er, Cr: SYGG laser treatment for the root canal and post surface. Group 1: the root canal were treated with laser, Group 2: the surface of glass fiber posts received by this group were treated with laser, Group 3: the surface glass fiber posts and the roots canals were subjected to laser treatment, and Group 4: the control group (without laser treatment) .

The roots canals were irradiated with the Er,Cr:YSGG laser working at 2780nm (Biolase, Europe GmbH, Germany) at power setting of 1.25W, at 50 HZ level according to manufacturer's instructions. A gold dental hand piece were used with a cylindrical sapphire fiber optic tip(RFT3,21mm) , the canal wall were irradiated by introducing the fiber optic tip to the 9mm established by post space preparation with spiral continuous movement clockwise from the cervical part to the apex and anticlockwise from apical part to cervical part, this procedure improves distribution of laser light inside the root canal. Irradiation of each root canal was repeated 6 time for 10 sec, with 10 sec rest intervals between each lasing cycle. Thus, the total irradiation time 60 sec per root canal.

Post surface were prepared using Er, Cr: YSGG laser at power setting at 1 W, 10HZ using fiber- optic tip (MZ6-ZIPTIP,6mm) the tip was used at an incidence angle of 90° , 1.5mm from the post surface. The surface of the post were irradiated for 60sec divided into 4 quarter 15 on each surface of fiber post using digital timer. The glass fiber post were fixed in mechanical rotator horizontally using sticky wax, for each quarter turn of fiber post the laser applied 15 sec for that surface with 10 sec rest between each surface Figure (1) the surface of the fiber post before and after laser treatment examined under stereomicroscope under magnification power 20X Figure (2).

The fiber post were luted in all groups using dual cur self adhesive resin cement (BisCem, Bisco, USA) in accordance with manufacture's instruction. Excess cement removed with a scaler. The specimens were stored in lightproof boxes after polymerization for 24h in distilled water at 37°C. Each root was sectioned perpendicular to its long axes to create 2mm thickness coronal, middle and apical segments. The exact length of each segment was measured using a digital verina. Then each segment was marked on its apical side with marker, to make sure that the load applied in apico-coronal direction. The post was loaded with a 0.8 mm diameter cylindrical plunger. The tip of plunger was sized and positioned to touch the center of the post. Loading was performed on a universal testing machine(Alfa, UK) Figure (3) at a crosshead speed of l.0 mm/min until bond failure occurred. The maximum force (N) required to extrude the post from the root segments was recorded. To express the bond strength in MPa, the load at failure (N) was divided by the area of the bonded interface, which was calculated with the following formula:

$$A = \pi(r_1 + r_2)\sqrt{(r_1 - r_2)^2 + h^2}$$

Where π=constant 3.14, r_1= larger radius, r_2= smaller radius, h=the thickness of the section in mm. Statistical analyses were performed using a one-way analysis of variance to determine if there were statistically significant differences among groups.

The failure mode were evaluated under stereomicroscope (Motic, TAIWAN) at X 20 magnification and classified into one of the following catigaries:1) adhesive failure between resin cement and root canal dentine.2) adhesive failure between resin cement and fiber post.3) mixed failure modes 1 and 2.

Data were analyzed using one-way analysis of variance and Duncan's multiple rang test. Statistical significance was defined as $P < 0.05$.

RESULTS

The mean and standard deviation of push-out bond strength of the different groups with Duncan's multiple rang test are given in Table (1).The highest mean of push out bond strength seen in group 3 (21.8± 5.06) MPa and the less mean of push out bond strength seen in group 4 (9.8 ± 2.86) MPa , and there was no significance different between group 2(15.6 ± 1.64) MPa and group 3(17.5± 1.51) MPa.

Regarding the effect of root regions on push-out bond strength, the cervical third presented higher mean bond strength then followed by the middle third, while the apical third show the lowest mean bond strength Table (2).

The failure mode recorded were mostly adhesive in nature in the control groups, and mainly mixed failure in the other groups(Table 3, Figure 4).

