J Dent Mater Tech 2024; 13 (2): 85-90
https://doi.org/ 10.22038/jdmt.2024.79286.1621

JDentMaterTech

Original Article Open Access

# Effects of 980 nm diode laser irradiation on bond strength of fiber posts to root canal dentin

Fargol Mashhadi Akbar Boojar [1], Ezatolah Kazeminejad [2], Azizeh Karimian [1], Amir Reza Ahmadinia [3] *

## Abstract

**Objective:** The present in vitro study aimed to evaluate the effect of a 980 nm diode laser irradiation on the bond strength of fiber posts to intracanal dentine.

**Methods:** Twenty-four extracted human maxillary central incisors were obtained. After root canal treatment, the samples were randomly divided into two groups (n=12): In group 1, root canal dentin was subjected to diode laser irradiation (980 nm, 1W, continuous wave) whereas group 2 was considered the control group and was not irradiated. Fiber posts were cemented using resin cement. The pull-out bond strength of the fiber posts was assessed with a universal testing machine. The data were analyzed by an independent samples t-test (α=0.05).

**Results:** The average fracture strength of the laser-irradiated group (90.04 ± 30.45 MPa) was significantly higher than the control group (62.95 ± 22.09 MPa; P = 0.021).

**Conclusions:** Diode laser irradiation to the root canal can increase the bond strength of fiber posts to intraradicular dentin.

**Keywords:** Bond strength, Diode Laser, Endodontic treatment, Fiber post, Pull-out test, Root canal

## Introduction

Restoring endodontically treated teeth with fiberglass posts has become an excellent option for clinicians and patients due to their esthetic characteristics, simplified treatment procedures, and the ability to bond to dentin with resin cement (1-3). Fiberglass posts have a similar elastic modulus to dentin, and their survival rate is approximately 93% (2). They also have longevity similar to that of metallic posts (4). The failure rate of fiberglass posts after five years has been reported to be 1.7%, with root fractures and post-debonding being the leading causes (5). Post-debonding commonly happens by adhesive failure between dentin and cement (25-80%) or between the post and cement (5-15%) (6, 7).

Several studies have examined the bonding properties of fiberglass posts to root dentin. Different intracanal post designs and adhesive agents and various conditioning/priming treatments for post and intracanal dentin have been introduced to enhance the bond strength by improving micromechanical and chemical adhesion to tooth structures (1).

High-power lasers have been used for dentin pretreatment before luting a fiber post to enhance its adhesion (8). High-intensity laser irradiation, including Nd: YAG (1064 nm) and diode lasers can cause dentin (and enamel) surface ablation and recrystallization (9). This process produces physical, morphological, and chemical modifications that develop an irregular surface and fuse the smear layer with the underlying intact

[1]Dental Research Center, Golestan University of Medical Sciences. Gorgan, Iran.
[2]Department of Endodontics, School of Dentistry, Golestan University of Medical Sciences, Gorgan, Iran.
[3]Department of Periodontics, School of Dentistry, Golestan University of Medical Sciences, Gorgan, Iran.

*Corresponding Author: Amir Reza Ahmadinia
Email: ar.ahmadinia@gmail.com

Accepted: 11 June 2024. Submitted: 12 April 2024.

dentin (10, 11). Furthermore, dentin irradiation with these lasers has a proven anti-microbial effect (11, 12). On the other hand, erbium family lasers may be effective in enhancing bond strength by removing the smear layer. It is assumed that the bonding quality between the fiber post and dentin is influenced by the physical properties of dentin and the presence of a smear layer produced during canal preparation. The smear layer can be removed by using suitable chemical substances or lasers (13).

Despite the favorable effects of diode laser irradiation, its effect on dentin bond strength is rather controversial. Mekky et al. (14) reported that surface treatment of fiber posts with a diode laser led to significantly lower bond strength than the control group. On the other hand, Farmakis et al. (15) reported that diode laser irradiation with short pulses improved the intraradicular adhesion of self-etch and self-curing luting cement. Borges et al. (16) found that dentin irradiation with a 970 nm diode laser enhanced the pull-out bond strength of fiber posts bonded with self-adhesive resin cement; however, the push-out bond strength was not affected.

