



# Effect of Laser Treatment of Root Dentine on Retention of Dental Fiber Post in Endodontically Treated Teeth: An In Vitro Study

Rawaa Abdul Hadi Ahmed<sup>1\*</sup>, Basima Mohammed Ali Hussein<sup>1</sup>

<sup>1</sup>Institute of Laser for Postgraduate Studies, University of Baghdad, Baghdad, Iraq

## \*Correspondence to

Rawaa Abdul Hadi Ahmed,  
Email: [rawaa.abd2102m@ilps.uobaghdad.edu.iq](mailto:rawaa.abd2102m@ilps.uobaghdad.edu.iq)

Received: January 14, 2024

Accepted: May 19, 2024

ePublished: July 31, 2024



## Abstract

**Introduction:** The most common causes of fiber post-failure are inadequate restorations and dislodgement. This study aimed to evaluate fiber post-bond strength to dentin following Er,Cr:YSGG laser irradiation.

**Methods:** A total of 65 human mandibular premolars with single roots were included. The 14 mm root length was instrumented with the rotary system using the crown-down technique. Gutta-percha was used for obturation, followed by conventional post space preparation. The samples were divided into two major groups: control (A) and Er,Cr:YSGG (2780 nm) laser group (B). The laser group was subdivided into (B1) 1.25 W, (B2) 1.5 W, and (B3) 1.75 W. All laser groups were set at 20 Hz, 10% and 30% water/air ratio. Fiber posts were cemented with self-adhesive cement. Each sample was divided horizontally into two slices, coronal and apical. The universal testing equipment was used to conduct a push-out test. All groups were examined by SEM and temperature changes. The statistical analysis was performed by using one-way ANOVA and Tukey HSD tests.

**Results:** SEM images of all laser groups revealed the elimination of the smear layer and opened dentinal tubules, which was particularly noticeable in the apical region with no thermal risk to the periodontal tissue. In the push-out test, all laser groups had highly significant ( $P < 0.001$ ) increases in the bond strength of fiber post to dentin. The failure mode of the control group was a predominantly adhesive failure, whereas the laser groups were a predominantly mixed type.

**Conclusion:** The three laser protocols can be used safely in the surface treatment of the fiber post space of endodontically treated teeth. Laser help to increase the bond strength of fiber post to dentin, especially in the apical area.

**Keywords:** Bond strength; Er,Cr:YSGG laser; Smear layer; Fiber post; Push-out test.

## Introduction

Root-canal-treated teeth frequently need special restorative considerations since they have lost a significant portion of their coronal hard tissue as a result of decay, prior restorations, and fractures. After a root canal filling, coronal restoration is essential to optimize the outcome of the therapy.<sup>1</sup> Considering that teeth subjected to root canal therapy would function normally and tolerate the masticatory shearing stresses, almost in all cases, it is necessary to place an intra-canal post to support the retention and function of the coronal restoration.<sup>2</sup> Glass fiber posts are generally accepted to provide adequate retention for teeth restorations with a limited residual structure. For restoration longevity, there must be a strong and effective adhesion between the post, dentine, and adhesive resin cement.<sup>3</sup> Compared to metal posts, fiber posts have a modulus of elasticity similar to dentine, which lowers the likelihood of vertical root fracture and stress transmission to the root canal walls. In contrast to posts with different materials, these give or create more

pleasing aesthetic results and fewer treatment visits.<sup>4</sup> Studies denote that the failure of metal-free posts is linked to bonding degradation, which is mostly caused by debonding at the adhesive resin-dentin interface.<sup>5</sup>

Because of the geometric shape of the canal and certain defects in the physical and chemical properties of the adhesive materials, it is difficult to ensure or obtain reliable bonding to the root canal dentine. Additionally, endodontic treatment steps carried out before fiber post-cementation may impede the bonding process to the root canal walls.<sup>6,7</sup> Trials to overcome this shortage as a single-step technique of adhesive cement were developed to enhance the bond between fiber posts and radicular dentine.<sup>8</sup> Despite that, there is still a need for optimizing the fiber post-retention to tolerate proper function and prognosis.

The use of high-power lasers has been proposed for the treatment of dentin in root canals before luting to enhance disinfection, smear layer removal, and adhesion.<sup>9</sup> 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.<sup>10</sup> The Er,Cr:YSGG laser can be used in the treatment of hard tissue due to its water and hydroxyapatite crystal affinity.<sup>11-13</sup> In endodontics, Er,Cr:YSGG can adapt to the varying complexity of root canal geometry. Its sapphire optical fibers are compatible with the restricted diameters of root canals and are designed specifically for use in endodontics. Investigations indicated that dentinal tubules can be opened and that dentin permeability is increased by the Er,Cr:YSGG laser.<sup>14</sup> It can be applied to improve cement penetration in dentinal tubules and remove the smear layer.<sup>15</sup> The push-out test is a useful tool for testing bonding strength because it produces shear stress when a force is applied parallel to the adhesion interface and simulates the loading in the restored root canal.<sup>16</sup> The present study aimed to evaluate the effect of the Er,Cr:YSGG laser on the pre-treatment of dentine before fiber post-cementation by using the push-out test. The null hypothesis stated that there would be no variations in fiber post-adhesion whether the Er,Cr:YSGG laser was applied before fiber post-cementation or not.

