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Effect of 940-nm Diode Laser Power on the Bond Strength of Fiber Posts to Root Canal Dentin

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Abstract

The retention of fiber posts is reliant upon the successful adhesion of resin cement to root canal dentin. Laser-assisted treatment may modify the dentin surface and influence post bond strength; however, the impact of various power settings of a 940-nm diode laser requires further investigation. The objective of this study was to assess the effectiveness of different 940-nm diode laser powers on fiber post retention. Thirty extracted premolars have been sorted into three groups (n = 10): 1.2-W laser, 2-W laser, and control. Fiber posts have been retained using dual-cure resin cement and pull-out force was recorded using a universal testing machine. Data were analyzed using non-parametric tests. Significant differences were found between all groups ($p < 0.001$). Median pull-out forces were 93 N, 79 N, and 72 N for the 1.2-W, 2-W, and control groups, respectively. All pairwise comparisons were significant ($p < 0.001$). Both laser-treated groups showed higher median post retention than the control, with the 1.2-W group showing the highest median value.

Introduction

Endodontically treated teeth with insufficient remaining crown are usually supported with fiber-reinforced posts [1]. Fiber post, resin cement, and root canal dentin bonding are crucial to the enduring efficacy of fiber post restorations [2]. However, factors such as smear layer formation, dentinal debris, and the anatomical complexity of root canals may interfere with adhesion and reduce post retention [3].

When the dentinal surface is covered with smear layer, this may lead to dentinal tubules obstruction. Presence of smear layer can interfere with the interaction of adhesive and resin-based materials with root canal dentin [4]. Therefore, effective irrigation and activation of irrigants are crucial to enhance root canal cleanliness and modifying the dentinal surface before fiber post cementation [5]. Various methods have been introduced for irrigant activation, including manual, sonic, ultrasonic, and laser-assisted techniques [6].

Laser-activated irrigation has gained attention as an alternative approach for enhancing root canal cleaning [7]. Laser energy can produce photothermal, photomechanical, and photoacoustic effects, which may improve the movement and effectiveness of irrigating solutions and assist in debris and smear layer elimination [8]. Diode lasers have also been investigated in endodontics because of their ability to interact with intracanal tissues and irrigants [9]. In particular, the 940-nm diode laser may enhance the cleaning effect of irrigation and potentially alter the dentinal surface, which could subsequently influence resin cement and root canal dentin interaction [11].

The impact of laser treatment on fiber posts bonding strength may depend on the amount of energy delivered to the root canal [12]. Different laser power settings may produce different degrees of surface modification and cleaning, while excessive energy may potentially cause undesirable thermal effects. Therefore, determining an appropriate laser power is important when considering its application before fiber post cementation [13,14].

Although laser-assisted irrigation has demonstrated potential for improving root canal cleaning, there is scant data concerning the effect of various power settings of a 940-nm diode laser on fiber posts bonding strength. Consequently, this investigation was aimed to

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evaluate and differentiate the bond strength of fiber posts placed in root canals treated with a 940-nm diode laser at 1 W and 2 W, with a non-laser-treated control group.

Material and Methods

Study design

This study was an in vitro experimental study involving 30 extracted human single rooted teeth randomly allocated into three groups (n = 10) to evaluate the effect of different 940-nm diode laser power settings on fiber post retention. The groups received laser exposure at 1.2 W, 2 W, or no laser treatment (control). The force required to remove the fiber posts was recorded using a universal testing machine and compared along the groups.

Inclusion criteria

- Extracted human single rooted teeth.
- Teeth suitable for root canal preparation and fiber post placement.
- Roots suitable for endodontic treatment and mechanical testing.

Exclusion criteria

- Teeth with root fractures or cracks.
- Teeth with root canal abnormalities that prevent standardized preparation.
- Roots with severe resorption or structural defects.
- Specimens damaged during preparation or testing.
- Multi rooted teeth

Ethical Considerations

The study complied with the Declaration of Helsinki and obtained authorization from the Ethics Committee at Al Hadi University, College of Dentistry, Iraq (number HD141026, 14-10-2026).

Specimen Preparation

Thirty extracted human single rooted teeth have been decoronated. Gutta-percha cones (Spident Ltd., Incheon, Korea) and resin-based root canal sealers (AH Plus Dentsply) have been used to obturate the root canals using the crown down technique. Following obturation, the specimens were incubated in 100% humidity at 37 °C for 24 hours to allow the sealer to set. Post spaces were subsequently prepared using Peeso drill.

Group Allocation and Root Canal conditioning

The specimens were randomly distributed into three groups (n = 10) according to fiber post space treatment protocol.

