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# Effect of Photodynamic Therapy with Four Light-Sensitive Materials on the Bond Strength of Fiber Posts to Root Dentin

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**Abstract**

**Introduction:** Fiber-reinforced composite posts (FRCP) have become popular due to their multiple advantages in teeth with extensive crown destruction. Proper disinfection is essential for the successful bonding of these posts. Commonly used solutions for cleaning and disinfecting the root canals adversely affect the bond strength (BS). Photodynamic therapy is an alternative method for irrigating the root canal and disinfecting the post space.This study was designed to evaluate the impact of photodynamic therapy on the BS of fiber posts to root canal dentin.

**Methods:** Human maxillary canines were recruited for this study. The tooth crowns were removed at the cervical line and endodontically treated. After fiber post spaces were prepared, the teeth were assigned to five groups based on the light-sensitive material: deionized water, indocyanine green and 810-nm laser, methylene blue and 660-nm laser, toluidine blue and 635-nm laser, curcumin and LED. The posts were cemented after photodynamic therapy. Cervical, middle, and apical samples were prepared by transverse sectioning. Push-out bond strength (PBS) values were measured in a universal testing machine. Finally, the data underwent statistical analyses with ANOVA and Howell-Games tests.

**Results:** One-way ANOVA revealed no significant differences between the groups ($P<0.001$). The Games-Howell test showed that curcumin ($7.23 \pm 3.75$) and the control group ($5.92 \pm 4.04$) had a similar BS ($P>0.005$). The BS was lower in the methylene blue ($3.34 \pm 2.15$), indocyanine green ($2.59 \pm 3.16$), and toluidine blue ($2.45 \pm 1.73$) groups than in the control group ($P<0.005$).

**Conclusion:** Unlike other light-sensitive materials, curcumin did not adversely affect the BS.

**Keywords:** Bond strength; Fiber post; Photodynamic therapy.

## Introduction

Disinfection of the root canal and long-lasting (durable) restoration are the main objectives of successful treatment.[1] Conventional root canal cleaning techniques eliminate microbial invasion but cannot disinfect it effectively,[2] especially in the apical third, considering the complexities of the root canal system and the resistance of microorganisms.[3] Mechanical instrumentation and irrigants such as sodium hypochlorite (NaOCl) and chlorhexidine digluconate are used to clean root canals. Applying chlorhexidine digluconate before fiber post cementation results in a reaction between the solution and the phosphate in the hydroxyapatite crystals, forming a barrier and decreasing the contact between the luting agent and dentin.[4]

NaOCl disintegrates collagen fibrils, disrupting proteins and breaking down carbon. In contact with the tooth, the solution decomposes into hypochlorous acid and oxygen bubbles, deactivating the polymerization process of resin materials and reducing the bond strength (BS) between the root canal wall and the luting cement.[5-7]

On the other hand, endodontically treated teeth may need reconstruction with an intracanal post as a result of losing a significant portion of their coronal structure.[7,8] Among various posts, i.e., ceramic, metal, and fiberglass posts, fiber-reinforced composite posts (FRCP) offer better tensile strength, fatigue performance, and hardness, a better esthetic appearance, and higher BS.[9,10]

Bonding FRCP to the root dentin is critical. One of the influential factors is the smear layer,[9] the removal of which, before cementing the post to the root canal, results in deeper penetration of the adhesive, sealer, and obturation materials. In addition, the smear layer may result in the loss of dentinal tubules.[7,8]

Free radicals are involved in the polymerization of resin components, which includes chemical reactions in methacrylate structures. Therefore, the reactions of the materials with free radicals affect the degree of conversion

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(DC) and the adhesion of resin materials to dentin. NaOCl is converted into sodium hydroxide and hypochlorous acid, creating free oxygen. In addition, oxygen can act as a barrier to the adhesive surface, preventing the formation of the hybrid layer in the dentin.[6] Therefore, photodynamic therapy with special light-sensitive materials can be a good option due to its acceptable antimicrobial activity in the infected root canal. Photodynamic therapy is a non-invasive, repeatable, low-cost procedure and can be easily performed.[6,7]