## Materials and Methods

The research proposal was approved by the local Research Ethics Committee of Baghdad University, Institute of Laser for Postgraduate Studies (Registration No. 1783). A total of 65 freshly extracted human mandibular premolar teeth were collected from subjects indicated for extraction due to orthodontic or periodontic reasons. These teeth had a straight root, no external root resorption or fissures, no history of endodontic treatment, and no root deterioration. All the teeth were investigated by using a diagnostic X-ray to verify these criteria. After cleaning the teeth with distilled water and an ultrasonic scaler (UDS-K Woodpecker, China), the soft tissue remnants or deposits were removed and the teeth were polished with pumice. The samples were then kept in plastic containers with a 0.1% thymol solution (Sigma –Aldrich, Steinheim, Germany) for disinfection.<sup>14</sup> A 14 mm root length from the apex was marked with the aid of a digital caliper (Vernier, China) and a permanent red marker. Every root was stabilized in a bench vice and sectioned by a diamond disc mounted on a slow-speed handpiece (Sirona contra-angle handpiece, NSK, Japan) adapted on a dental surveyor (Dentaurum, paratherm, Germany) to ensure parallelism. The teeth were de-crowned under continuous water cooling. Using a #10 and #15 stainless steel K file (Dentsply Maillefer, Switzerland), each root canal's original negotiation length was decreased by 0.5 mm to determine the working length. After that, the samples were inserted within a plastic tube filled with putty consistency silicone rubber base impression material (Protesil, Italy).<sup>17</sup> ProTaper Next rotary files (Dentsply, Maillefer, Switzerland) up to X4 were used to

instrument every root. The endo motor E-connect pro (Eighteeth, China) was configured with a rotation speed of 300 rpm and a torque range (4-5.2 Ncm). Following the completion of the instrumentation, 3 mL of 17% EDTA solution (Cerkamed, Stalowa Wola, Poland), 3 mL of 5.25% NaOCl (Cerkamed, Stalowa Wola, Poland), and 3 mL of distilled water were used as the final irrigation for the canal.<sup>18</sup> The gutta-percha cone (X4) with AH Plus sealer (Dentsply, Konstanz, Germany) was used to obturate the root canals by using the single cone obturation technique after drying the canals with paper points. All of the roots' coronal openings were sealed with glass ionomer cement (Glass liner, Germany), and the samples were kept for a week at 37 °C and 100% humidity.<sup>19</sup> After that, Exacto fiber post drill size #1 (white) (Exacto -Brazil) was used to prepare the post space to a depth of 10 mm.

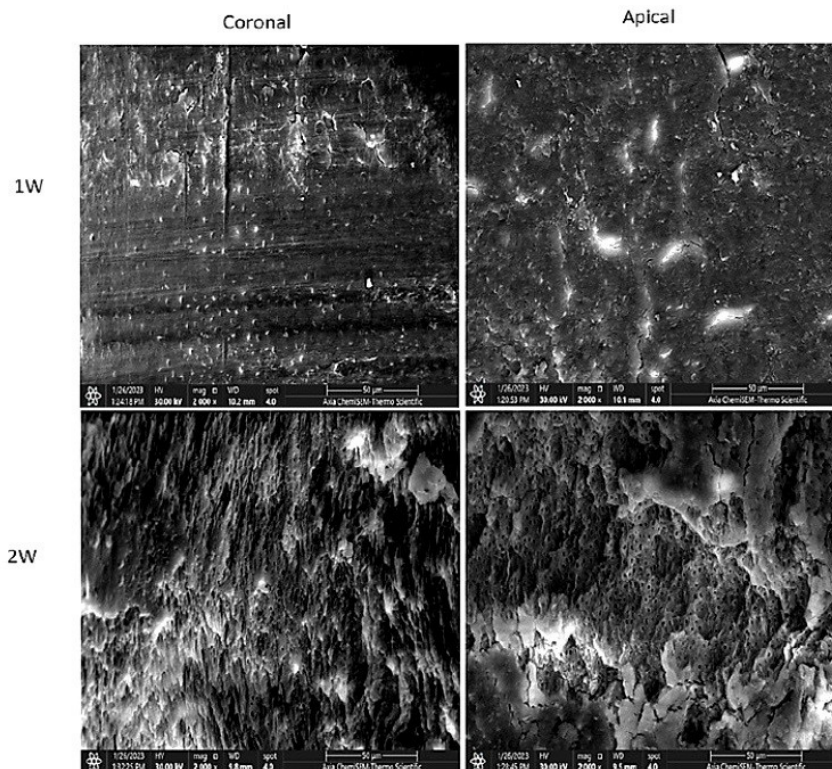
A pilot study was conducted to evaluate different Er,Cr:YSGG laser (Biolase, Waterlase, iPlus, CA, USA) parameters considering laser power (1 W, 1.25 W, 1.50 W, 1.75 W, 2 W), 20 Hz, 30% air, and 10% water. SEM images showed that 1 W had no effect on post-space dentine. On the other hand, 2 W showed melting and severe structural changes (Figure 1). Therefore, the final laser powers tested in this research were 1.25 W, 1.5 W, and 1.75 W.

## Samples Grouping

According to post-space management, the samples were divided into two main groups: control (A) and laser group (B) in which Er,Cr:YSGG 2780 nm was used. The laser group was subdivided into three groups with ten samples in each group. These roots were randomly distributed (simple randomization) by using this website (<https://www.randomizer.org>).

- Group A (control group): Post spaces were irrigated with 5ml of 0.9% normal saline with a total time of 60 seconds.
- Group B1: Post spaces were conditioned with the Er,Gr:YSGG laser at 1.25 W, 20 Hz, energy per pulse 62.5 mJ, 30% air, and 10% water.
- Group B2: Post spaces were conditioned with the Er,Gr:YSGG laser at 1.5 W, 20 Hz, energy per pulse 75 mJ, 30% air, and 10% water.
- Group B3: Post spaces were conditioned with the Er,Gr:YSGG laser at 1.75 W, 20 Hz, energy per pulse 87.5 mJ, 30% air, and 10% water.

Laser treatment of the root canal was performed by using an RFT3 tip (320 μm Biolase Waterlase Laser) with H mode and pulse duration of 60 μs. The tip was placed inside the canal and moved along it in a helical movement against the canal wall at an average rate (1-2 mm/s). Four cycles were used to irradiate the root canal; each cycle time was 10 seconds. with a 5-second. rest between cycles. A dental surveyor was used to ensure standardization.



**Figure 1.** SEM Photomicrographs of Fibre Post Space After 1 W and 2 W Laser Application in Apical and Coronal Sections at 2000 ×

#### **Fourier Transform Infrared spectroscopy Test**

Fourier transform infrared (FTIR) test was carried out by a spectrophotometer (Perkin Elmer, USA) for root dentin (fiber post space) to understand laser wavelength absorption and interaction.