DISCUSSION

Tooth elements that have been submitted to endodontic therapy are generally weak due to dental structure loss and dentinal dehydration, therefore need to be rehabilitation with use of intraradicular post system. Among the available intraradicular retention systems, fiber posts have been widely used due to their esthetic appearance. [(12)] The success of fiber post restorative procedures depends, in part, on the cementation technique used to link between the post and root canal dentine. [(13)]

The present study investigate bond strengths of self adhesive resin cement to root canal dentine after different laser treatment using a push-out test. Push bond testes produce stress at the post-cement interface as well as at the dentin-cement interface. This is more comparable with stresses under clinical conditions than linear shear stress test.[(14)] In addition, the push-out test when used to measure the bond strength of fiber posts adhesively luted root canal dentin showed more efficient and dependable than the microtensile technique. Therefore, the push-out test was used in this study. [(15)]

The results of this study indicated that the control group(without laser treatment) showed less push-out bond strengths than other groups this was attributed to the fact that when tooth surfaces prepared by rotary instruments, smear layer formed and Studies have shown that this self-adhesive cement was unable to demineralize or dissolve the smear layer completely, and no decalcification and infiltration of dentin occurred and no hybrid layer or resin tags were observed [(16,17)]. Some reasons have been proposed for the limited capacity of self-adhesive resin cements to diffuse and decalcify the underlying dentine effectively which includes: 1) high viscosity, which may rapidly increase as an acid-base reaction; 2) a neutralization effect may occur during setting, because these chemical reactions involve water release and alkaline filler that may raise the pH level [(18)]. In addition to that the non treated posts had a relatively smooth surface area, which limited mechanical interlocking between the post's surface and the resin cement.

In the current study, it has been found that laser treatment of the root canal dentin has appositive effect in increasing push out bond strength of fiber post to the root canal dentine and this related to the ability of Er, Cr: YSGG laser to remove the adhering smear layer and produce rough surface with open dentinal tubules.[(19,20)] and this finding supported by previous study [(21)].

Under the condition of this study, surface treatment of the glass fiber posts with laser lead to increase push out bond strength between the glass fiber and root canal dentin this attributed to that irradiate surface of the glass fiber posts became rough and irregular Figure (2) and appeared to provide an increased in the surface area, which improved mechanical interlocking for the resin cement.This finding is contrary to the study by Mohammadi *et al.*, which concluded that laser treatment for the post surface will not increase bond strength of post to the root canal dentin this may due to that they use of other kind of laser and fiber post in their study.[(22)] Greater resistance to push-out forces has been found when laser used for both dentin and glass fiber posts pretreatment, this may due to the combination of the effect of the smear layer removal and the roughness of the post surface.

In this study, Push-out bond strength was evaluated in the coronal, middle and apical root section. The push – out bond strengths highest in coronal section and lowest in apical section for all tested groups. This finding may due to that in the deep part of post space , the light penetration is limited which may result in lower degree of conversion of polymerized methacrylate monomer of the dual cure resin cement and this lead to lower bond strength at the apical segments of the root. Other cause of the lower Push-out bond strength in the apical area is the present of residual gutta perch and endodontic sealer and incomplete hybridization of the dentin. Which may lead to lack of sealing between cement and dentin at the apical regions. [23,24]

The mode of failure and position give an idea about quality of the bond between the tooth and the adhesive. In the control group the failure mostly adhesive mode between the resin cement and root canal dentine, this finding supported by previous study. [25, 21] In laser treated groups the failure mode is mainly mixed failure, which is understandable given the considerable increase in bond strength after laser treatment.[21]

Conclusions

Within the limitations of the present study, it can be concluded that the use of Er,Cr:YSSG for root canal and glass fiber posts surface treatment potentially modify the root canal dentin and the surface of glass fiber posts and increase the bond strength of resin cements to root canal dentin. The regional bond strength decreased from coronal to apical direction. The mode of failure in laser treated groups was mostly mixed in nature.

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Table (1) The Mean and Standard Deviation of Push Out Bond Strengths in MPa of The Different Groups with Duncan's Multiple Rang Test

Root segment / Groups	Coronal	middle	apical
Group 1	**15.6± 1.65 a**	**13.5± 1.08 a**	**12.9± 1.19 a**
Group 2	**17.6± 1.51 a**	**14.2± 5.59 a**	**13.4± 2.22 a**
Group 3	**21.8± 5.06 b**	**18.3± 4.14 b**	**16.7± 2.13 b**
Group 4	**9.8± 2.86 c**	**7.3± 1.49 c**	**6.86± 2.64 c**

Group 1: the root canal treated with laser, Group 2: the fiber post treated with laser, Group 3: the fiber post and the root canal subjected to laser treatment, and Group 4: the control group

* different letters vertically mean significant difference.