The present in vitro study investigated the effect of 980 nm diode laser irradiation on the bond strength between fiber post and radicular dentin following the endodontic treatment.

## Methods and materials

### *Study design*

The protocol of the present study was approved by the ethics committee of Golestan University of Medical Sciences ( IR.GOUMS.REC.1401.356).

The sample size was calculated to be 12 teeth in each group, according to a study conducted by Borges et al. (16), using a confidence level of 0.95 and a power of 0.80.

A total of 24 human maxillary central incisors with closed apexes were obtained. Teeth were extracted due to severe caries or periodontal diseases. Samples were immersed in a 3% hydrogen peroxide solution for 24 hours and then transferred to a normal saline solution. The teeth were carefully examined to ensure apex closure and the absence of any cracks, caries, resorptive defects, and canal curvature. Periapical radiographs were taken to confirm that there was only one canal in the roots. The mesiodistal, buccolingual, and apico-coronal dimensions of the teeth were standardized using a caliper. Samples were mounted in gypsum and then decoronated with a diamond disk under copious water irrigation above the cementoenamel junction to achieve a standardized apical-coronal length of 13 ±1 mm.

### *Sample preparation*

Root canal treatment was performed using the standard step-back technique with sterile K files (Mani, Korea). A #10 k-file was introduced into the root canal until the tip extended to the apical foramen. The working length was established 1 mm short from the apical foramen to achieve a 12-mm working length. Apical preparation was carried out up to a file size of #30, followed by shaping the canals to a file size of #50. The root canals were copiously irrigated with 2.5% sodium hypochlorite between each instrumentation step. The smear layer was removed using 15% EDTA (MORVA-Prep/IRAN) for 1 minute, followed by a final rinse with 5 ml of distilled water and drying with sterile paper points (coltene-whaldent, Germany). Subsequently, the teeth were obturated by the lateral condensation technique with 2% gutta-percha (Meta-Biomed, Korea) and AH26 (Dentsply, Germany) as the sealer. The samples were incubated at 100% humidity and 37 °C for a week to ensure the sealer was set and then transferred to distilled water.

In the next step, gutta-percha was carefully removed up to 7 mm of the total root length, and the root canal was shaped by Gates-Glidden drills sizes # 1 to #3. The canals were rinsed with 15% EDTA for 1 minute, followed by irrigation with normal saline to remove any remaining debris. Finally, the canals were dried with paper points (Roeko; Coltene/Whaledent, Langenau, Germany). Figure 1 illustrates an overall view of the procedures performed in this study.

### *Laser irradiation*

The specimens were randomly divided into two groups (n=12). In the irradiated group, the root canal was treated with a 980 nm diode laser (Wiser, Doctor Smile, Italy) following the method described by Strefezza et al. (17). The procedure involved inserting a 200 µm optical fiber into the entire post space and irradiating at 1 W power in the continuous wave mode. The fiber was moved in a spiral movement from the apical to the cervical area of the canal at a 2 mm/sec rate. Five irradiation cycles with 20 sec time intervals were performed, allowing cooling of the roots between the cycles. Each cycle lasted 4 seconds, and the total radiation time for each sample was 20 seconds. The control group did not receive laser irradiation.

