ISSN Print: 2394-7489
ISSN Online: 2394-7497
Impact Factor (RJIF): 7.85
IJADS 2025; 11(3): 438-445

www.oraljournal.com
Received: 14-07-2025
Accepted: 16-08-2025

Dr. Bhavana S
Bapuji Dental College and Hospital, Davangere, Karnataka, India

Dr. Nandinini TN
Professor, Bapuji Dental College and Hospital, Davangere, Karnataka, India

Dr. Roopa B
Professor, Bapuji Dental College and Hospital, Davangere, Karnataka, India

Dr. Arun J
Professor, Bapuji Dental College and Hospital, Davangere, Karnataka, India

Dr. Rashmi NC
Professor, Bapuji Dental College and Hospital, Davangere, Karnataka, India

Dr. Sophia Thakur
Professor, Bapuji Dental College and Hospital, Davangere, Karnataka, India

Corresponding Author:
Dr. Bhavana S
Bapuji Dental College and Hospital, Davangere, Karnataka, India

Comparative evaluation of micro tensile bond strength of root dentin treated with different canal disinfectants and photodyanamic therapy when bonded to flowable short fiber reinforced resin composite: An *in vitro* study

Bhavana S, Nandinini TN, Roopa B, Arun J, Rashmi NC and Sophia Thakur

DOI: https://www.doi.org/10.22271/oral.2025.v11.i3f.2239

Abstract
Background: The restoration of non-vital teeth with extensive coronal destruction poses a significant clinical challenge due to compromised structural integrity and the risk of bacterial recontamination. Achieving an effective coronal seal while preserving remaining tooth structure is critical for long-term endodontic success.
Objective: This study aimed to evaluate and compare the micro-tensile bond strength (μTBS) of flowable short fiber-reinforced resin composite (FSFRRC) to root dentin following disinfection with four different agents: 2% Chlorhexidine (CHX), 17% Ethylenediaminetetraacetic acid (EDTA), 5.25% Sodium hypochlorite (NaOCl), and diode laser-activated photodynamic therapy (PDT) using Toluidine Blue.
Materials and Methods: Forty extracted single-rooted human mandibular premolars were prepared and obturated using standardized endodontic protocols. Post spaces were disinfected with the assigned agents, and 4 mm of FSFRRC was placed and light-cured. Micro-tensile bond strength testing was conducted on sectioned dumbbell-shaped specimens using a universal testing machine, and results were statistically analyzed using one-way analysis of variance (ANOVA).
Results: The NaOCl and CHX groups showed lower μTBS values, with no statistically significant difference between them. The EDTA group exhibited significantly higher bond strength compared to NaOCl and CHX and was statistically comparable to the PDT group. PDT demonstrated significantly higher μTBS than both CHX and NaOCl, indicating enhanced bonding performance.
Conclusion: Disinfection protocol plays a critical role in influencing the bonding efficacy of FSFRRC to root dentin. Both 17% EDTA and PDT enhanced micro-tensile bond strength, while NaOCl was associated with reduced bonding performance despite its antimicrobial advantages.

Keywords: FSFRRC, photodynamic therapy, micro-tensile bond strength, root dentin bonding, postendodontic restoration.

1. Introduction
Restoration of endodontically treated teeth (ETT), particularly those with substantial coronal loss, presents a complex clinical challenge. Structural compromise, altered mechanical properties, and increased fracture susceptibility make it difficult to achieve predictable and long-lasting outcomes [1]. A critical determinant of restorative success lies in both the quality of root canal disinfection and the adhesion between restorative materials and root dentin [2].
Commonly used irrigants such as sodium hypochlorite (NaOCl), chlorhexidine (CHX), and ethylenediaminetetraacetic acid (EDTA) are effective antimicrobials but may negatively affect dentin structure and its bonding potential [3]. These agents alter the smear layer and surface characteristics, potentially compromising the substrate for adhesion. Achieving a reliable intra-radicular seal remains essential aid to prevent reinfection and enhance the longevity of treatment [4].