In photodynamic therapy, the photons of the light source are absorbed by the light-sensitive material, which causes the electrons to be excited from the normal state to the excited phase. In the presence of oxygen, the light-sensitive material transfers this energy to a lower layer. The return of the energy to the ground state creates highly reactive oxygen species with low molecular weight and generally single oxygen, irreversibly oxidizing microorganisms.[1,11]

Methylene blue is a hydrophilic, light-sensitive material with a positive charge and low molecular weight that penetrates the membranes of gram-positive and gram-negative bacteria, leading to the irreversible oxidation of microorganisms.[4]

The curcumin light-sensitive material with antibacterial properties mainly reacts with cationic components in dentin, such as calcium, due to the formation of superoxide and hydrogen peroxide anions.[4,12]

It is not clear whether these reactive oxygen species can affect the mechanical properties of dentin and bonding to dentin, leading to changes in hydroxyapatite crystals and the adhesive interface of dentin and fiber post.[11]

This study assessed the effect of photodynamic therapy using four light-sensitive materials, including indocyanine green and 810-nm laser, methylene blue and 660-nm laser, toluidine blue and 635-nm laser, and curcumin and LED, on the BS of the fiber post to root dentin.

## Methods

In this study, human maxillary canine teeth were collected with an almost equal root length and similar root anatomy, extracted for periodontal or orthodontic reasons (not due to pulp and periapical diseases and periodontal abscesses). Teeth with excessive root curvature and cracked and broken teeth were excluded.

Soft tissue ligaments and calculi were eliminated from the tooth surfaces. Then, the crowns were removed at the CEJ buccolingually using a low-speed diamond bur to achieve 15-mm-long roots.

The step-back technique was adopted to prepare the root canals 1 mm short of the root apex. K- file (Mani, Kiyohara Industrial Park, Tochigi, Japan) and #2, #3, and #4 Gates-Glidden (Mani-Kiyohara Industrial Park, Tochigi, Japan) drills were used to shape and clean each root canal, followed by root canal irrigation with 2.5% NaOCl using a 10-mL syringe. A #35 file was selected as a master apical file (MAF), and the prepared root canals were dried with sterile paper points (Gapadent Co., Tianjin City, China) and air pressure. The obturation was accomplished with the lateral compaction technique applying gutta-percha (Dentsply-Ballaigues-Maillefer, Switzerland) and AH26 sealer (Dentsply-Detrey, Konstanz). After obturation, the cervical area and apical foramen were coated with glass-ionomer (FGM, Brazil), and the roots were stored under 100% humidity at 37ºC for one week. Then, 11 mm of the root canal length was prepared by fiber post kit drills (FGM-White Post Drill DC #2, Brazil) for post placement. After irrigating the root canals with distilled water and drying with paper points,[5] they were randomized into five groups based on the type of light-sensitive material (n = 12): group 1: deionized water, group 2: indocyanine green with a concentration of 1000 mg/mL and an 808-nm laser with a power of 250 mW, group 3: methylene blue with a concentration of 100 µg/mL and a 660-nm laser with a power of 150 mW, group 4: toluidine blue with a concentration of 100 µg/mL and a 635-nm laser with a power of 220 mW, and group 5: curcumin with a concentration of 5 µM and an LED at a light intensity of 1000 ± 100 mW/cm$^2$.

In the next step, each group's post space was filled with its specific light-sensitive material until some material overflowed. Then, the roots were left undisturbed for 5 minutes. Then, a three-dimensional tip (Konftec Tips WF-354A) (PACT) was placed in the entire length of the prosthetic space with an up-and-down motion, and the laser was irradiated for 60 seconds. The light-sensitive material was removed, followed by post space irrigation with normal saline solution and drying with paper points.