#### **Scanning Electron Microscope**

For scanning electron microscope (SEM) analysis, one sample from each group was prepared. After canal conditioning, the roots were divided into two sections, with the section that contained the most noticeable part of the apex being used for the test. The samples were sputtered with a layer of gold and imaged by the Scanning Electron Microscope (Axia ChemiSEM, Thermo Scientific Fisher, USA) at apical and coronal areas under different magnification powers.

#### **Root Surface Temperature Changes Measurement**

To assess temperature changes during laser application, we included five samples from each group in this test. These teeth were placed in a stone mold and connected to a thermocouple wire using K-type (ASWAR, China). The tip of the thermocouple was attached mesially to the external root surface half the distance of its length. The baseline temperature was 37 °C, which was adjusted by the water path (HH-2 Numerical Show Constant, China).<sup>20</sup> Temperature changes during laser application were recorded.

#### **Fiber Post Cementation**

Before the cementation procedure, X-rays were taken for the root samples and any root with remnant obturation materials was discarded. With absorbent paper points, all of the post spaces were dried. Fiber post size #1 (white-Exacto, Brazil) at a length of 10 mm was seated passively inside the prepared post space. Following the manufacturer's instructions, the fiber post was cleaned with 70% ethanol and dried with air. Then one drop of silane (silano, Angelus, Brazil) was applied for one minute and dried. After applying self-adhesive resin cement (RelyX U200 Automix; 3M ESPE, Germany) directly to the post space by using an endo tip, the entire working length of the fiber post was inserted into the prepared canal. The cement was then light-cured for 40 seconds by using an LED curing pen (Eighteenth, China) at 1000 mW/cm<sup>2</sup>. Glass ionomer cement was used to seal the root's coronal access, and the root was kept in an incubator for a week at 37 °C and 100% humidity.<sup>19</sup>

#### **Push-out Bond Strength Test**

Before the application of the push-out test, the samples were embedded in transparent acrylic. Using a diamond disk with water cooling, we sectioned the samples horizontally, perpendicular to their long axis. Two sections were obtained from each root, each with 2mm thickness, at levels 5 and 11 mm from the root apex, representing the apical and coronal areas respectively. Each side of the slice was examined by using a digital microscope

(Q-Scope, the Netherlands), and the diameters of the post were measured by the ImageJ software program (Version 1.46; National Institutes of Health, USA). The push-out test was carried out by a universal testing machine (Tinius Olsen, UK) in the apical-coronal direction at a crosshead speed of 0.5 mm/min (Figure 2).

Push-out bond strength (MPa) = Maximum load (N) / Adhesive area (mm<sup>2</sup>)

The adhesive area recorded from:  $A = \pi (R+r) [(h/2 + (R-r) / 2)]^{0.5}$ . (R) and (r) represents the largest and the smallest post radius respectively,  $\pi$  is the constant 3.14, and (h) represents the slice thickness. The mode of failure was analysed by using a digital microscope with a 50× magnification. The failure mode was identified as follows<sup>21</sup>:

1. Adhesive failure.
2. Cohesive failure.
3. Mixed adhesive and cohesive failure.

Statistical analysis using student t-test, one-way analysis of variance (ANOVA), and Tukey's HSD were used to test the difference in means at ( $P \leq 0.05$ ).

## Results

### FTIR Test

The FTIR spectrum of root dentine after fiber post-space preparation reveals that the Er,Gr:YSGG laser (2780 nm) acts at 3500 cm<sup>-1</sup>. Approximately 95.34% to 92.81% of the laser transmits through the root dentin (Figure 3).

### Scanning Electron Microscope

A thick smear layer was cornering post-space dentinal

walls seen in the SEM images of the control group. On the other hand, SEM images revealed that the smear layer was removed in the laser groups when compared to the control one. Generally, the apical region shows better clearance from the smear layer than the coronal as shown in (Figure 4).

### Temperature Changes Measurement

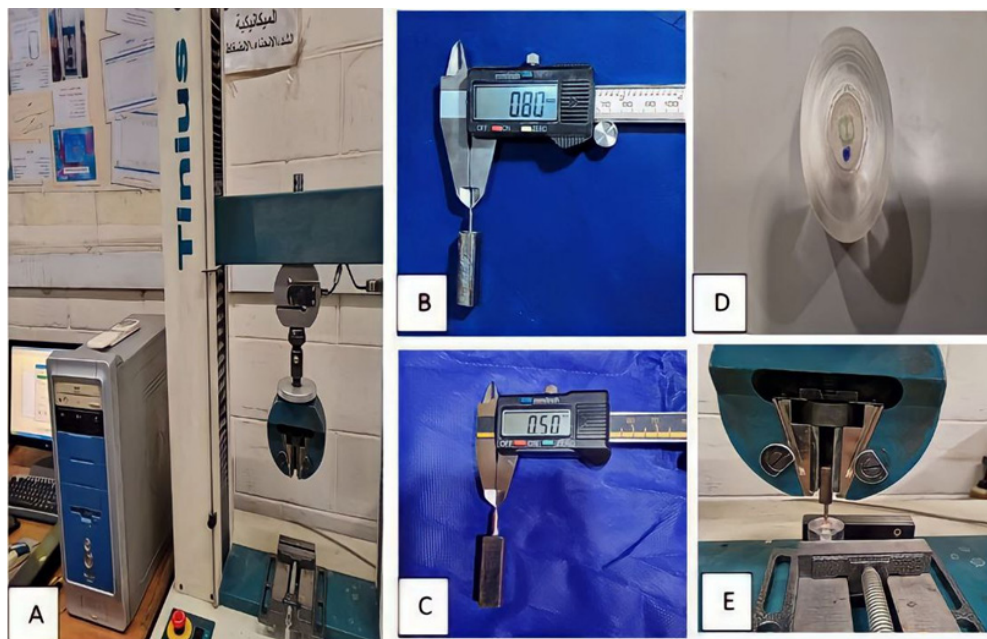
Measurement of the temperature changes of the external root surface during laser application in this study did not exceed 1 °C for all laser groups, which were below the critical temperature rise level. Statistically, no significant difference was observed between all laser groups (Figure 5).