Traditionally, metal and fiber post systems have been employed to restore severely compromised ETT. However, these systems often require additional dentin removal and may not adapt biomimetically to the natural tooth [5, 6]. In contrast, flowable short-fiber reinforced resin composite (FSFRRC) offers a promising alternative. Its fiber-reinforced matrix enhances fracture resistance, mimics dentin's mechanical properties, and can be directly adapted to the root canal, reducing the need for extensive post space preparation [7, 8].

Meanwhile, photodynamic therapy (PDT) has emerged as an adjunctive disinfection strategy. It uses a photosensitizer-activated by light of a specific wavelength in the presence of oxygen-to generate reactive oxygen species that effectively kill microorganisms [9]. While PDT's antimicrobial potential is well-supported, its influence on dentin surface integrity and bonding with advanced composites like FSFRRC is not fully understood.

Given that bond strength plays a vital role in restorative success, any chemical alteration of the bonding substrate may influence long-term performance. Although FSFRRC has demonstrated favorable outcomes in high-stress areas [8], limited data exist on its bond strength within root canals after different disinfection treatments.

This *in vitro* study aims to compare the micro-tensile bond strength (μTBS) of FSFRRC to root dentin following disinfection with 2% CHX, 17% EDTA, 5.25% NaOCl, and diode laser-activated PDT using Toluidine Blue. By evaluating these interactions, the study seeks to identify disinfection protocols that optimize adhesion in endodontic restorations.

Null hypothesis

There is no significant difference in μTBS of FSFRRC to root dentin following various disinfection protocols, including PDT.

Methodology

Sample selection

This *in vitro* study was conducted on forty freshly extracted human mandibular premolar teeth, extracted for orthodontic or periodontal purpose with approximately similar root lengths and single straight canals were selected (Fig 1). The presence of a single canal was confirmed using both mesiodistal and buccolingual radiographs (Fig 3,4). Teeth exhibiting cracks, root caries, fractures, resorptions, or calcifications were excluded. Soft tissue remnants and calculus were mechanically debrided using a periodontal scaler. All selected specimens were disinfected by immersion in 0.5% chloramine t solution for 48 hours and subsequently stored in distilled water at 4°c until further use.

Sample preparation

Each tooth was decoronated perpendicular to the long axis using a diamond disc under water coolant to standardize the root length to 13 mm (Fig 2). Canal patency was verified with a #10 K-file inserted until visible at the apex, and working length was established 1 mm short of this measurement (12 mm). Root canal preparation was performed using the ProTaper Gold rotary file system (Dentsply Sirona, Ballaigues, Switzerland) up to F3 (ISO size 30), following the manufacturer's instructions. During instrumentation, canals were irrigated with 1% sodium hypochlorite. Following chemo-mechanical preparation, canals were dried with paper points and obturated using the lateral compaction technique with gutta-percha cones and AH Plus resin sealer (Dentsply DeTrey GmbH, Konstanz, Germany).

Post space preparation

Twenty-four hours post-obturation, post space preparation was done by removing gutta-percha up to 4 mm from the CEJ using Peeso reamers up to size #3. Canals were irrigated with distilled water between each reamer size to remove debris. Paper points were used to eliminate residual moisture. Radiographs were taken to confirm complete removal of gutta-percha from the canal walls (Fig 5). Following the post space preparation, all 40 samples were randomly divided into four experimental groups based on the disinfection protocol administered prior to restorative placement and they were grouped as follows (Table 1).

Table 1: Sample groups based on the disinfection protocol.

Group I	Canals of each specimen were disinfected by 5ml 2% Chlorhexidine (CHX).
Group II	Canals of each specimen were disinfected by 5ml of 17% EDTA solution
Group III	Canals of each specimen were disinfected by 5ml of 5.25% NaOCl solution
Group IV	Canals of each specimen were disinfected by 0.5 ml of concentration 0.1 mg/ml Toluidine blue photosensitizer and canals were subjected to a diode laser having a wavelength of 660 nm and power output of 150mW for 90sec in a pulse mode.