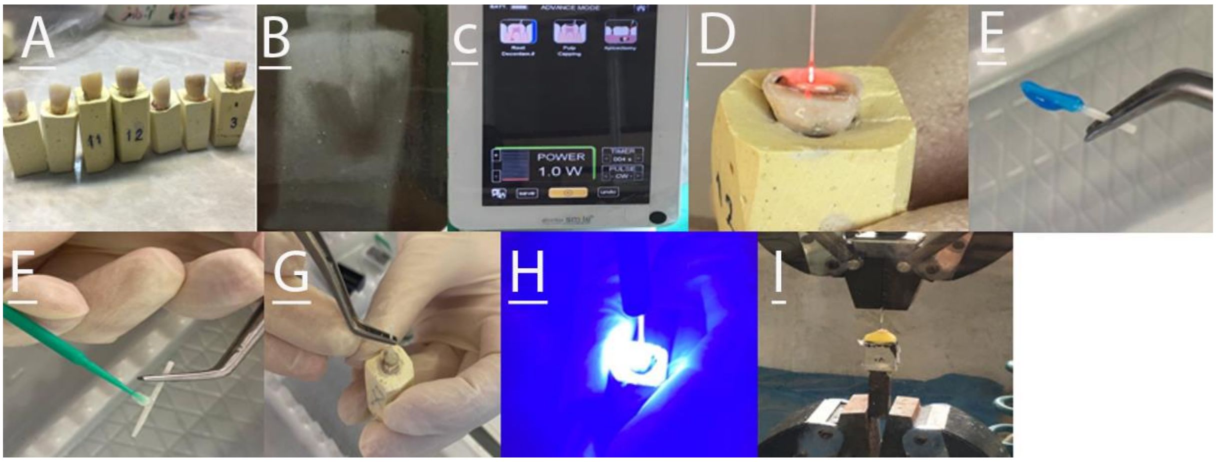


**Figure 1.** A) Specimens for endodontic procedures. B) Periapical image showing the canal after gutta-percha removal. C) Laser parameters used during the study. D) Laser radiation applied from the apical to coronal direction. E) Fiber post-surface etching with 37% phosphoric acid. F) Fiber post surface coated with a universal bonding agent. G) Placing the post inside the root canal, H) Light curing, and I) Measuring the bond strength of fiber post by a universal testing machine.

### *Post cementation*

The fiber posts (Nordin Dental, Clarens, Switzerland) were etched with 37% phosphoric acid (Pentron, Wallingford, CT, USA) for 15 seconds, rinsed with water, and dried. The post surfaces were coated with a bonding resin (BISCO, USA) using a micro brush and cured for 10 seconds at 650 mW/cm$^2$ power density (LTD, Premium Plus, UK).

The canals were rinsed with sterile normal saline and dried with a paper point. A universal adhesive (G-Premio Bond; GC, Tokyo, Japan) was applied to the root canals and light-cured. The resin cement (DUO-LINK Universal Resin Luting Cement, BISCO, USA) was delivered into the canals by a #25 k-file. The post surface was also coated with cement. The fiber post was then inserted into the canal, and excess cement was removed using a micro brush. The cement was light-cured for 10 seconds. The samples were kept at 100% humidity before the bond strength assessment.

### *Pull-out test*

After one week, the pull-out bond strength of the posts to the root canals was measured using a universal testing machine (Koopa, Tehran, Iran). A controlled force was applied at a speed of 1 mm/min (pull-out test) until the post dislodged from the canal. The force was recorded in newtons (N) and then converted to megapascals (MPa) by dividing the force by the bonded surface area (A).

### *Statistical analysis*

The data were analyzed using SPSS software version 26 (IBM Inc., NY, USA). The normal distribution of the data was assessed using the Shapiro-Wilk test. An independent samples t-test was employed to compare the bond strength between the two groups. A significance level of 0.05 was chosen to determine statistical significance.

## Results

The mean bond strength values of both study groups are presented in Table 1. The result of the independent samples t-test revealed that the fracture strength of the samples in the laser group (90.04 ± 30.45 MPa) was significantly higher than that of the control group (62.95 ± 22.09 MPa; P = 0.021).

## Discussion

The present in vitro study compared the pull-out bond strength of fiber posts to irradiated and non-irradiated intraradicular dentin. Irradiation was performed with a

**Table 1.** Mean ± standard deviation of the bond strength and maximum fracture strength (MPa)

| | Laser-irradiated | Non-irradiated | P-value |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | |
| Fracture strength | 90.04 ± 30.45 | 62.95 ± 22.09 | 0.021* |

*P-value less than 0.05 represents a significant difference between the groups according to the independent samples t-test.