The FGM fiber post surface (White Post DC System; FGM, Joinville, SC, Brazil) was sterilized with 95% ethanol. The entire length of the fiber post was conditioned with Bisco silane (Schaumburg, USA). Panavia F2.0 dual-cured resin cement (Kuraray Co. Ltd., Osaka, Japan) was used following the manufacturer's instructions. First, equal amounts of ED PRIMER II A & B were mixed and then applied to the prosthetic root canal space and left for 30 seconds. Then, the excess primer was eliminated from the root canal by paper points. Next, equal amounts of pastes A & B were mixed and applied on the fiber post surface, which then was placed properly within the root canal and cured by a light-curing device with an output intensity of 1000 mW/cm$^2$ for 20 seconds. Afterward, all the samples underwent 10 000 cycles of thermocycling, consisting of 15 seconds hot, 15 seconds cold, and 15 seconds of dwell time (5–55 °C), and were placed vertically in a polyvinyl chloride matrix (diameter: 15 mm, length: 16.5 mm). The matrix with polyester resin was left for 24 hours for a complete setting. Then, the samples were retrieved from the matrix, and 1 mm was cut from the top and bottom.

The part prepared for the post space was sectioned by a cutting machine (Mecatome T210) perpendicular to the tooth's long axis. Finally, two apical, two middle and two cervical pieces with a thickness of 0.2 ± 1 mm were prepared from each tooth, and 12 transverse sections were assigned to each group (n = 12). To examine push-out bond strength (PBS) values, cylindrical pressure was applied apicocoronally in an electromechanical testing machine (Zwick/Roell Group, ULM, Germany) using a stainless steel cylindrical piston with a diameter of 0.7 mm. The 5-kN load cell force was applied at a 0.5-mm/min crosshead speed. Then, the PBS values of the samples were calculated with software connected to the universal testing machine. The maximum applied force before the bond failure was recorded in Newton, which was then reported in MPa using the following formula:

Debond stress = N/A
N = the force at which the fiber post was dislodged from the root
A = the cylinder bonding surface

Then, each sample was examined to determine the failure modes by a stereomicroscope (Nikon SMZ800) at × 20[6]:

1. Adhesive: failure at the dentin-root canal filling material interface (no cement on dentinal walls)
2. Cohesive: failure within the cement (the presence of cement on dentinal walls)
3. Mixed: a combination of both failure modes

## Results

The mean, maximum and minimum PBS of all study groups was shown in Table 1. A universal testing machine was used to achieve the PBS values of the fiber post to root dentin in MPa. The data were analyzed by one-way ANOVA, which revealed significant differences between the groups ($P < 0.001$). However, the data dispersion was not equal ($P < 0.006$); therefore, the Howell-Games test was used for the two-by-two comparison of the groups (Table 2), and the conventional tests were not used. This test showed values in the control and curcumin (CR) groups ($P < 0.005$).

The mean PBS values (Figure 1) in the control and the CR groups were similar and higher than the other three groups. Indocyanine green (IG), toluidine blue (TB), and methylene blue (MB) groups exhibited lower BS values, which were similar to each other and different from the control and CR groups.

The frequencies of failure modes (adhesive, cohesive, mixed) were examined in each group (Figure 2). The failures in the control, CR, and toluidine blue groups were similar, and the frequency of each failure mode was equal in these three groups. In the MB group, the most and the least common failure modes were cohesive and mixed, respectively. In the IG group, the most and the least common failure modes were mixed and adhesive, respectively.

The samples were examined under a stereomicroscope at × 20 to determine the failure modes, and their images were prepared (Figure 3A-3C).

## Discussion

In this study, the BS was comparable in the curcumin and control groups, indicating no adverse effect of curcumin on the BS of the fiber post to the root dentin; therefore, curcumin can be a material of choice for photodynamic therapy. However, the results were different in other groups, and these groups showed BS values different from the control group ($P < 0.005$). Methylene blue,

**Table 1.** Mean, minimum, and maximum push-out bond strength values in each group

| | Number | Mean | Minimum | Maximum |
|---|---|---|---|---|
| MB | 12 | 3.3414 | 1.38 | 5.68 |
| TB | 12 | 2.4590 | 0.76 | 4.23 |
| IG | 12 | 2.5984 | 0.27 | 6.59 |
| CR | 12 | 7.2397 | 3.24 | 10.74 |
| Cntrl | 12 | 5.9200 | 2.20 | 10.29 |
| Total | 60 | 4.3117 | 0.27 | 10.74 |