### Push-out Test

One-way ANOVA showed statistically high significant differences in the mean bond strength values between the control and laser groups at  $P < 0.001$  in both coronal and apical areas (Tables 1 and 2). In addition, the bonding strength between coronal and apical parts was different for all groups; it is higher apically than coronally, as shown in Table 3. The failure mode of the control group was a predominantly adhesive failure, whereas in the laser-treated groups failure modes were a predominantly mixed type as shown in (Figures 6 and 7).

## Discussion

The difficulty of fiber post-adherence to radicular dentin often affects the prognosis of the restoration. Methods for modifying or treating the surface of root canal dentine may be suggested to enhance the interaction and increase the bond strength of fiber posts. This trial attempted to



**Figure 2.** Push-out Test. (A) Universal testing machine. (B) and (C) verification of the plungers' tip diameters with a digital caliper (D) Root-acrylic slice before testing (E) Shear bond strength testing

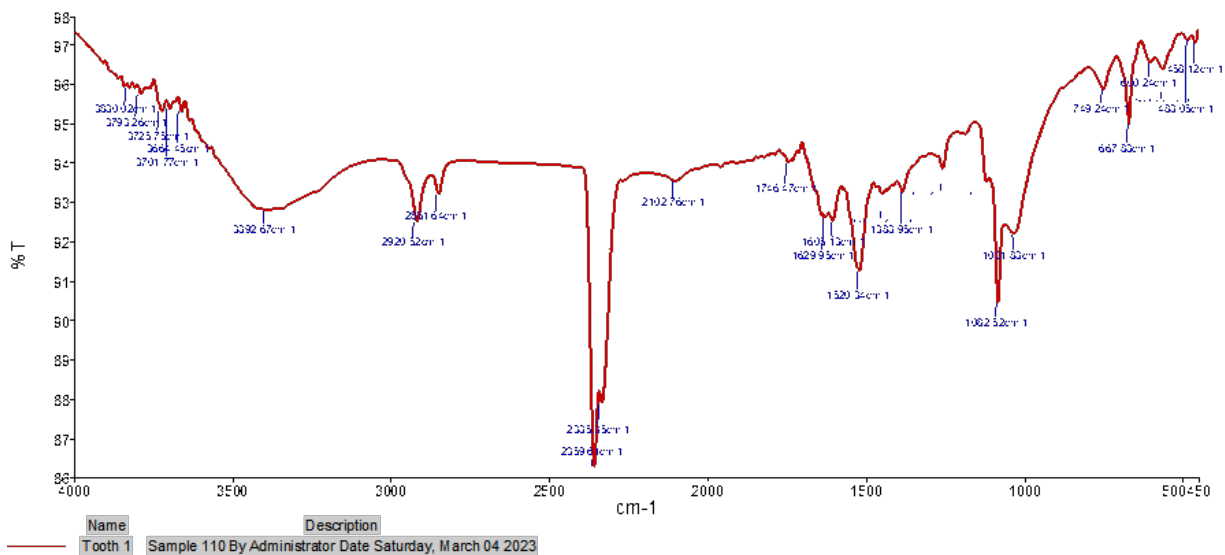


Figure 3. FTIR Spectrum of Root Dentine After Preparation of Fibre Post Space

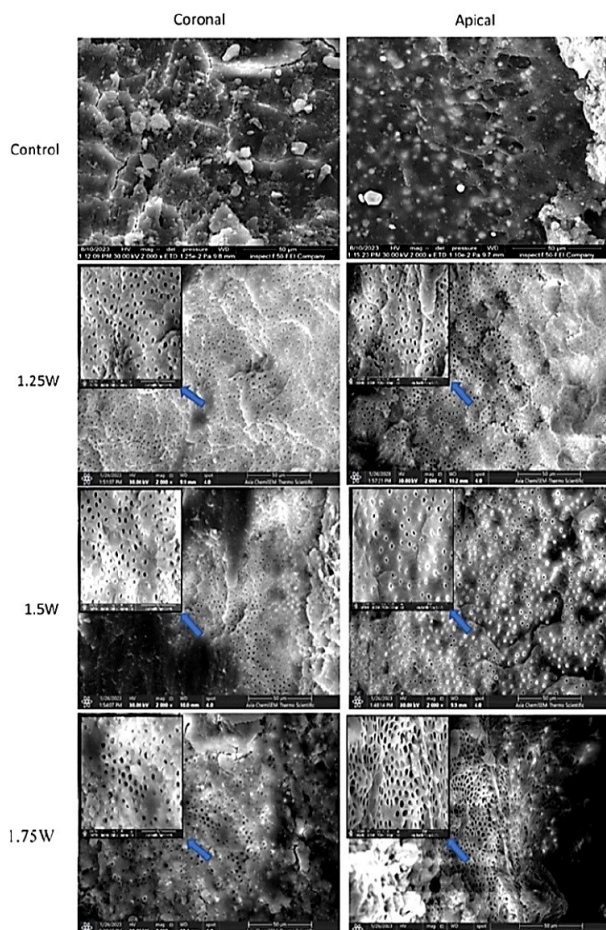


Figure 4. SEM Photomicrographs of the Coronal and Apical Area of the Root After Fibre Post Space Prepared of the Control Group and Laser Groups at 2000x and 7000x

use an Er,Cr:YSGG laser with a wavelength of 2780 nm and to evaluate its effect on the retention of the fiber post when used to treat the post space before fiber post cementation. The absorption coefficient of this laser in

