EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 71, 2247:2255, July, 2025

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 10-03-2025 • Accept Date : 31-05-2025 • Available online: 10-07-2025 • DOI : 10.21608/edj.2025.366540.3412

EFFECT OF ERBIUM LASER SURFACE TREATMENT OF GLASS FIBER POSTS ON THEIR BOND STRENGTH TO INTRA-RADICULAR DENTIN AT DIFFERENT ROOT LEVELS: AN IN-VITRO STUDY

Doaa Mohamed Reda*, Shams Waz** *and* Mostafa Seror**

ABSTRACT

Objective: This study aimed to assess the pull-out bond strength of glass fiber posts to root dentin after varying surface treatments with the Er-Cr:YSGG laser.

Materials and Methods: Eighteen (n=18) single-rooted upper central incisors that had been extracted recently. All root canals were underwent endodontic treatment and post spaces were prepared for fiber posts. The specimens were then divided into three groups based on the surface treatment of the fiber post, group 1 (Control group) (n=6) fiber posts were etched with 9.5% hydrofluoric acid and then coated with silane, while group 2 (n=6) fiber posts were laser irritated with Er-Cr:YSGG laser 2W and group 3 (n=6) fiber posts were laser irritated with Er-Cr:YSGG laser 3W. An scanning electron microscope (SEM) was used to inspect every surface of the post. According to manufacturer instructions, we used self-adhesive resin cement to bond all of the posts. After that, the samples underwent a pull-out test with a universal testing machine. In the end, the data were statistically analyzed.

Results: The result showed that group (2) was higher bond strength than group (1). Group (2) had the highest bond strength, followed by group (3), while group (1) (control group) had the lowest. The mean pull-out value (P=0.382) indicated no statistically significant difference.

Conclusion: The bond strength of fiber posts treated with a 2W Er-Cr:YSGG laser was better than the fiber posts subjected to conventional surface treatment.

KEYWORDS: Fiber post, Er-Cr:YSGG, pull-out bond strength.

* Fixed Prosthodontics, Minia University, Minia, Egypt
** Lecturer of Fixed Prosthodontics, Faculty of Dentistry, Minia University, Minia, Egypt.

INTRODUCTION

As a result of severe damage from decay and/or traumatic dental injuries, a tooth may lack sufficient coronal structure, requiring a post system to be is inserted into the root canal after suitable root canal treatment to gain retention for the core and coronal restoration(1). Fiber posts provide optimal biomechanical performance due to their modulus of elasticity, which is comparable to dentin's. Consequently, the main causes of treatment failure are retention reduction and cement loss(2).

Multiple studies focused their efforts on finding the most effective luting cements and surface treatments to enable the highest retention of these posts(3,4).

As a result of these studies, it became possible to apply surface treatment techniques that are chemical, the inherent dual reactivity of silane's hybrid organic-inorganic molecules makes it the most often used chemical mediator in dentistry, improving adhesion between organic and inorganic matrices. Another form of surface treatment involves mechanical or chemico-mechanical methods(5-8).

Dental offices commonly use Er:YAG with a wavelength of (2940 nm) and ErCr:YSGG with a wavelength of (2780 nm) as the two most widely used instruments for applications on hard and soft tissues in dental clinics. Dental lasers is able to be utilized to mechanically alter the surface of the fiber post using adjusted parameters (power, time of application, distance of application, coolant presence, and laser beam type), and the results achieved from both devices are equivalent because of their near wavelength(9-11).

Selecting the right laser wavelength is crucial and regarded as the first step in assuming the desired interaction and preventing the undesired effects on the surrounding structures due to heat(12).

The Er,Cr:YSGG laser is useful for treating hard tissues due to its affinity for water and hydroxyapatite crystals(13-15).

Surface treatments applied to the dentin of the root, the glass-fiber posts , or to both may enhance the retention between the fiber post and root dentin. In dental root canal therapy, the Erbium laser can be employed to assist with cleaning, disinfecting, and increasing the surface roughness of the canal processes that influence the bond strength of the root canal. Laser irradiation of the root surface enhances the bonding strength of prefabricated glass-fiber posts that have been surface-treated (16).