Allocation to experimental groups

The samples were randomly allocated into four groups (n=10) based on the disinfection protocol administered following post space preparation: Group I was irrigated with 5 mL of 2% chlorhexidine solution using a 31-gauge needle for 30 seconds, rinsed with distilled water, and dried with paper points; Group II with 5 mL of 17% ethylenediaminetetraacetic acid (EDTA) using a 31-gauge side-vented needle for 30 seconds, followed by distilled water rinse and paper point drying; Group III was irrigated with 5 mL of 5.25% sodium hypochlorite (NaOCl) using a 31-gauge side-vented needle for 30 seconds, then rinsed with water and dried with paper points; and Group IV received 0.5 mL of 0.1 mg/mL Toluidine Blue O photosensitizer, allowed to remain in the canal for 5 minutes (pre-irradiation time), followed by irradiation with a 660 nm diode laser at 150 mW power output for 90 seconds in pulse mode using a 200 μm intracanal optical fiber, as per manufacturer's recommendations.

Restorative Procedures with FSFRRC

Following the respective disinfection protocols, all specimens were thoroughly rinsed with distilled water and gently dried using sterile paper points. The radicular dentin surfaces were etched with 37% phosphoric acid gel for 10-15 seconds, rinsed with distilled water for 5 seconds, and subsequently dried with paper points. A dual-cure adhesive system was then applied to the canal walls with active agitation for 10 seconds and light-cured for 10 seconds in accordance with the manufacturer's guidelines.

Subsequently, flowable short fiber-reinforced composite (FSFRRC) was injected into the prepared post space up to a depth of 4 mm using manufacturer-supplied delivery tips. The material was then polymerized with a high-intensity LED curing unit (1200 mW/cm²) for 10 seconds. All specimens were stored at 37°C in 100% relative humidity within a

thermostatically controlled incubator until further evaluation by micro-tensile bond strength testing.

Micro tensile bond strength test

Each root specimen was sectioned under distilled water cooling using an Isomet saw to obtain four slices of 1.0 ± 0.1 mm thickness (Fig 6). Under 3.0× magnification, slices were held manually and trimmed from both mesial and distal surfaces using a tapered diamond rotary instrument in a high-speed handpiece under water coolant, until the post was exposed, forming dumbbell-shaped specimens (Fig 7). All sections were inspected under a stereomicroscope at 20× magnification to confirm post exposure. Slice thickness was verified using a digital caliper. The specimens were then affixed to a universal testing machine with cyanoacrylate adhesive and subjected to tensile loading at a crosshead speed of 1 mm/min (Fig 8). The bonded interface area was calculated using a formula described earlier by Mallmann *et al*[10].

Failure mode analysis

Failure loads were recorded in N, and micro tensile bond strength were measured in MPa as

follows: μTBS = F / 1/2 C x T

where;

F is the force at failure, C is the circumference of the FSFRRC

(C= 2 π R [π= 3.14, R = radius of the FSFRRC]), and T is the thickness of the rod used.

Fig 1: Freshly extracted human mandibular premolar teeth extracted for orthodontic/periodontal reasons

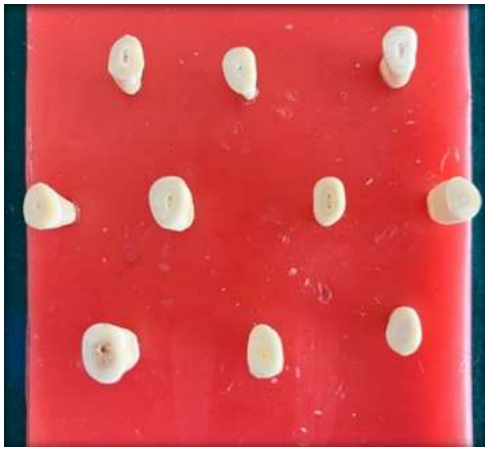


Fig 2: Tooth was decoronated using a diamond disc operated perpendicular to its long axis to obtain a standardized root length of 13mm