dentine is approximately  $67 \text{ mm}^{-1}$ . This means that laser light penetrates almost  $15 \mu\text{m}$  in dentine. This superficial effect on root dentine is favourable in this application since only surface treatment or modification and removal of the smear layer are the targets of this use; this was also proposed by Diaci and Gaspirc.<sup>22</sup> Karteva and Manchorova<sup>23</sup> observed a typical spectrum of intact dentine marked in the range between 800 and  $3500 \text{ cm}^{-1}$ . These peaks correspond to the vibrations of certain chemical bonds of the 3 major dentin components – hydroxyapatite, collagen, and water. This finding is also confirmed by the result of the FTIR. Dentin has a water content of around 20% by volume; therefore the main interaction occurs when the Er,Cr:YSGG laser is absorbed by water molecules because the coefficient of absorption is high (about  $0.4 \times 10^4 \text{ cm}^{-1}$ ).<sup>24</sup> Er,Cr:YSGG laser irradiation results in thermomechanical ablation of the dentinal tissue through the vaporization of heated water, which expands and then creates micro explosions, which are responsible for the ejection of both organic and inorganic dentin surface components.<sup>25</sup> Mechanical retention is given by resin cement penetrating opened dentinal tubules to produce resin tags. This leads to intimate contact, without intervention, between the dentin and the cement which resulted from the removal of the smear layer. This was considered a primary reason for bonding enhancement to the dentine surface after laser irradiation.<sup>26</sup> Therefore, in this study, all laser groups were superior to the control in the push-out test, which could support the positive effect of the laser. It was suggested that thermal heat and micro-explosions caused by laser irradiation could promote the formation of microscopic fissures and micro-cracks in the dentin surface, which are probably difficult or poorly penetrated by the resin cement, resulting in interference with optimal bonding.<sup>27</sup> This was overcome or prevented in this study since laser power was in the range of 1.25,

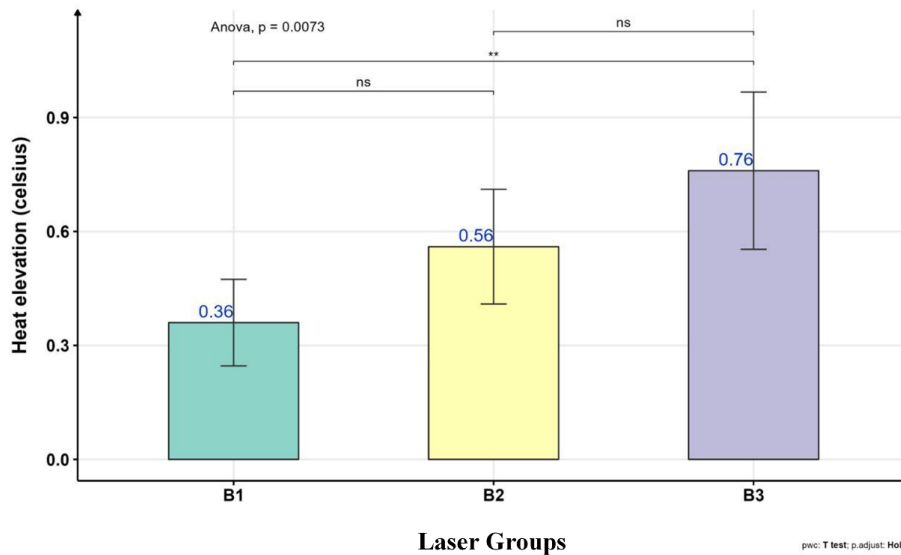


Figure 5. Post Hoc Analysis Showing the Differences Between Laser Groups Regarding Heat Elevation for Each Root

Table 1. One-Way ANOVA Test Between the Groups Regarding Push-out Bond Strength at the Coronal or Apical Regions

Groups	A Mean ± SD	B1 Mean ± SD	B2 Mean ± SD	B3 Mean ± SD	df	F Value	P Value
Coronal	9.6 ± 1.4	12.9 ± 2.2	13.5 ± 1.9	12.9 ± 1.3	3	10.4	<0.001
Apical	11.4 ± 1.8	16.7 ± 2.2	15.0 ± 3.0	16.5 ± 1.5	3	12.21	<0.001

Table 2. Tukey HSD Multiple Comparisons of Push-out Means Between the Groups

Groups	Mean Difference	95% CI (Lower)	95% CI (Upper)	Adjusted P Value
<b>Coronal</b>				
B1-A	3.25	1.17	5.33	<0.001
B2-A	3.91	1.83	5.10	<0.001
B3-A	3.26	1.18	5.34	<0.001
B2-B1	0.66	-1.42	2.74	0.83
B3-B1	0.01	-2.07	2.10	0.99
B3-B2	-0.65	-2.73	1.43	0.83
<b>Apical</b>				
B1-A	5.25	2.59	7.90	<0.001
B2-A	3.57	0.92	6.22	0.004
B3-A	5.10	2.41	7.72	<0.001
B2-B1	-1.68	-4.33	0.97	0.33
B3-B1	-0.18	-2.83	2.47	0.99
B3-B2	1.50	-1.15	4.14	0.43

Table 3. Student T Test Between Apical and Coronal Push-out Tests for Every Group

Groups	N	Coronal	Apical	P Value
A	10	9.6 ± 1.4	11.4 ± 1.8	0.022
B1	10	12.9 ± 2.2	16.7 ± 2.2	<0.001
B2	10	13.5 ± 1.9	15.0 ± 3.0	0.2
B3	10	12.9 ± 1.3	16.5 ± 1.5	<0.001

elimination of the smear layer and the opening of dentinal tubules. The smear layer usually results from routine post-space preparation in endodontically treated teeth, which interferes with the hybrid layer’s creation and affects the bond strength of the self-adhesive resin cement.<sup>28</sup> Furthermore, the difference in laser efficacy in smear layer removal between apical and coronal areas is due to the narrower diameter of the root canal apically. In the apical area, the laser tip was closer to the canal wall which promoted the laser effect. These findings agree with the study of Al-Baker and Al-Huwaizi<sup>29</sup> but disagree with the results of Kirmali et al<sup>30</sup> who showed that apical dentinal tubules are closed; this can be attributed to the higher power application during laser irradiation.

Testing temperature changes on the root surface during laser application indicated a minimal rise which is less than the critical limit which is less than 7 °C above the normal human body temperature (37 °C).<sup>31</sup> This supports the safety of lasers in such applications and the preservation of periodontal tissues during laser usage. The negligible temperature rise could be explained by the low energy

1.5 and 1.75 W applied under a vigorous water jet to prevent overheating or dehydration of the dentine to prevent adverse effects such as cracks. Furthermore, the RFT3 laser tip is used in laser application with a unique beam pattern that does not fire directly into the apex but permits laser distribution in an apico-lateral direction, which leads to concentrating the interaction in the target area of the canal wall.