980 nm diode laser in the experimental group. Various methods have been used for bond strength testing in the literature. The pull-out bond strength was selected in the current study, as it can better simulate the oral environment and reproduce masticatory forces with a more uniform stress distribution (18).

Fiberglass posts offer several advantages over metal posts. These posts can be bonded to root dentin using resin cement, reducing stress concentration and minimizing the risk of root fractures (1-3). Failures in fiber post-restorations are often attributed to bonding fractures in the post-resin or resin-dentin interface (6, 7). One possible reason for adhesive bond failure is the presence of a smear layer that originates from the mechanical preparation of the root canal and covers the radicular dentin, thus hindering proper resin cement penetration into tooth structure (19, 20). Traditionally, various chemical agents have been used for smear layer removal and eradicating intracanal microorganisms. The removal of the smear layer and elimination of the number of microorganisms can also be achieved by high-power lasers, enhancing the adhesion of cement to human radicular dentin (21).

In this study, a 980 nm diode laser was applied with a power of 1 W in continuous wave mode. Alfredo E et al. (22) showed that laser irradiation with these parameters increases temperature up to 10 °C without exceeding the tolerance of periapical tissues. The results of the present study indicated a higher bond strength between cement and the canal walls in the group irradiated with a 980 nm diode laser. It is believed that diode lasers (810-980 nm wavelength range) have a penetration depth per pulse that is 10,000 times greater than the Er:YAG laser, potentially allowing greater penetration into dentinal tubules (23). Several studies indicated that diode lasers can reduce the number of microorganisms during root canal disinfection (24, 25). Gutknecht et al. (26) reported that 980 nm diode laser radiation could eliminate microorganisms that have penetrated up to 500 µm into dentin, compared to chemical solutions that reach only 100 µm.

The finding of this study is in alignment with several studies that indicated the efficacy of high-power lasers in enhancing cement adhesion to root canal walls. Garcia et al suggested that high-power lasers including Er:YAG (2940 nm) and Nd: YAG (1064 nm) modify dentin structure and increase the adhesion of fiberglass posts to intraradicular dentin by removing the smear layer without causing thermal damage to surrounding tissues (27). Kasraei et al. (28) exhibited a significant increase in composite bond strength to dentin following diode laser radiation at 940 nm wavelength. Strefezza et al. (17) found that laser radiation with an 830 nm wavelength in continuous or pulsed mode significantly improved the bond strength of fiber posts to root canal dentin. However, Malekipour et al. (29) did not report a positive effect on the bond strength of composite resin to coronal dentin after irradiation with an 808 nm diode laser with 0.5, 1, and 1.5 W for 20 s. In the study conducted by Borges et al. (16), dentin irradiation with a 970 nm diode laser enhanced the pull-out bond strength of fiber posts using self-adhesive resin cement; but, the push-out bond strength was not affected. Borges et al. (16) did not use EDTA before laser irradiation and this may cause some controversial results to the present finding.

It should be noted that irradiation from the diode lasers cannot open the dentinal tubules of the canal walls (16). Therefore, in the present study, the smear layer was removed with EDTA 15% and normal saline irrigation before laser radiation inside the root canal. Amin et al. (30) reported that using 17% EDTA, followed by diode laser irradiation, led to a significantly lower smear layer index than laser irradiation alone. It can be assumed that following smear layer removal, laser radiation can further enhance bond strength compared to the non-radiated group by promoting cement penetration into opened and disinfected dentinal tubules, thus increasing resistance against post displacement (31).

The present study has some limitations including the in vitro nature and the use of only one set of laser parameters to enhance bond strength. Further studies are suggested to compare the effect of various lasers with different parameters on the bond strength of fiber posts to root canal dentin.

## Conclusions

Within the limitations of the present study, irradiation of root canal walls by a 980 nm diode laser at 1 W and continuous wave mode effectively enhanced the bond strength of fiber posts to intraarticular dentin. This method can be considered a possible option for mitigating the chances of fiber post-debonding or displacement.