**Table 2.** Intergroup Comparisons of Bond Strength Values by Games-Howell Test

| (I) group | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| MB | TB | 0.88241 | 0.49932 | 0.418 | -0.6100 | 2.3748 |
| | IG | 0.74309 | 0.62814 | 0.761 | -1.1259 | 2.6121 |
| | CR | -3.89823* | 0.75400 | 0.001 | -6.1713 | -1.6251 |
| | Cntrl | -2.57859 | 0.91915 | 0.041 | -5.3963 | -0.2391 |
| TB | MB | -0.88241 | 0.49932 | 0.418 | -2.3748 | 0.6100 |
| | IG | -0.13932 | 0.56680 | 0.999 | -1.8506 | 1.5720 |
| | CR | -4.78065* | 0.70372 | 0.000 | -6.9441 | -2.6172 |
| | Cntrl | -3.46100* | 0.87838 | 0.011 | -6.2037 | -0.7183 |
| IG | MB | -0.74309 | 0.62814 | 0.761 | -2.6121 | 1.1259 |
| | TB | 0.13932 | 0.56680 | 0.999 | -1.5720 | 1.8506 |
| | CR | -4.64133* | 0.80029 | 0.000 | -7.0307 | -2.2519 |
| | Cntrl | -3.32168* | 0.95749 | 0.021 | -6.2217 | -0.4217 |
| CR | MB | 3.89823* | 0.75400 | 0.001 | 1.6251 | 6.1713 |
| | TB | 4.78065* | 0.70372 | 0.000 | 2.6172 | 6.9441 |
| | IG | 4.64133* | 0.80029 | 0.000 | 2.2519 | 7.0307 |
| | Cntrl | 1.31964 | 1.04439 | 0.715 | -1.7960 | 4.4353 |
| Cntrl | MB | 2.57859 | 0.91915 | 0.041 | 0.2391 | 5.3963 |
| | TB | 3.46100* | 0.87838 | 0.011 | 0.7183 | 6.2037 |
| | IG | 3.32168* | 0.95749 | 0.021 | 0.4217 | 6.2217 |
| | CR | -1.31964 | 1.04439 | 0.715 | -4.4353 | 1.7960 |