In the present study, SEM images revealed the

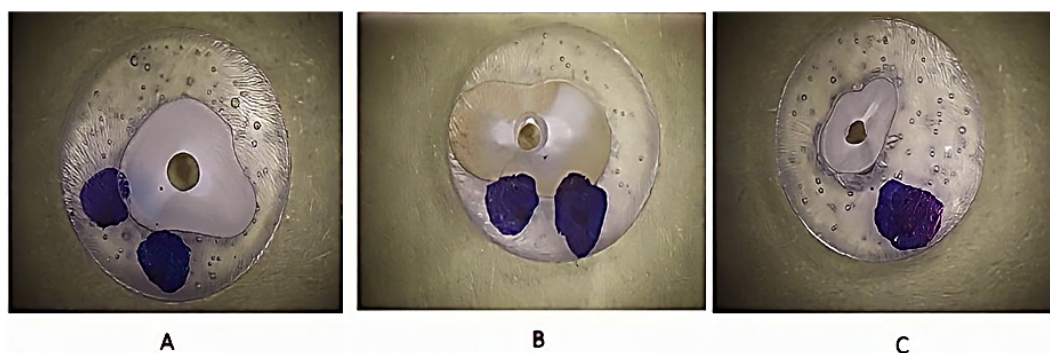


Figure 6. Digital Microscopic Images at 50×Magnification for Failure Mode Types. (A) Adhesive failure. (B) Cohesive failure and (C) Mixed failure

### Failure mode distribution between control and laser groups.

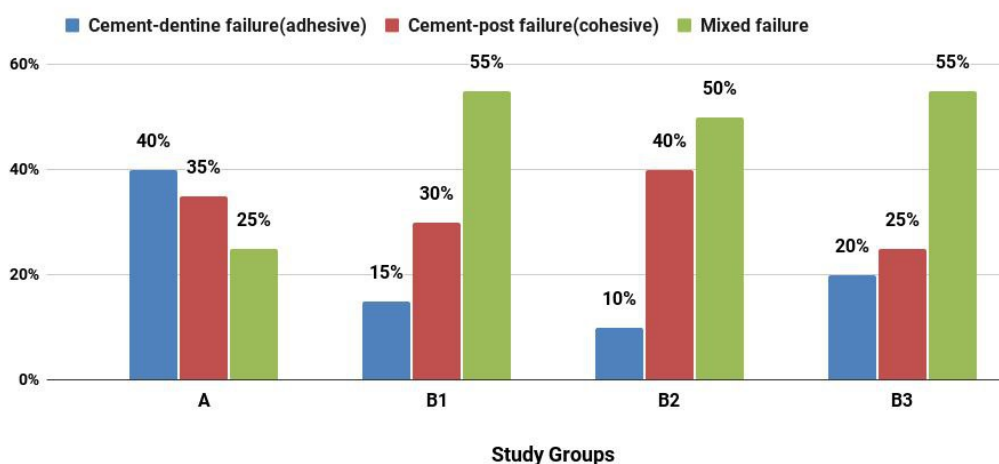


Figure 7. Bar Chart of Failure Mode Distribution Between Control and Laser Groups

generated during laser application, water cooling and rest time between laser sessions; all also helped to limit the temperature rise during lasing.<sup>29</sup>

The present study also found that the push-out test of group B had higher bond strength values compared to the control group; therefore, the null hypothesis was rejected. The use of radial firing tips in conjunction with the influence of the Er,Cr:YSGG laser on the dentin wall results in an increase in bond strength. These results agree with Borges et al<sup>15</sup> and Çökük et al<sup>32</sup> who also suggested 1.5 W to improve fibre post-retention. Mohammadi et al<sup>33</sup> concluded that applying the Er,Cr:YSGG laser twice to root dentine increased the bonding of the post when adhesive cement was used. Considering radial firing tip use, the results of this investigation coincide with the results from a study by Šimundić Munitić et al<sup>34</sup> who also concluded that laser-activated irrigation protocols by Er,Cr:YSGG, radial firing tip (RFT2), 1.25 W, 20 Hz, 140 μs and pulse energy 62.5 mJ provided higher bond strength of self-adhesive cemented fiber posts to root canal dentine. On the other hand, Kirmali et al<sup>30</sup> reported that different powers (1, 2, and 3 W) had no significant effects when compared with the control group, which is generally agreed by this study since the results of the pilot

study excluded the 1 and 2 W laser power because the 1 W laser power had no effect, while the 2 W laser power caused some structural damage. The disagreement with Nagase et al<sup>35</sup> who concluded that the fiber post-retention in bovine teeth was unaffected by the Er,Cr:YSGG laser could be explained by the differences in the methodology.

In this study, the coronal and apical regions demonstrated different bond strengths. For every group, the bond strength values of the apical sections were noticeably higher than those of the coronal regions. Apical section bond strength was highly significant in groups B1 and B3. This result was in agreement with Ali et al<sup>8</sup> who attributed the higher bonding of the fiber post apically due to the close contact between the fiber post and canal walls, while dos Santos Almeida et al<sup>36</sup> attributed the result to the higher thickness of the cement coronally which may induced higher polymerization shrinkage, leaving a gap and stresses that negatively affected bonding strength. However, this result is in contrast with Alofi et al<sup>37</sup> who state that an enhancement of the push-out bond strength test to resin cement, mainly in the cervical region of the root canal, could be attributed to the use of an axial fiber tip. All of the above factors explain the failure mode results, which revealed that the most prevalent

form of failure mode in the control group was adhesion between dentine and resin cement. Conversely, in every laser group, the mixed failure mode was predominant. This finding agreed with Ali and colleagues' study<sup>8</sup> which shows enhanced dentine-resin cement adherence.

Researchers in this experiment faced some limitations, such as working blindly in the canal and variations in the anatomy of teeth among individuals which could lead to variations in the readings. The researchers attempted to overcome all possible interferences by method standardization and sample size. The results of this study could be more effective and can be included as a step to enhance fiber post-retention, especially in teeth with some anatomical variations that may interfere with optimal fiber post-retention.