This study aimed to determine how various surface treatments, such as etching with 9.5% hydrofluoric acid, salinization, and irradiation with Er-Cr:YSGG lasers at 2W and 3W, affected the pull-out bond strength of glass fiber posts. The null hypothesis stated that there was no significant difference in the pull-out bond strength of the glass fiber post to root dentin with surface treatment. Pull-out bond strength was evaluated in this study since it calculates the post's entire debonding value through the length of the canal.

MATERIALS AND METHODS

Sample size calculation

The sample size for posts was calculated by windows software named G-power 3.1.9.7. Based on previous study(31), the predicted sample size (n) was established as a minimum of 6 participants per group, using a significance level (α) of 5%, a beta (β) level of 20% (i.e., power = 80%), and an effect size (f) of 0.89 (calculated based on the pilot data). Sample size calculation was carried out using G*Power version 3.1.9.7.

Tooth preparation

Eighteen (N=18) maxillary central incisors with single and complete roots were extracted and collected the from Oral Surgery department at Minia University, due to periodontal and orthodontic reasons. To ensure that there was no caries and that the root canal architecture was normal, visual and radiographic examinations were conducted. Using inclusion criteria, teeth were chosen for inclusion. The requirements for inclusion are as follows: teeth with average length of 21 ±1 mm, straight-rooted teeth, uniformly sized and shaped teeth, and intact clinical crowns. These are the exclusion criteria: Teeth having immature open apices, cracks, root resorption (internal or external) carious or fractured roots, and endodontically treated teeth. Teeth were cleaned using an ultrasonic cleaner and were kept at room temperature in a container with 0.9% saline solution.

To standardize the root lengths in the samples to 14 ± 1 mm, Samples were sectioned horizontally 2mm above the coronal cemento-enamel junction with high-speed disk.

Root canal treatment for samples

After pulp extirpation, a 15 K- was used to verify the patency of the canals and to acquire a standard working length to be (14± 1 mm). All root canal preparations were carried out manually using the step-back approach with the master file number of 60. Two milliliters of 5.25% NaOCl were irrigated into the canals after each file was used for root canal preparation. The canals were then obturated using cones of gutta percha and root canal sealant by the lateral condensation technique. Finally, the canal orifices were sealed by eugenol-free temporary filling material. The roots were kept for seven days at 37°C with 100% relative humidity[17].

Post-space preparation

After decoronization, the roots measured, on average 15 mm in length. Consequently, the post space for each tooth was calibrated to 10 mm in length, which left 5 mm of gutta percha in the apical third to preserve the apical seal[18].After measuring the length at 10 mm, the gutta percha was removed using a pilot reamer. Drills N1 (white coded) and N2 (yellow coded) were next, and drill N3 (red coded) was the last one to be used. Between each drill, saline solution was used to flush the canal. Following post-space preparation, radiographs were taken on each sample to confirm complete removal of any remaining gutta-percha and sealer.

Surface treatments

The posts were randomly distributed divided into three groups based on surface treatment of the post as follows:

Surface treatment in Group (1) (Control group) (n=6)

Following an alcohol swab cleaning and air drying, a specialist brush was used to apply silane to the surface. The post was then left to evaporate for one minute.

Surface treatment in Group (2) (n=6)

After cleaning the post surface with an alcohol swab and allowing it to air dry, the specimens were subjected to treatment with the Er, Cr: YSGG laser. The laser operated at an average power of 2 W and a repetition rate of 20 Hz.

Surface treatment in Group (3) (n=6)

After cleaning the post surface with an alcohol swab and allowing it to air dry, the specimens were subjected to treatment with the Er, Cr: YSGG laser. The laser operated at an average power of 3W and a repetition rate of 20 Hz.

Samples were irradiated in a scanning motion using the Biloase I plus 2780 nm, Er,Cr;YSGG Device (BIOLASE, Inc. 27042 Towne Centre Drive, Suite 270 Foothill Ranch, CA 92610-2811 USA) in the Dental Materials Laboratory of the Oral and Dental Research Institute at Egypt's National Research Centre. The MZ8 tip was attached to a YSGG handpiece parapedicular to the surface and positioned 1 mm away from the surface, with a power of 2W and 3W, a frequency of 20Hz, 50% water spray, and 50% air spray for 60 seconds, while the tip moved forward and backward throughout the entire post length, as shown in **Figure (1).**