* Significant difference, $P<0.05$

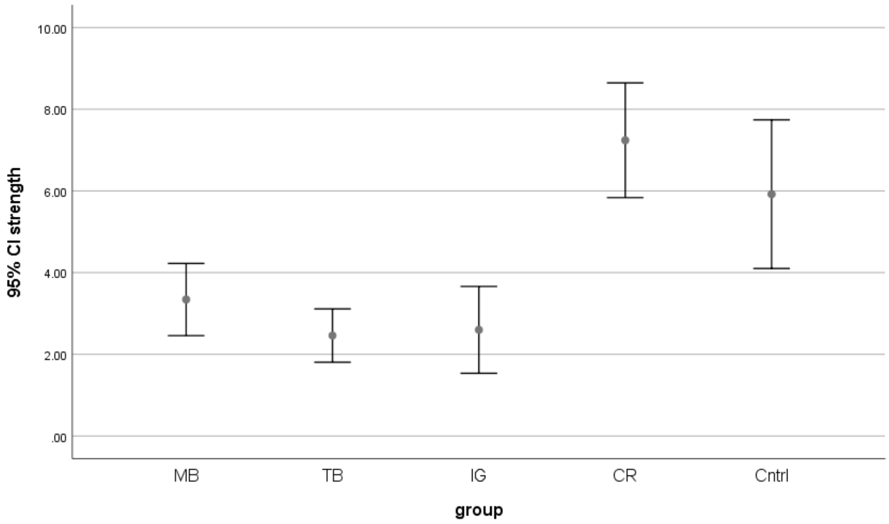


**Figure 1.** Means and 95% Confidence Intervals of Push-out Bond Strength Values

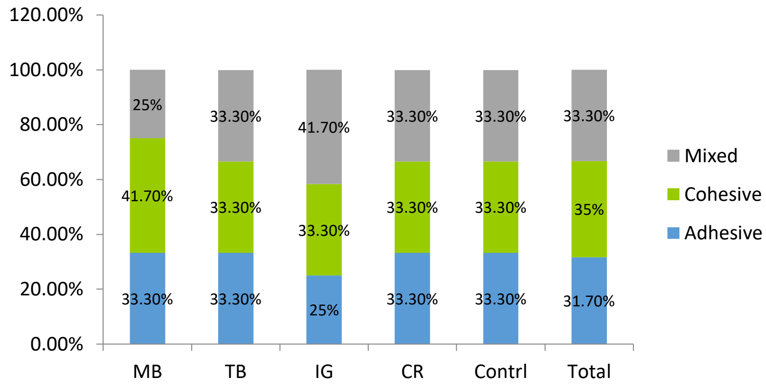


**Figure 2.** Frequencies of Failure Modes in the Study Groups

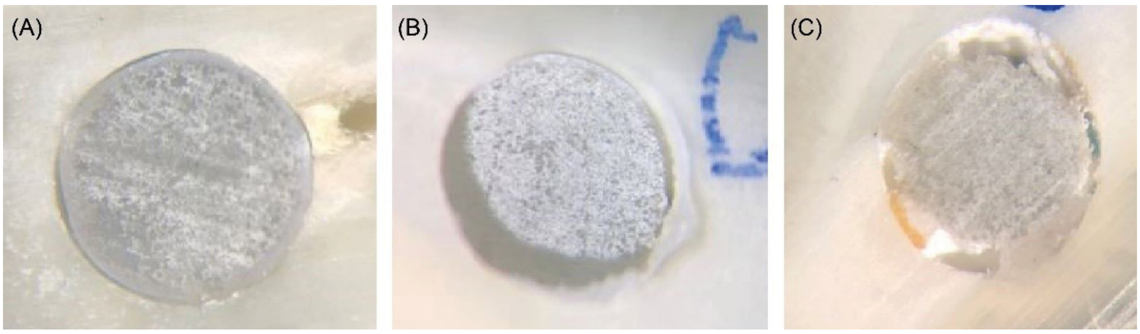


**Figure 3.** (A) Cohesive, (B) Adhesive, and (C) Mixed Failure

indocyanine green, and toluidine blue exhibited the lowest BS values.

Consistent with the present study, Ramos et al investigated the effect of photodynamic therapy on the BS of the fiber post to root dentin as well as the permeability of the dentin to various cementum protocols and showed that methylene blue at a concentration of 50 mg/L decreased the BS of the fiber post to root dentin.[6]

In addition, Strazzi-Sahyon et al evaluated the effect of methylene blue photodynamic therapy on Martens hardness, elastic modulus, and BS of the fiber post in one-third sections of root dentin, and they showed that methylene blue with a concentration of 100 mg/L and activated with the laser had a lower BS in the middle third, confirmed the results of the present study.[11]

Strazzi-Sahyon et al reported that curcumin, as a light-sensitive agent, had no impact on the BS of the fiber post to root dentin, which is consistent with the present study.[12]

Abrar et al studied the antimicrobial effects of silver diamine fluoride, NaOCl, chlorhexidine, and photodynamic therapy on the root canal treatment and the BS of FRCP to the root dentin, reporting results similar to the present study: methylene blue reduced the BS.[7]

Al Jeaid evaluated the PBS of FRCP to the root dentin using different cement systems prepared by photodynamic therapy (PDT) and concluded that methylene blue with a concentration of 100 mg/L reduced the BS of the fiber post to the root dentin, confirming the present study.[10]

Some studies have reported different results in this field. Strazzi-Sahyon et al evaluated the effect of PDT on the BS of the fiber post to the root, Martens hardness, and elastic indentation modulus of root dentin with light-sensitive material, concluding that curcumin improved the BS of the fiber post to root dentin. In addition, methylene blue with a concentration of 50 mg/L had no effect on the mechanical properties and BS, contrary to the present study's findings.[1] Furthermore, Strazzi-Sahyon et al investigated the effect of methylene blue photodynamic therapy on Martens hardness, elastic modulus, and the BS of the fiber post in different thirds of the root dentin, reporting that methylene blue with a concentration of 50 mg/L had no effect on the mechanical properties and the BS of the fiber post to dentin, which is different from the present study.[12]