### Conclusion

In this investigation, the use of the Er,Cr:YSGG laser (2780 nm) with three irradiation powers (1.25 W, 1.5 W, and 1.75 W) in the treatment of fiber post space of root canal treated teeth before cementation can be considered as an alternative protocol to improve bonding between the fiber post and dentine without adverse thermal effects on the root surface or supporting structures.

### Authors' Contribution

**Conceptualization:** Rawaa Abdul Hadi Ahmed, Basima Mohammed Ali Hussein.

**Data curation:** Rawaa Abdul Hadi Ahmed.

**Formal analysis:** Rawaa Abdul Hadi Ahmed, Basima Mohammed Ali Hussein.

**Funding acquisition:** Rawaa Abdul Hadi Ahmed.

**Investigation:** Rawaa Abdul Hadi Ahmed, Basima Mohammed Ali Hussein.

**Methodology:** Rawaa Abdul Hadi Ahmed, Basima Mohammed Ali Hussein.

**Project administration:** Rawaa Abdul Hadi Ahmed, Basima Mohammed Ali Hussein.

**Resources:** Rawaa Abdul Hadi Ahmed.

**Software:** Rawaa Abdul Hadi Ahmed, Basima Mohammed Ali Hussein.

**Supervision:** Basima Mohammed Ali Hussein.

**Validation:** Basima Mohammed Ali Hussein.

**Visualization:** Basima Mohammed Ali Hussein.

**Writing—original draft:** Rawaa Abdul Hadi Ahmed.

**Writing—review editing:** Basima Mohammed Ali Hussein.

### Competing Interests

No conflict of interest.

### Ethical Approval

The ethical committee of the Institute of laser for postgraduate studies approved this study.

### Funding

This work was financially supported by the author.

### References

- Gomes KG, 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(1):97-102. doi: [10.1016/j.prosdent.2017.01.013](https://doi.org/10.1016/j.prosdent.2017.01.013).
- Irmak Ö, Yaman BC, Lee DY, Orhan EO, Mante FK, Ozer F. Flexural strength of fiber reinforced posts after mechanical aging by simulated chewing forces. *J Mech Behav Biomed Mater.* 2018;77:135-9. doi: [10.1016/j.jmbbm.2017.09.001](https://doi.org/10.1016/j.jmbbm.2017.09.001).
- Costa S, Silva-Sousa Y, Curylofo F, Steier L, Sousa-Neto M, Souza-Gabriel A. Fracture resistance of mechanically compromised premolars restored with polyethylene fiber and adhesive materials. *Int J Adhes Adhes.* 2014;50:211-5. doi: [10.1016/j.ijadhadh.2014.01.030](https://doi.org/10.1016/j.ijadhadh.2014.01.030).
- Kırmalı Ö, Üstün Ö, Kapdan A, Kuştarıcı A. Evaluation of various pretreatments to fiber post on the push-out bond strength of root canal dentin. *J Endod.* 2017;43(7):1180-5. doi: [10.1016/j.joen.2017.03.006](https://doi.org/10.1016/j.joen.2017.03.006).
- Maroulakos G, He J, Nagy WW. The post-endodontic adhesive interface: theoretical perspectives and potential flaws. *J Endod.* 2018;44(3):363-71. doi: [10.1016/j.joen.2017.11.007](https://doi.org/10.1016/j.joen.2017.11.007).
- Xu H, Ye Z, Zhang A, Lin F, Fu J, Fok ASL. Effects of concentration of sodium hypochlorite as an endodontic irrigant on the mechanical and structural properties of root dentine: a laboratory study. *Int Endod J.* 2022;55(10):1091-102. doi: [10.1111/iej.13800](https://doi.org/10.1111/iej.13800).
- Özgülven Akbulut M, Özbay Y, Erdemir A. Comparison of various irrigation activation procedures after post space preparation on push-out bond strength of fiber posts: an in vitro study. *G Ital Endod.* 2021;35(1):10-8. doi: [10.32067/gie.2021.35.01.19](https://doi.org/10.32067/gie.2021.35.01.19).
- Ali RJ, Kadhim AJ. The effect of the type of post space irrigation on the push-out bond strength of glass fiber post (an in vitro study). *J Res Med Dent Sci.* 2021;9(5):118-23.
- Araújo AI, Martins M, Campos JR, Barros A, Azevedo A, Oliveira T. Influence of the Er,Cr:YSGG laser and radial firing tips on the push-out bond strength of glass fiber posts. In: *Biodental Engineering V.* CRC Press; 2019. p. 95-100. doi: [10.1201/9780429265297-19](https://doi.org/10.1201/9780429265297-19).
- 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.
- 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.
- 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.
- 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](https://doi.org/10.34172/jlms.2023.68).
- Rasheed SS, Jawad HA. Permeability of radicular dentine after using different irrigant activation techniques including photo induce photoacoustic streaming technique. *Iraqi J Laser.* 2021;20(1):43-50.
- 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. doi: [10.1089/photob.2019.4668](https://doi.org/10.1089/photob.2019.4668).
- Al-Azzawi AK. The effect of waterlase laser and herbal alternative, green tea and *Salvadora persica* (Siwak) extract on push-out bond strength. *J Baghdad Coll Dent.* 2014;26(2):1-6. doi: [10.12816/0015187](https://doi.org/10.12816/0015187).
- Al-Huwaizi HF, Al-Ani YH. Push out bond strength of different obturation systems (an in vitro study). *J Baghdad Coll Dent.* 2011;23(3):37-43.
- Al-Khafaji HA, Al-Huwaizi HF. Cleaning efficiency of root canals using different rotary instrumentation systems: a comparative in vitro study. *Int J Med Res Health Sci.*