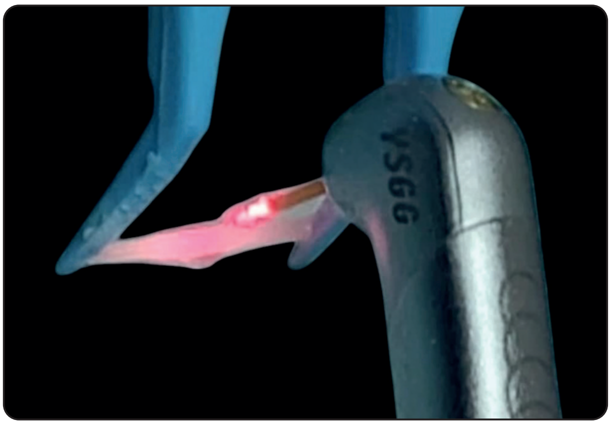

Fig. (1) Er,Cr;YSGG Non-contact laser irradiation tip applied to post surface

On the side of the post that has not been treated, the process was repeated after the post was rotated 180 degrees. Every 15 seconds, the laser fiber optic tip was cleaved at a 90-degree angle to make sure that all of the energy was transmitted to the post surface. After the full surface was treated, the posts were wiped down with alcohol and let to dry using an oil-free compressor. The posts were microbrushed with a silane coupling agent for 60 seconds after each group's surface treatments, and then let to dry for one minute. As part of the cementation procedure, the dentin was cleaned and dried with absorbent paper points after being etched by 37% phosphoric acid for 15 seconds.

Fiber post cementation

A 0.9% saline solution was used to rinse the canal. Then,by using 5.25% NaOCl as a disinfected solution inside the root canals. After that, 3 milliliters of 0.9% saline solution were used to flush the canal. Finally, paper points were employed to dry the canal. A dual-polymerizing auto-mixing syringe with self-adhesion was used. As instructed by the manufacturer, the resin cement, which is self-adhesive, was placed into the canal with an attached intracanal micro-tip. The post was put inside the canal. Using a micro brush, extra cement was removed around the post. LED polymerization light cure unit was used to light cure the resin cement at 1,200 mW/cm2 for 40 seconds, and after that, these samples were put at room temperature in 0.9% saline solution for 7 days to guarantee complete resin cement polymerization prior to testing.

After cementation, all samples were kept for a week at 37˚C in a light proof box containing sterile saline. Then, each root was mounted to plastic mold (2.5 x 5 cm) which was isolated with separating medium (Acrostone) for easily removing and fixed apically then a self-cured acrylic repair material was poured into the mold to make acrylic block. Coding acrylic block was done according to different surface treatment that was done[18].

Pull-out test:

Pull-out test on the post using a universal testing machine with a customized mandrel, at a crosshead speed of 1 mm/min until the post separated from the root dentin, the maximum load value is recorded for each sample in Newton (N), as illustrated in **Figure (2).**

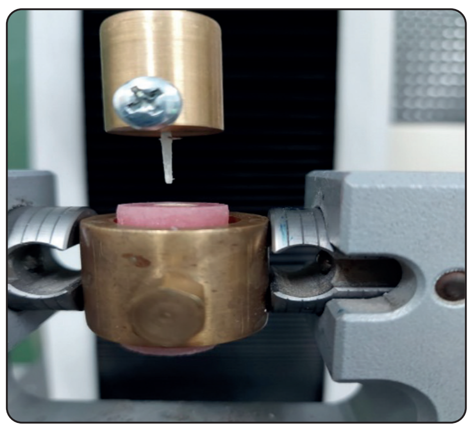

Fig. (2) The pull-out test was next done using a universal testing machine with a customized mandrel at a crosshead speed of 1 mm/min

The data was examined for normality using the Shapiro-Wilk and Kolmogorov-Smirnov tests. The results showed that the data followed a parametric (normal) distribution. For non-related samples, a one-way ANOVA was used to compare more than two groups. A significance level of $p < 0.05$ was set. Version 26 of IBM SPSS statistics for Windows was used to do the statistical analysis.

All test groups' samples were ready for scanning electron microscopy (SEM) examination. The images were captured using a Quanta 3D 200i scanning electron microscope (FEI Co., Netherlands) with an acceleration voltage of 20 kV and a magnification of 1000X.