Al Ahdal et al studied the effects of different light-sensitive materials on the BS of the fiber post to root dentin. The results of this study were consistent with the present study as 500 mg/L curcumin and 100 mg/L toluidine blue resulted in the highest BS, respectively, higher than the control group.[13]

As mentioned above, various studies are available in support of and opposition to the present study, which might be due to several reasons. For example, due to its positive charge, methylene blue mainly reacts with anionic elements in the root dentin. This reaction might pose dangers to the mineral contents in the root dentin and minimize the fracture resistance of the dentin and the durability of the fiber post adhesion to the root dentin. On the other hand, the light-sensitive materials used in photodynamic therapy are adhesive materials that can penetrate the walls of the canal and the dentinal tubules and form a smear layer. This leads to microleakage and decreases the BS of the final restorations to the root canal dentin. Therefore, it is essential to use appropriate irrigation protocols after photodynamic therapy.[3]

It is not yet clear whether the loss of minerals in the dentin due to the creation of free oxygen species affects the mechanical properties of the dentin and the BS of the fiber post to the root dentin. It is believed that due to the formation of superoxide anions and hydrogen peroxide, curcumin reacts with cationic elements in dentine, such as calcium.[7,12] The lack of an adverse effect of photodynamic therapy with curcumin on the BS of the fiber post to root dentin may be attributed to this fact.

## Conclusion

Since curcumin exhibited BS similar to the control group and did not affect the BS of the fiber post to the root dentin, it can be concluded that curcumin can be used as a light-sensitive material in photodynamic therapy to disinfect the root canal and the post space. On the other hand, toluidine blue, indocyanine green, and methylene blue showed negative effects on the BS and decreased the BS of the fiber post to the root dentin. Therefore, these three light-sensitive materials were not suitable for the photodynamic therapy procedure during root canal treatment for cleaning the root canal and disinfecting the prosthetic space.

### Authors' Contribution

**Conceptualization:** Sedighe Sadat Hashemikamangar, Nasim Chiniforush.
**Data curation:** Shadi Pourahmadi.
**Formal analysis:** Shadi Pourahmadi.
**Funding acquisition:** Sedighe Sadat Hashemikamangar, Nasim Chiniforush.
**Investigation:** Shadi Pourahmadi, Nasim Chiniforush.
**Methodology:** Sedighe Sadat Hashemikamangar, Nasim Chiniforush.
**Project administration:** Sedighe Sadat Hashemikamangar.
**Resources:** Shadi Pourahmadi, Nasim Chiniforush.
**Software:** Shadi Pourahmadi.
**Supervision:** Sedighe Sadat Hashemikamangar.
**Validation:** Sedighe Sadat Hashemikamangar, Nasim Chiniforush.
**Visualization:** Shadi Pourahmadi.
**Writing–original draft:** Shadi Pourahmadi.
**Writing–review & editing:** Sedighe Sadat Hashemikamangar, Nasim Chiniforush.

### Competing Interests

None.

### Ethical Approval

This study was approved by the ethics committee of Tehran University of Medical Sciences (IR.TUMS.DENTISTRY.REC.1399.239).

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### References

1. Strazzi-Sahyon HB, da Silva PP, de Oliveira MS, Cintra LT, Gomes-Filho JE, Dos Santos PH, et al. Effect of photodynamic therapy on the mechanical properties and bond strength of glass-fiber posts to endodontically treated intraradicular dentin. J Prosthet Dent. 2018;120(2):317.e1-.e7. doi: 10.1016/j.prosdent.2018.05.009.
2. Souza MA, Bonacina LV, Ricci R, Padilha Rauber MG, Zuchi N, Hoffmann IP, et al. Influence of final irrigation protocols and type of resin cement on bond strength of glass fiber posts in root dentin previously treated with photodynamic therapy. Photodiagnosis Photodyn Ther. 2019;26:224-8. doi: 10.1016/j.pdpdt.2019.04.007.
3. Alonaizan FA, AlFawaz YF, Alsahhaf A, Alofi RS, Al-Aali KA, Alrahlah A, et al. Effect of photodynamic therapy and ErCrYSGG laser irradiation on the push-out bond strength between fiber post and root dentin. Photodiagnosis Photodyn Ther. 2019;27:415-8. doi: 10.1016/j.pdpdt.2019.06.022.
4. Strazzi-Sahyon HB, da Silva PP, Nakao JM, da Silva PZ, Nunes