## Conflict of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

## Authors' contributions

FMAB conducted data curation and investigation. ARA conducted conceptualization, supervision, writing, and validation. AK performed a formal analysis. ARA and EK helped data collection and reviewed and edited the manuscript. All authors are accountable for all aspects of the work and give final approval of the published version.

## Ethical approval

The protocol of the present study was approved by the ethics committee of Golestan University of Medical Sciences ( IR.GOUMS.REC.1401.356).

## Funding

Not applicable.

## References

1. Fragkouli M, Tzoutzas I, Eliades G. Bonding of Core Build-Up Composites with Glass Fiber-Reinforced Posts. Dent J 2019;7(4):105.
2. Tsintsadze N, Margvelashvili-Malament M, Natto ZS, Ferrari M. Comparing survival rates of endodontically treated teeth restored either with glass-fiber-reinforced or metal posts: A systematic review and meta-analyses. J Prosthet Dent 2024;131(4):567-578.
3. Karteva EG, Manchorova NA, Vladimirov SB, Keskinova DA. Clinical assessment of endodontically treated teeth, restored with or without radicular posts. Folia Medica 2018;60(2):291-299.
4. Maciel CM, Baroudi K, Oliveira KCF, dos SANTOS C, Lima CS, Vitti RP. Clinical longevity of metallic versus fiberglass intraradicular posts: a systematic review. Braz Dent Sci 2024;27(1):e4114-e4125.
5. Sarkis-Onofre R, Pinheiro HA, Poletto-Neto V, Bergoli CD, Cenci MS, Pereira-Cenci T. Randomized controlled trial comparing glass fiber posts and cast metal posts. J Dentistry 2020;96:103334.
6. Akman M, Eldeniz AU, Ince S, Guneser MB. Push-out bond strength of a new post system after various post space treatments. Dent Mater J 2016;35(6):876-880.
7. Alkhudhairy FI, Yaman P, Dennison J, McDonald N, Herrero A, Bin-Shuwaish MS. The effects of different irrigation solutions on the bond strength of cemented fiber posts. Clin Cosmet Investig Dent 2018;10:221-230.
8. Davoudi A, Shadmehr E, Savoj M, Akhavan-Khaleghi M, Tabesh M, Zakizade M, et al. Laser Treatment of Fiber Post and Final Push-Out Bond Strength: A Systematic Review and Meta-Analysis. Photobiomodul Photomed Laser Surg 2021;39(5):321-333.
9. Kiomarsi N, Salim S, Sarraf P, Javad-Kharazifard M, Chiniforush N. Evaluation of the Diode laser (810nm,980nm) on dentin tubule diameter following internal bleaching. J Clin Exp Dent 2016;8(3):e241-e245.
10. Benitez Sellan PL, Zanatta RF, Gomes Torres CR, Tian FC, Bergeron BE, Niu LN, et al. Effects of calcium-phosphate, laser and adhesive on dentin permeability and bond strength. Heliyon 2020;6(5):e03925.
11. Khorasanchi M, Hoseinzadeh M, Khadem Rezaeian M, Kazemian A, Moradi A, Sarabadani J. The development of a serious game for laser applications in dentistry and the evaluation of dental students' satisfaction. BMC Med Edu 2024;24(1):583.
12. Raoux MCC. Influence of laser pre-treatments of intra-radicular dentin on the bond strength of cemented posts: A systematic review. Eur J Oral Sci 2021;130:e12881-12885.
13. Silva FFTd, Saguchi AH, Paiva SAF, Pires GE, Isidoro M, Brugnera A, et al. Effect of intracanal diode laser irradiation on fracture resistance of roots restored with CAD/CAM posts. Braz J Oral Sci 2022;21:e223759-e223770.
14. 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". J Fandom Clin Res 2022;2(1):1-13.
15. Farmakis ETR, Beer F, Tzoutzas I, Kurzmann C, Shokoohi-Tabrizi HA, Pantazis N, et al. Influence of Laser Irradiation Settings, during Diode-Assisted Endodontics, on the Intraradicular Adhesion of Self-Etch and Self-Curing Luting Cement during Restoration—An Ex Vivo Study. Materials 2022;15(7):2531.
16. Borges CC, Palma-Dibb RG, Rodrigues FCC, Plotegher F, Rossi-Fedele G, de Sousa-Neto MD, et al. The effect of diode and Er, Cr: YSGG lasers on the bond strength of fiber posts. Photobiomodul Photomed Laser Surg 2020;38(2):66-74.
17. Strefezza C, Amaral MM, Quinto Jr J, Gouw-Soares SC, Zamataro CB, Zezell DM. Effect of 830 nm diode laser irradiation of root canal on bond strength of metal and fiber post. Photomed Laser Surg 2018;36(8):439-444.
18. Goracci C, Grandini S, Bossù M, Bertelli E, Ferrari M. Laboratory assessment of the retentive potential of adhesive posts: a review. J Dent 2007;35(11):827-835.
19. Iandolo A, Pisano M, Abdellatif D, Amato A, Giordano F, Buonavoglia A, et al. Effectiveness of Different Irrigation Techniques on Post Space Smear Layer Removal: SEM Evaluation. Prosthesis 2023;5(2):539-549.
20. Alessi RS, Jitumori RT, Bittencourt BF, Gomes GM, Gomes JC. Effect of irrigation protocols on smear layer