RESULTS

The mean and standard deviation were measured for all groups **(Table 1)** and showed in a box plot **(Figure 3).**

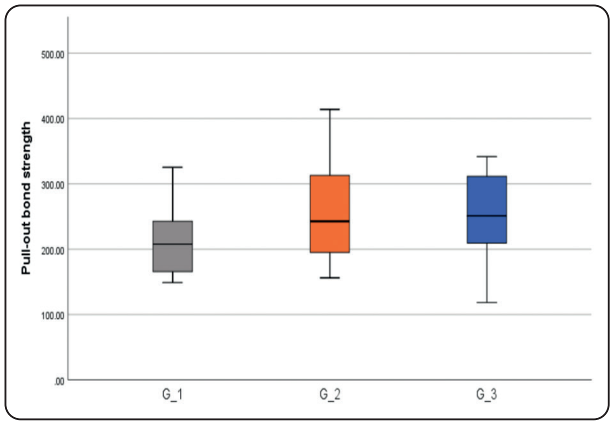

Fig. (3): Box plot showing mean and standard deviation values for pull-out bond strength in different groups.

Pull-out bond strength

Regarding to surface treatment the result was showed the highest bond strength mean value was recorded for group (II) followed by group (III), while the lowest bond strength was recorded for group(I).

The mean pull-out value (P=0.382) indicated that the bond strength between the groups tested was not statistically significantly different.

Scanning electron microscope

Group I: The untreated glass fiber posts showed a parallel arrangement of uninterrupted fibers that were densely integrated into a resin matrix, which held the fibers together.

Group II: With an output of 2 W, the Er-Cr:YSGG laser produced a great modification of the post surface that was directed only the matrix resin, leaving the highest amount of surface fibers among all groups. The surface fibers that were exposed demonstrated a great preservation of their parallel arrangement, exhibiting no indications of destruction or interruption along the post surface.

Group (III): Er-Cr:YSGG laser 3W showed the greatest surface roughness values with destruction of fiber post integrity and cracks.

TABLE (1) The mean and standard deviation (SD) values of pull-out bond strength of different groups.-

Variables	Mean	S.D	95% Confidence Interval for Mean (CI)	
			Lower Bound	Upper Bound
G_1	214.6	52.7	176.9	252.2
G_2	257.4	79.2	200.7	314.1
G_3	245.7	75.6	191.7	299.8
p-value			0.382	

DISCUSSION

Because their elastic moduli matching to dentin and their ability to produce a good stress distribution, Glass fiber posts are being considered as potential substitutes for cast metal posts. Additional benefits of these posts include mechanical strength, resistance to corrosion, and biocompatibility. Additionally, they improve light transmission within the gingival and root tissues above it, which eliminates or lessens the dark appearance that metal posts and cores and non-vital teeth are frequently associated with[19].

Numerous factors influence the bond strength between a post and a root canal, including the post's material type, surface treatment, and adhesive cement utilized[20] . Glass fiber posts can be luted with several types of cements (i.e. conventional cements, self-adhesive cements). The best option has shown out to be resin-bonded luting, however traditional cementation may also be used. If post/resin cement bonds are associated with micromechanical retentions, they might be stronger and more effective. This is because surfaces that have been roughened may facilitate the entry and flow of resin cement into the micro-retentions, strengthening the micromechanical interlock[21,22].

The self-adhesive cementation approach was selected as it offers clinical advantages over the self-etch and etch-rinse protocols. Besides the procedure being faster and easier, it also provides fewer interfaces between different types of materials and therefore a less risk of failure in potentially critical areas. Regarding the bond strength values, studies proved that the self-adhesive approach offers a satisfactory comparable result to other multi-step approaches[23-25].

Erbium-chromium (ErCr:YSGG) dental lasers have a different mode of action due its higher wavelength (2780 nm). It is highly absorbed by water molecules which can be found in most of the dental soft and hard tissues. Erbium laser devices effect relies on the thermo-mechanical ablation process, where water molecules in the substrate is vaporized producing different effects according to the substrate being worked upon (ex. Bone, soft tissue, resin-based material). In this study, the laser tip chosen was a (MZ8) tip attached to a handpiece. The parameters for the laser's irradiation were adjusted to pulse at 20 Hz with power levels of 2W and 3W. It was applied for 60 seconds using a mixture of 50% water and 50% air while moving longitudinally along the post surface. The selected parameters matched a study done by **Barutcigil, et al.(2015)** [26] who proved that, in comparison to a high-power 3W laser, surface treatments with the 1 W or 2 W Er, Cr: YSGG laser increased bond strength without causing post-surface damage.