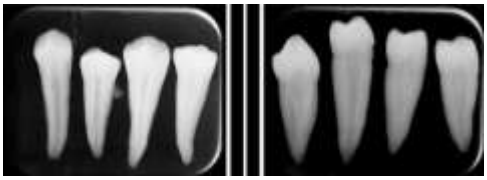


Fig 3,4: Single root canal verified by using mesiodistal and buccolingual radiographs

Fig 5: The presence of any residual GP on walls of the post space evaluated by radiographic imaging

Fig 6: sectioning the root of specimen of 1.0 ± 0.1 mm in thickness

Fig 7: sectioning the root of specimen of 1.0 ± 0.1 mm in thickness, dumbbell-shaped specimens

Fig 8: Universal testing machine, specimen subjected to microtensile bond test

Statistical Analysis and Results

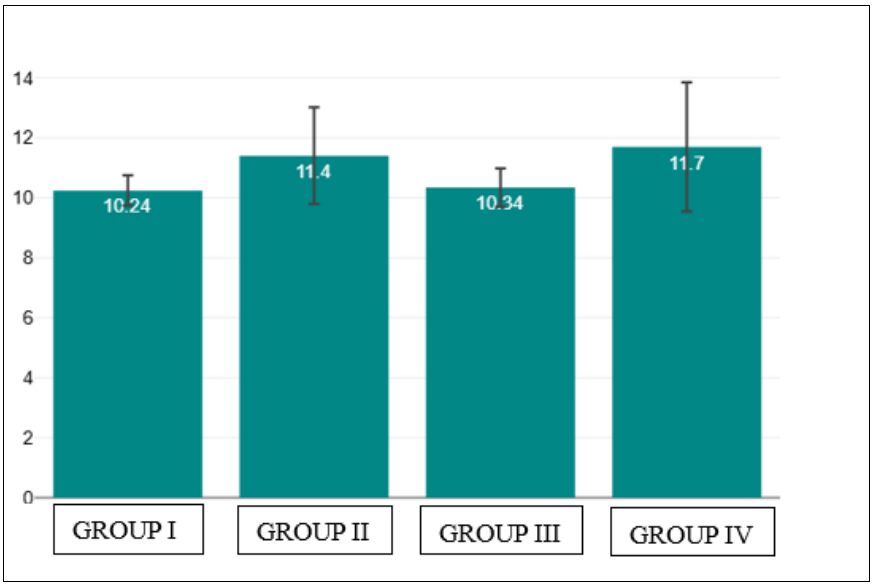
The data was tabulated and analysed using SPSS software (Version 28, IBM Corp., USA). The descriptive statistics, including mean, standard deviation (SD), minimum, and maximum values, were calculated for each group. Micro-tensile bond strength differences among the four groups were analyzed using one-way ANOVA, followed by Dunn-Bonferroni post hoc tests was done for pairwise comparisons. A p-value < 0.05 was considered statistically significant.

Each group (N = 40) showed the following mean micro-tensile bond strengths (±SD): Group I (CHX) - 10.24 ± 0.51, Group II (EDTA) - 11.40 ± 1.61, Group III (NaOCl) - 10.34 ± 0.64, and Group IV (PDT) - 11.70 ± 2.15 (Table 2), (Graph 1).