removal, bond strength, and nanoleakage of fiber posts using a self-adhesive resin cement. Restor Dent Endod 2023;48(3):e28.

21. Garcia Lda F, Naves LZ, Farina AP, Walker CM, Consani S, Pires-de-Souza Fde C. The effect of a 980 nm diode laser with different parameters of irradiation on the bond strength of fiberglass posts. Gen Dent 2011;59(1):31-37.

22. Alfredo E, Marchesan MA, Sousa-Neto MD, Brugnera-Júnior A, Silva-Sousa YT. Temperature variation at the external root surface during 980-nm diode laser irradiation in the root canal. J Dent 2008;36(7):529-534.

23. Bornstein E. Near-infrared dental diode lasers. Scientific and photobiologic principles and applications. Dent Today 2004;23(3):102-108.

24. Dawasaz AA. In vivo efficacy of diode laser as a monotherapy in root canal disinfection: A systematic review and meta-analysis. Photobiomodul Photomed Laser Surg 2022;40(1):59-70.

25. Benezra MK, Karaaslan E, Doymaz MZ, Dincer AN. Antibacterial efficacy of 810-nm diode laser on the biofilm formation by Enterococcus faecalis in root canals: an in vitro study. Lasers Dent Sci 2020;4(2):73-78.

26. Gutknecht N, Franzen R, Schippers M, Lampert F. Bactericidal effect of a 980-nm diode laser in the root canal wall dentin of bovine teeth. J Clin Laser Med Surg 2004;22(1):9-13.

27. Nagase DY, de Freitas PM, Morimoto S, Oda M, Vieira GF. Influence of laser irradiation on fiber post retention. Lasers Med Sci 2011;26(3):377-380.

28. Kasraei S, Yarmohamadi E, Ranjbaran Jahromi P, Akbarzadeh M. Effect of 940nm Diode Laser Irradiation on Microtensile Bond Strength of an Etch and Rinse Adhesive (Single Bond 2) to Dentin. J Dent (Shiraz) 2019;20(1):30-36.

29. Malekipour M, Alizadeh F, Shirani F, Amini S. The effect of 808 nm diode laser irradiation on shear bond strength of composite bonded to dentin before and after bonding. J Dent Laser 2015;9(2):69.

30. Amin K, Masoodi A, Nabi S, Ahmad P, Farooq R, Purra AR, et al. Effect of diode laser and ultrasonics with and without ethylenediaminetetraacetic acid on smear layer removal from the root canals: A scanning electron microscope study. J Conserv Dent 2016;19(5):424-427.

31. Alfredo E, Silva SR, Ozório JE, Sousa-Neto MD, Brugnera-Júnior A, Silva-Sousa YT. Bond strength of AH Plus and Epiphany sealers on root dentine irradiated with 980 nm diode laser. Int Endod J 2008;41(9):733-740.