Table (2) The Mean and Standard Deviation of Push Out Bond Strengths in MPa at Different Root Segments in Each Group with Duncan's Multiple Rang Test.

Root segment / Groups	coronal	middle	apical
Group 1	15.6± 1.65 a	13.5± 1.08 b	12.9± 1.19 b
Group 2	17.6± 1.51 a	14.2± 5.59b	13.4± 2.22 b
Group 3	21.8± 5.06 a	18.3± 4.14 b	16.7± 2.13 b
Group 4	9.8± 2.86 a	7.3± 1.49 b	6.86± 2.64 b

Group 1: the root canal treated with laser, Group 2: the fiber post treated with laser, Group 3: the fiber post and the root canal subjected to laser treatment, and Group 4: the control group

* different letters horizontally mean significant difference.

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Table (3): Failure Modes Aamong Tested Materials by Push Out Bond Test.

Tested Materials	Failure Mode %		
	Adhesive[a] *	Adhesive[b*]	Mixed
*Group 1	10	30	60
*Group 2	30	20	50
*Group 3	10	10	80
*Group 4	60	20	20

*Group 1:the root canal will be treated with laser, Group 2: the surface of glass fiber posts will be treated with laser, Group 3: the surface glass fiber posts and the root canal will be subjected to laser treatment, and Group 4: the control group (without laser treatment) .

a*) adhesive failure between resin cement and root canal dentin. b* adhesive failure between resin cement and fiber post.

Figure (1): The Fiber Post Fixed in Mechanical Rotator Horizontally.

Figure (2): The Surface of the Fiber Post Under Stereomicroscope X20. a:Before Treatment, b: After Laser Treatment.

Figure (3): Loading Performed Using a Computer Controlled Universal Testing Machine (Afa,UK)

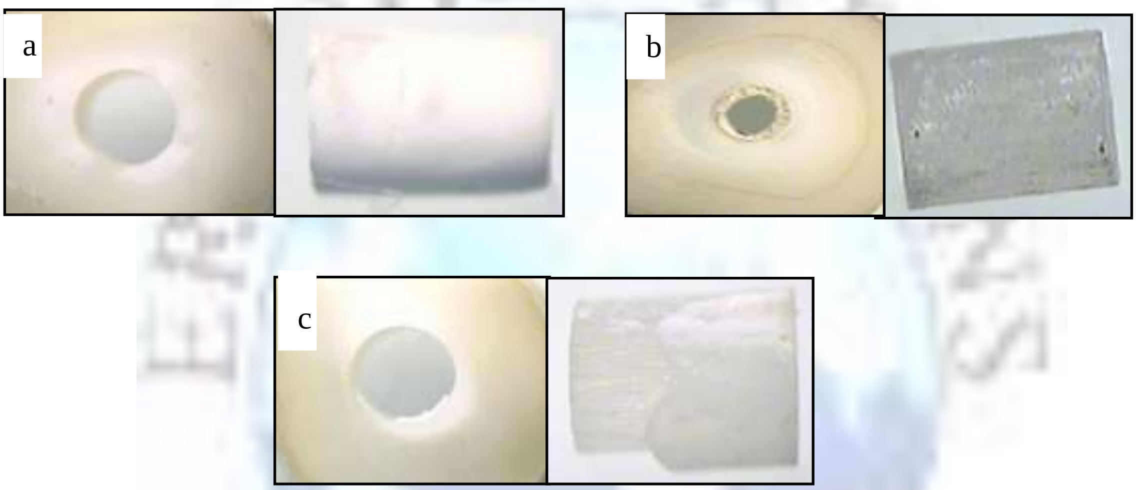

Figure (4) Types of Failures a: Adhesive Failure Between Resin Cement and Root Canal Dentin. b: Adhesive Failure Between Resin Cement and Fiber Post c: Mixed Failure.