The bond strength was tested in this study by varying the power levels of the Er,Cr:YSGG laser used for fiber post surface treatment. Fibre posts treated with an Er, Cr:YSGG laser at 2W and 3W was greater than that of posts without surface treatment, according to the results.

The bond strength increased further by raising the laser power (control group, 2W and 3W), as evidenced by the mean pull-out values of 214.6N, 257.4N, and 245.7N, respectively.

The result may be due to the irritation with different surface treatment and with different laser parameters showed varying surface roughness values. HF acid showed that the resin matrix on the post surface could be partially and superficially removed, resulting in flatter, more uniform surfaces with small porosities. Resin matrix removal was more effective with the 2W Er, Cr: YSGG laser than with HF acid. Because the ablation process only removes a thin layer of the resin matrix, the glass fibers remain intact and undisturbed. This improves the micromechanical interlocking between the post surface and resin cement, which in turn increases the micro-retentive surfaces. In the 3W Er, Cr: YSGG laser exhibited the greatest surface roughness values, with damage to the integrity of the fiber post and the presence of cracks.

These findings were in agreeing with the findings obtained by **Barutcigil, et al. (2015)** [26] and **Rezaei-Soufi, et al.(2019)** [27] , which showed that surface treatments using 1 W and 2 W Er, Cr: YSGG lasers resulted in more effective removal of the resin matrix compared to HF acid. In the 3 W Er, Cr: YSGG laser group application, the fibers were scattered and ruptured, with no remains of the surrounding methacrylate resin matrix found.

The current study's findings showed that the mean bond strength values for Er-Cr:YSGG laser irradiation (group 2) were higher than those for all other groups. The same findings were confirmed by **Hossain et al.(1999)** [28] and **Hashemikamangar, et al.(2018)**[29], which demonstrated that surface treatments using low Er, Cr: YSGG laser powers increased bond strength compared to high Er, Cr: YSGG laser powers with continuous air/water flow.

Results from the present investigation demonstrated that, compared to the other groups, the mean bond strength values for the Er-Cr:YSGG laser irradiation (group 2) were significantly greater. The same findings were confirmed by **Hossain et al.(1999)** [28] and **Hashemikamangar, et al.(2018)** [29], which demonstrated that surface treatments utilizing low Er, Cr: YSGG laser powers increased bond strength compared to high Er, Cr: YSGG laser powers with continuous air/water flow.

Fiber posts treated with the Er,Cr:YSGG laser at 0.5, 1.0, and 1.5 W demonstrated greater bond strength to dentin compared to untreated posts, as indicated by **Rezaei-Soufi, et al.(2019)** [27]. The bond strength was unaffected by the directions of laser irradiation's motion. To minimize damage to the post surface and achieve maximum bond strength, it is recommended to treat the posts in longitudinal direction with an Er,Cr:YSGG laser set at 1.0 W.

Davoudi, et al. (2021) [30] in a systematic review Compared the efficacy of Nd:YAG and diode lasers, Er:YAG and Er,Cr:YSGG lasers for preparing FPs, who found that the Er:YAG and Er,Cr:YSGG lasers seem to be more effective than Nd:YAG or diode lasers for FP preparation. The FP surface could be damaged and the final PBS reduced due to the high energy energy of lasers. When it comes to laser irradiation, glass FPs are better than quartz FPs.

Additionally, **Mekky, et al.(2022)** [31] verified the same results. Compared to other lasers and the control group, the researchers discovered that Er,Cr:YSGG significantly enhanced the glass fiber post's bonding strength to the cement-post-dentin interfaces

The results obtained were not consistent with that of **Yamazaki R, et al. (2001)** **[32]** who suggested that more damaging thermal effects on dentin have been related to high energy values. Particularly in the absence of cooling during irradiation. Dentin surfaces were subjected to treatment with an Er,Cr:YSGG laser at different output power levels varying from 1 to 6W. All samples that were irradiated without cooling noted signs of carbonization and cracking, according to researchers' observations. While samples exposed to irradiation with cooling exhibited minimal or no carbonization and smear layer.

Furthermore, **Tasar S, et al.(2014)**[33] found that irradiation outputs of 1.25 to 5 W can be used, and determined that using the Er,Cr:YSGG laser at power settings of 2 W and 3.5 W effectively removed resin residues.