Group1 (1.2-W laser group): Root canals were treated with 17% ethylen ediamine tetra acetic acid for one minute and were subsequently dried using paper points. The canals were subsequently irradiated using a diode laser at 1.2 W with a 200-µm optical fiber tip. Laser irradiation was performed in four cycles of 5 minutes each, with a 10-second resting interval between cycles. The optical fiber tip was moved helically from the middle to the coronal part at 2 mm/s speed. Following laser treatment, the canals were rinsed using normal saline.

Group2 (2-W laser group): Root canals were treated with 17% ethylen ediamine tetra acetic acid for 1 minute and dried using paper points. Laser irradiation was then performed at 2 W using the same 200-µm optical fiber tip and helical movement from the middle to the coronal part at 2 mm/s speed. The treatment consisted of four 5-minute cycles, with a 10-second resting interval between cycles. The canals were subsequently rinsed using normal saline.

Group3 (control group): Root canals were treated with 17% ethylen ediamine tetra acetic acid for 1 minute and dried using paper points. No laser irradiation was applied.

Fiber Post Cementation

Following the assigned root canal treatment, dual cure resin cement (Breeze™) was used to retain fiber posts inside all specimens. The specimens have been incubated in 100% humidity at 37 °C for 72 hours before testing.

Measurement of Fiber Post Bond Strength

Fiber post bond strength was evaluated utilizing a universal testing machine (Zwick /Roll, Ulm, Germany). Each specimen was securely fixed in the machine, and a pulling force was applied to remove the fiber post from the root canal. The force required to pull out the post was recorded in Newtons (N) using the machine's software and considered the bond strength measurement.

Results

Shapiro–Wilk test revealed statistically significant deviations from normality in all three groups. Therefore, nonparametric tests were used to compare fiber post bond strength along the experimental groups.

Based on the descriptive statistics, Group 1 had the greatest median bond strength, succeeded by Group 2 and group 3. The Kruskal–Wallis test revealed a statistically significant difference in bond strength along the three groups (Table 1 and Figure 1).

The Mann–Whitney U test for pairwise comparisons revealed statistically significant disparities between the experimental groups after Bonferroni correction, with an adjusted significance threshold of $p < 0.0167$.

Discussion

The current in vitro research examined the influence of various power levels of a 940-nm diode laser on the bond strength of fiber posts to root canal dentin. The results revealed significant differences between all groups. Group 1, treated with the diode laser at 1.2 W, revealed the greatest median bond strength, followed by Group 2, treated at 2 W, while group 3 showed the lowest median bond strength. Pairwise comparisons also revealed significant differences between all groups. These findings suggest that, under the conditions of the present study, diode laser treatment was associated with higher fiber post bond strength than the untreated control, with the 1.2-W setting producing the highest observed values. This result is consistent with other studies which suggested that laser surface treatment increases fiber post bonding strength [14,15].

During post-space preparation, the formation of a smear layer containing dentin debris and residual materials may interfere with intimate contact between the adhesive material and the dentin substrate. Bohrer et al. reported that post-space treatment can influence fiber posts adhesion, although the findings vary according to the treatment method and experimental conditions [16]. Therefore, modifying the dentin surface before fiber post cementation may be an important factor influencing adhesion.

The greater bond strength noticed in the laser-treated groups could be related to laser-induced changes in the root canal dentin surface. Diode laser irradiation can produce photothermal effects that may alter organic components, modify the smear layer, and influence dentinal tubule openings. Depending on the irradiation parameters, these changes may improve surface conditions for adhesive interaction. Nevertheless, the present study did not directly examine dentin morphology or adhesive penetration; therefore, these mechanisms remain possible explanations rather than confirmed causes of the observed differences. Previous research has demonstrated that the effects of diode laser exposure on post bond strength are not consistent across all experimental conditions. For example, Davalloo et al. found that diode laser exposure did not markedly influence the bond strength of fiber posts when compared with non-irradiated groups using the same resin cement system [17]. Differences in laser settings, cement type, irradiation protocol, and bond-strength testing methods may help explain the variation between studies.

A significant discovery of the current research indicated that the 1.2-W group exhibited greater binding strength compared to the 2-W group. This suggests that increasing laser power does not necessarily improve adhesion. A pilot study reported that increasing laser power may cause dentin structural damage which is consistent with our findings [18]. Laser–dentin interactions depend not only on power but also on wavelength, exposure duration, movement of the optical fiber, distance from the dentin surface, and the thermal characteristics of the surrounding tissues. Higher

power settings may produce greater thermal effects, which could potentially alter the dentin substrate in ways that are not favorable for resin adhesion.