- 2019;8(1):89-93.
19. Kasim H, Al-Shamma AM. Influence of the cross-linking agent "proanthocyanidins" on the push-out bond strength of fiber posts cemented with a self-adhesive resin cement. *Indian J Public Health Res Dev.* 2019;10(10):2788-92. doi: [10.5958/0976-5506.2019.03292.3](https://doi.org/10.5958/0976-5506.2019.03292.3).
  20. Donnermeyer D, Schäfer E, Bürklein S. Real-time intracanal temperature measurement comparing mechanically and laser-activated irrigation to syringe irrigation. *Aust Endod J.* 2021;47(1):59-66. doi: [10.1111/aej.12461](https://doi.org/10.1111/aej.12461).
  21. Hashem M, Altinawi A, Fouad H, Vellappally S, Khan AA. Effectiveness of photodynamic therapy on bonding strength and failure modes of fiber-posts in c-shaped treated root canals. *Photodiagnosis Photodyn Ther.* 2021;35:102469. doi: [10.1016/j.pdpdt.2021.102469](https://doi.org/10.1016/j.pdpdt.2021.102469).
  22. Diaci J, Gaspirc B. Comparison of Er:YAG and Er,Cr:YSGG lasers used in dentistry. *J Laser Health Acad.* 2012;1(1):1-13.
  23. Karteva E, Manchorova N. Root dentin analysis from using fourier-transform infrared spectroscopy with attenuated total reflectance (FTIR-ATR). *Int J Sci Res.* 2019;8(5):2123-6.
  24. Al-Karadaghi TS, Franzen R, Jawad HA, Gutknecht N. Investigations of radicular dentin permeability and ultrastructural changes after irradiation with Er,Cr:YSGG laser and dual wavelength (2780 and 940 nm) laser. *Lasers Med Sci.* 2015;30(8):2115-21. doi: [10.1007/s10103-015-1757-y](https://doi.org/10.1007/s10103-015-1757-y).
  25. Parlar Oz O, Secilmis A, Aydin C. Effect of laser etching on glass fiber posts cemented with different adhesive systems. *Photomed Laser Surg.* 2018;36(1):51-7. doi: [10.1089/pho.2017.4304](https://doi.org/10.1089/pho.2017.4304).
  26. Davari A, Sadeghi M, Bakhshi H. Shear bond strength of an etch-and-rinse adhesive to Er:YAG laser- and/or phosphoric acid-treated dentin. *J Dent Res Dent Clin Dent Prospects.* 2013;7(2):67-73. doi: [10.5681/joddd.2013.012](https://doi.org/10.5681/joddd.2013.012).
  27. Hassoon SN. Evaluation of shear bond strength of composite resin to dentin after etching with Er,Cr:YSGG laser and conventional acid etch (an in vitro study). *Tikrit J Dent Sci.* 2015;3(1):45-54.
  28. Latta MA, Radniecki SM. Bond strength of self-adhesive restorative materials affected by smear layer thickness but not dentin desiccation. *J Adhes Dent.* 2020;22(1):79-84. doi: [10.3290/j.jad.a43932](https://doi.org/10.3290/j.jad.a43932).
  29. Al-Baker HS, Al-Huwaizi HF. Efficacy of smear layer removal from root canal surface using: sonic, ultrasonic, different lasers as activation methods of irrigant (SEM study). *J Res Med Dent Sci.* 2021;9(5):65-72.
  30. Kirmali O, Kustarci A, Kapdan A, Er K. Effects of dentin surface treatments including Er,Cr:YSGG laser irradiation with different intensities on the push-out bond strength of the glass fiber posts to root dentin. *Acta Odontol Scand.* 2015;73(5):380-6. doi: [10.3109/00016357.2014.968872](https://doi.org/10.3109/00016357.2014.968872).
  31. Al-Karadaghi TS, Gutknecht N, Jawad HA, Vanweersch L, Franzen R. Evaluation of temperature elevation during root canal treatment with dual wavelength laser: 2780nm Er,Cr:YSGG and 940nm diode. *Photomed Laser Surg.* 2015;33(9):460-6. doi: [10.1089/pho.2015.3907](https://doi.org/10.1089/pho.2015.3907).
  32. Çökük N, Kara E, Kaki D, Aydoğdu M, Sarıdağ S. Influence of the ER,CR:YSGG laser and different irrigation methods on push-out bond strength of fiber post. *J Adhes Sci Technol.* 2016;30(11):1178-88. doi: [10.1080/01694243.2016.1143582](https://doi.org/10.1080/01694243.2016.1143582).
  33. Mohammadi N, Savadi Oskoe S, Abed Kahnemoui M, Bahari M, Kimyai S, Rikhtegaran S. Effect of Er,Cr:YSGG pretreatment on bond strength of fiber posts to root canal dentin using a self-adhesive resin cement. *Lasers Med Sci.* 2013;28(1):65-9. doi: [10.1007/s10103-012-1063-x](https://doi.org/10.1007/s10103-012-1063-x).
  34. Šimundić Munitić M, Bago I, Glockner K, Kqiku L, Gabrić D, Anić I. Effect of different laser treatments on the bond strength of intracanal fiber posts cemented with a self-adhesive resin cement. *J Prostodont.* 2019;28(1):e290-6. doi: [10.1111/jopr.12738](https://doi.org/10.1111/jopr.12738).
  35. 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):377-80. doi: [10.1007/s10103-010-0861-2](https://doi.org/10.1007/s10103-010-0861-2).
  36. dos Santos Almeida Junior LJ, de Souza Penha KJ, Souza AF, Lula EC, Magalhães FC, Lima DM, et al. Is there correlation between polymerization shrinkage, gap formation, and void in bulk fill composites? A  $\mu$ CT study. *Braz Oral Res.* 2017;31:e100. doi: [10.1590/1807-3107bor-2017.vol31.0100](https://doi.org/10.1590/1807-3107bor-2017.vol31.0100).
  37. Alofi RS, Alshiddi IF, AlFawaz YF, Alsahhaf A, Al-Aali KA, Abduljabbar T, et al. Influence of Er,Cr:YSGG laser irradiation on the push-out bond strength of zirconia and glass fiber posts with radicular dentin. *Int J Biomater.* 2019;2019:4869853. doi: [10.1155/2019/4869853](https://doi.org/10.1155/2019/4869853).