Inconsistent results of these studies **Cengiz et al.(2016)** [34] **and Gomes et al. (2018)** [35] utilized Er,Cr:YSGG laser to increase the final pull-out bond strength of FPs. Er,Cr:YSGG produced noticeably higher PBS values; nonetheless, producing significantly higher PBS values, while the results were comparable to those of samples treated with silane (control group).

CONCLUSION

Within the limitations of the present study, it can be concluded that:

The surface treatment of fiber posts treated with a 2W Er-Cr:YSGG laser was the highest bond strength to intra-radicular dentin while the surface treatment with silane and 3W Er-Cr:YSGG laser was comparable.

REFERENCES

1. Goracci, C., & Ferrari, M. Current perspectives on post systems: a literature review. Australian dental journal.2011; 56, 77-83.
2. Bru, E., Forner, L., Llena, C., & Almenar, A. Fibre post behaviour prediction factors. A review of the literature. Journal of clinical and experimental dentistry. 2013; 5(3), e150.
3. Aksornmuang J, Foxton RM, Nakajima M, Tagami J. Microtensile bond strength of a dual-cure resin core material to glass and quartz fibre posts. J Dent. 2004;32(6):443-50.
4. Goracci C, Raffaelli O, Monticelli F, Balleri B, Bertelli E, Ferrari M. The adhesion between prefabricated FRC posts and composite resin cores: Microtensile bond strength with and without post-silanization. Dent Mater. 2005;21(5):437-44.
5. Sahafi A, Peutzfeldt A, Asmussen E, Gotfredsen K. Bond strength of resin cement to dentin and to surface-treated posts of titanium alloy, glass fiber, and zirconia. J Adhes Dent. 2003;5(2).
6. Matinlinna JP, Lassila LV, Özcan M, YliUrpo A, Vallittu PK. An introduction to silanes and their clinical applications in dentistry. Int J Prosthodont. 2004;17(2).
7. Sahafi A, Peutzfeldt A, Asmussen E, Gotfredsen K. Retention and failure morphology of prefabricated posts. Int J Prosthodont. 2004;17(3).
8. Perdigão J, Gomes G, Lee IK. The effect of silane on the bond strengths of fiber posts. Dent Mater. 2006;22(8): 752-8.
9. Cho S, Rajitrangson P, Matis B, Platt J. Effect of Er, Cr: YSGG laser, air abrasion, and silane application on repaired shear bond strength of composites. Oper Dent. 2013;38(3):E58- E66.
10. Garbui BU, de Azevedo CS, Zezell DM, Aranha ACC, Matos AB. Er, Cr: YSGG laser dentine conditioning improves adhesion of a glass ionomer cement. Photomed Laser Surg. 2013;31(9):453- 60.
11. Křižnar I, Jevnikar P, Fidler A. Effect of Er: YAG laser pretreatment on bond strength of a composite core build-up material to fiber posts. Lasers Med Sci. 2015;30(2):733-40.
12. Almiran DA, Alkurtas SA. A comparison between Er,Cr:YSGG 2780 nm laser and carbide fissure bur in root-end resection. Iraqi J Laser. 2020;19(1):1-11.
13. Mubaraq RM, Hussein BM. Influence of Er,Cr:YSGG laser desensitization on SBS of resin cement to dentin. Iraqi J Laser. 2022;21(1):18-27.
14. Hadi AA, Hussein BM. Role of Er,Cr:YSGG laser and fluoride in caries resistance. J Res Med Dent Sci. 2022;10(8):19-25.
15. Salman SQ, Hussein BM. Topographical analysis of human enamel after phosphoric acid etching and Er,Cr:YSGG laser irradiation. J Lasers Med Sci. 2023;14:e68. doi: 10.34172/ jlms.2023.68
16. Gorus Z, Mese A, Yilmaz BD, Adiguzel O. Laser application to the root surface increases the bonding strength of surface-treated prefabricated glass-fiber posts in teeth with excessive substance loss. Med Sci Monitor: International Medical Journal of Experimental and Clinical Research. 2018;24:100.
17. Parameswaran, A. Grossman's endodontic practice. Journal of Conservative Dentistry 2010 , 13(3), 16.
18. Grandini S. Basic and clinical aspects of selection and application of fibre post. Dent Mater Clin Appl. 2004;18: 399-404.
19. Purton DG, Chandler NP, Qualtrough AJE. Effect of thermocycling on the retention of glass-fiber root canal posts. Quintessence Int (Berl). 2003;34(5).
20. Mohsen CA. Evaluation of push-out bond strength of surface treatments of two esthetic posts. Indian J Dent Res Off Publ Indian Soc Dent Res. 2012;23(5):596–602.
21. De Oyagüe RC, Monticelli F, Toledano M, Osorio E, Ferrari M, Osorio R. In cement selection on bonding to densely-sintered zirconium-oxide ceramic. Dent Mater. 2009;25(2):172–9.
22. Aboushelib MN, Matinlinna JP, Salameh Z, Ounsi H. Innovations in bonding to zirconia-based materials: Part I. Dent Mater. 2008;24(9):1268–72.
23. Pereira JR, Pamato S, Santini MF, Porto VC, Ricci WA, Só MVR. Push-out bond strength of fiberglass posts cemented with adhesive and self-adhesive resin cements according to the root canal surface. The Saudi Dental Journal. 2019.
24. Shiratori FK, do Valle AL, Pegoraro TA, Carvalho RM, Pereira JR. Influence of technique and manipulation on self-adhesive resin cements used to cement intraradicular posts. The Journal of prosthetic dentistry. 2013;110(1):56-60.