Several limitations should be acknowledged. First, the study included only 30 root specimens, with 10 specimens per group, which limits the generalizability of the findings. Second, an in vitro model cannot fully reproduce clinical conditions, including variations in root canal anatomy, moisture, temperature, occlusal loading, and long-term degradation of the adhesive interface. Third, the study did not include microscopic examination of the dentin surface, assessment of failure modes, or direct measurement of thermal changes during laser irradiation. These additional assessments could help explain the mechanisms underlying the differences in bond strength. Finally, the findings apply to the specific laser parameters and cementation protocol used and should not be generalized to all diode laser systems or resin cements.

Conclusion

The 940-nm diode laser-treated groups demonstrated higher median fiber post bond strength than the control group, with the 1.2-W group showing the highest observed median. Significant differences were also found between the two laser power settings. Further studies incorporating larger sample sizes, microscopic assessment, temperature monitoring, aging procedures, and different resin cement systems are recommended to confirm these findings and determine their clinical significance.

Conflicts of Interest

No conflict of interest has been disclosed by the authors.

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Table 1. Descriptive statistics and comparison among groups

Experimental group	N	Bond strength N Median	IQR
G1: 1.2 W laser	10	93	6
G2: 2 W laser	10	79	2
G3: Control	10	72	4
Kruskal–Wallis test	30	_	H = 26.454, df = 2, p < 0.001

IQR: inter quartile range, H: Kruskal–Wallis test, df: degree of freedom, p: p value

Table 2. Pairwise comparisons using the Mann–Whitney U test

Group comparison	Mann–Whitney U	Z	p-value	Bonferroni-adjusted interpretation
G1 vs. G2	0.000	−3.899	< 0.001	Significant
G1 vs. G3	0.000	−3.883	< 0.001	Significant
G2 vs. G3	0.000	−3.883	< 0.001	Significant

Z: standardized test statistic

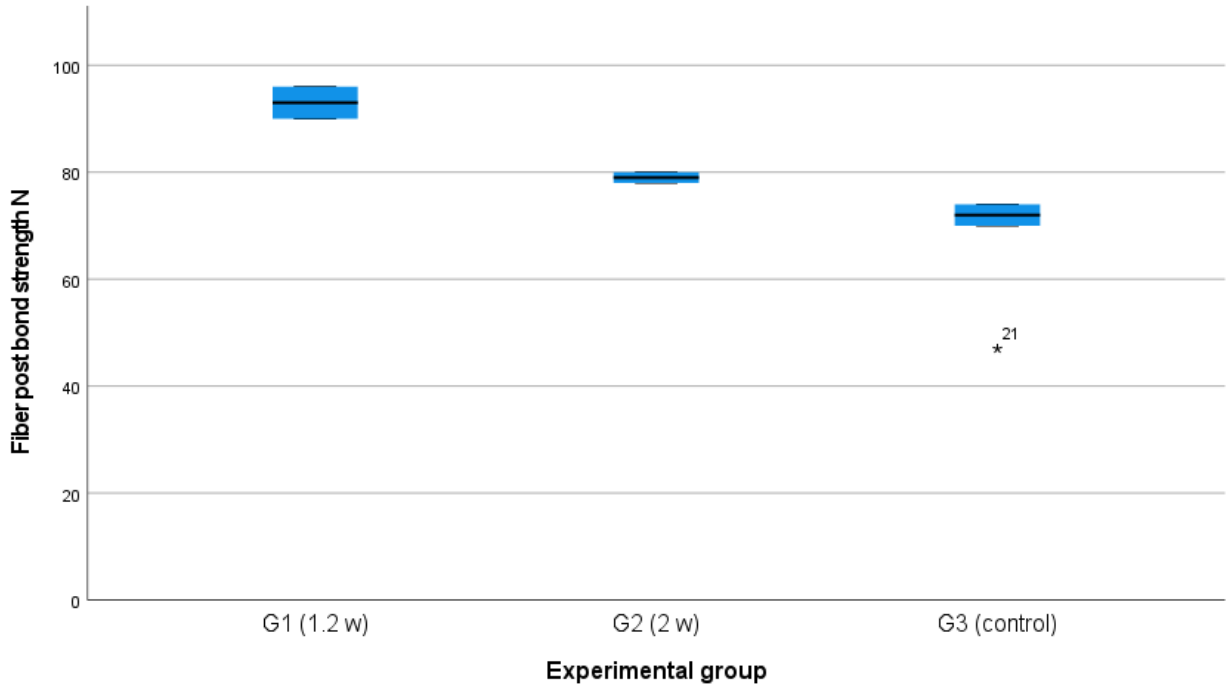


Figure 1. Simple boxplot of fiber post bond strength by experimental group.