LP, Seron MA, et al. Influence of two photodynamic therapy sessions and different photosensitizers on the bond strength of glass-fiber posts in different regions of intraradicular dentin. Photodiagnosis Photodyn Ther. 2021;33:102193. doi: 10.1016/j.pdpdt.2021.102193.

5. Ramos A, Garcia Belizário L, Fagundes Jordão-Basso KC, Shinohara AL, Kuga MC. Effects of photodynamic therapy on the adhesive interface using two fiber posts cementation systems. Photodiagnosis Photodyn Ther. 2018;24:136-41. doi: 10.1016/j.pdpdt.2018.08.017.
6. Ramos A, Garcia Belizário L, Venção AC, Fagundes Jordão-Basso KC, de Souza Rastelli AN, de Andrade MF, et al. Effects of photodynamic therapy on the adhesive interface of fiber posts cementation protocols. J Endod. 2018;44(1):173-8. doi: 10.1016/j.joen.2017.08.035.
7. Abrar E, Naseem M, Baig QA, Vohra F, Maawadh AM, Almohareb T, et al. Antimicrobial efficacy of silver diamine fluoride in comparison to photodynamic therapy and chlorhexidine on canal disinfection and bond strength to radicular dentin. Photodiagnosis Photodyn Ther. 2020;32:102066. doi: 10.1016/j.pdpdt.2020.102066.
8. Bin-Shuwaish MS. Impact of photodynamic therapy on the push-out bond strength of fiber posts to root dentin: a systematic review and meta-analysis. Photodiagnosis Photodyn Ther. 2020;32:102010. doi: 10.1016/j.pdpdt.2020.102010.
9. Vohra F, Bukhari IA, Sheikh SA, Naseem M, Hussain M. Photodynamic activation of irrigation (using different laser prototypes) on push out bond strength of fiber posts. Photodiagnosis Photodyn Ther. 2020;30:101716. doi: 10.1016/j.pdpdt.2020.101716.
10. Al Jeaidi ZA. Influence of resin cements and root canal disinfection techniques on the adhesive bond strength of fibre reinforced composite post to radicular dentin. Photodiagnosis Photodyn Ther. 2021;33:102108. doi: 10.1016/j.pdpdt.2020.102108.
11. Strazzi-Sahyon HB, de Oliveira MS, da Silva PP, Banci HA, de Melo FS, Martinez CM, et al. Does photodynamic therapy with methylene blue affect the mechanical properties and bond strength of glass-fiber posts in different thirds of intraradicular dentin? Photodiagnosis Photodyn Ther. 2020;30:101673. doi: 10.1016/j.pdpdt.2020.101673.
12. Strazzi-Sahyon HB, da Silva PP, de Oliveira MS, Cintra LT, Dezan-Júnior E, Gomes-Filho JE, et al. Influence of curcumin photosensitizer in photodynamic therapy on the mechanical properties and push-out bond strength of glass-fiber posts to intraradicular dentin. Photodiagnosis Photodyn Ther. 2019;25:376-81. doi: 10.1016/j.pdpdt.2019.01.025.
13. Al Ahdal K, Al Deeb L, Al-Hamdan RS, Bin-Shuwaish MS, Al Deeb M, Maawadh AM, et al. Influence of different photosensitizers on push-out bond strength of fiber post to radicular dentin. Photodiagnosis Photodyn Ther. 2020;31:101805. doi: 10.1016/j.pdpdt.2020.101805.