25. Bergoli C, Brondani L, Wandscher V, Pereira G, Cenci M, Pereira-Cenci T, et al. A multicenter randomized double-blind controlled clinical trial of fiber post cementation strategies. Oper Dent. 2018;43(2):128-35.

26. Barutcigil, Ç., Barutcigil, K., Yasa, B., Arslan, H., & Akcay, M. Build-up of a resin composite core in a fiber-reinforced post by a 2.78 mu m-pulsed laser treatment. Journal of Laser Micro Nanoengineering .2015;10(2).

27. Rezaei-Soufi, L., Tapak, L., Forouzande, M., & Fekrazad, R. Effects of motion direction and power of Er, Cr: YSGG laser on pull-out bond strength of fiber post to root dentin in endodontically-treated single-canal premolar teeth. Biomaterials Research. 2019; 23(1), 17.

28. Hossain M, Nakamura Y, Yamada Y, Kimura Y, Matsumoto N, Matsumoto K. Effects of Er,Cr:YSGG laser irradiation in human enamel and dentin: ablation and morphological studies. J Clin Laser Med Surg 1999

29. Hashemikamangar SS, Hasanitabatabaee M, Kalantari S, Gholampourdehaky M, Ranjbaromrani L, Ebrahimi H. Bond strength of Fiber posts to composite Core: Effect of surface treatment with Er, Cr: YSGG laser and thermocycling. Journal of lasers in medical sciences. 2018;9(1):36.

30. Davoudi, A., Shadmehr, E., Savoj, M., Akhavan-Khaleghi, M., Tabesh, M., Zakizade, M., & Ebadian, B. Laser Treatment of Fiber Post and Final Push-Out Bond Strength: A Systematic Review and Meta-Analysis. Photobiomodulation, Photomedicine, and Laser Surgery. 2021; 39(5), 321-333.

31. Mekky, A., El-Hakim, M., & Shokry, T. Effect of Posts Surface Treatments on the Pull-out Bond Strength of Glass Fiber Post to Root Dentin “A Comparative In-Vitro Study”. Journal of Fundamental and Clinical Research.2022; 2(1), 1-13.

32. Tasar S, Ulusoy MM, Meric G. Microshear bond strength according to dentin cleansing methods before recementation. J Adv Prosthodont 2014;6:79–87

33. Yamazaki R, Goya C, Yu DG, Kimura Y, Matsumoto K. Effects of erbium, chromium:YSGG laser irradiation on root canal walls: a scanning electron microscopic and thermographic study. J Endod 2001;27:9–12

34. Cengiz S, Koçak S, Koçak M, Velioğlu N, Sadettinoğlu K, Ö zcan M. Effect of Er,Cr:YSGG laser surface conditioning on the adhesion of fiber-reinforced composite and zirconia intraradicular posts to the root dentin. J Adh Sci Technol 2016; 30:1957–1967.

35. Gomes KGF, Faria NS, Neto WR, Colucci V, Gomes EA. Influence of laser irradiation on the push-out bond strength between a glass fiber post and root dentin. J Prosthet Dent .2018;119:97–102