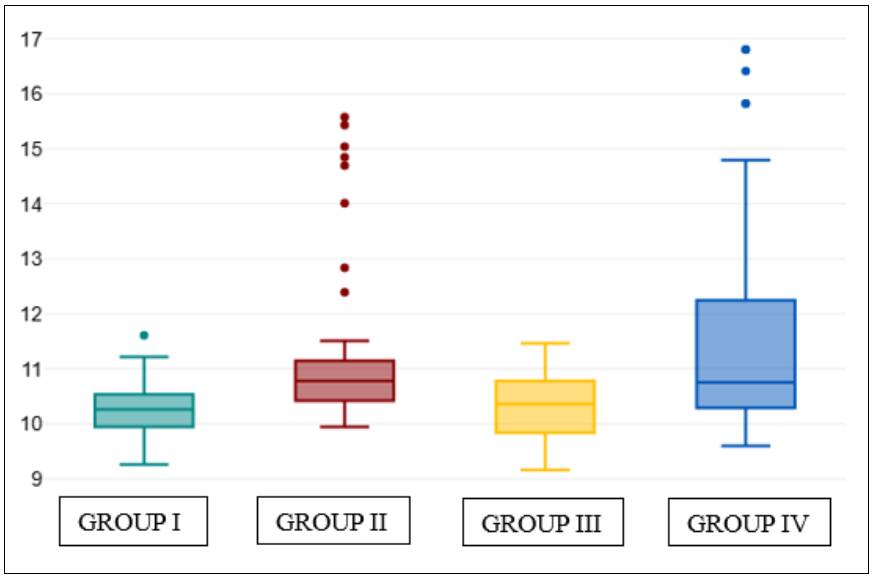
Table 2: Mean micro-tensile bond strength (MPa) values of each group.

	Mean	Std. Deviation	Minimum	Maximum
GROUP I (CHX)	10.24	0.51	9.26	11.61
GROUP II (EDTA)	11.4	1.61	9.95	15.58
GROUP III (NAOCL)	10.34	0.64	9.16	11.46
GROUP IV (PDT)	11.7	2.15	9.6	16.81

One-way ANOVA revealed a significant difference in micro-tensile bond strength among the four groups (p=0.001). Post hoc analysis showed that Group I (CHX) had significantly lower bond strength than Group II (EDTA) and Group IV (PDT), while no significant difference was observed between Group I and Group III (NaOCl). Group II demonstrated significantly higher bond strength than Group III but was comparable to Group IV. Additionally, Group IV exhibited significantly higher bond strength than Group III (Graph 2), (Table 3).



Graph 1: Bar graph showing mean micro-tensile bond strength (MPa) among four groups



Graph 2: Box plot comparing micro-tensile bond strength among four groups.

Table 3: Multiple Comparison of micro-tensile bond strength (MPa) between four groups.

	Mean diff.	Std. Error	t	p	95% CI lower limit	95% CI upper limit
GROUP I - GROUP II	-1.16	0.31	-3.69	.002	-2.02	-0.3
GROUP I - GROUP III	-0.09	0.31	-0.3	1	-0.95	0.77
GROUP I - GROUP IV	-1.45	0.31	-4.63	<.001	-2.31	-0.59
GROUP II - GROUP III	1.07	0.31	3.39	.005	0.21	1.92
GROUP II - GROUP IV	-0.3	0.31	-0.94	1	-1.15	0.56
GROUP III - GROUP IV	-1.36	0.31	-4.33	<.001	-2.22	-0.5

Discussion

This study was undertaken in response to the growing need for post-endodontic restorative materials that not only seal the root canal system but also reinforce structurally compromised teeth. Endodontically treated teeth are susceptible to fracture due to structural loss, altered dentin properties, and treatment-induced stresses. Flowable short fiber-reinforced composites (FSFRRCs) have shown promising results due to their dentin-mimicking and crack-resisting properties[8] however, their bonding efficacy under varying disinfection protocols remains under explored. Conventional irrigants like sodium hypochlorite and EDTA can modify dentin surfaces, potentially impairing adhesion, while emerging modalities such as photodynamic therapy (PDT) lack definitive evidence regarding their effect on dentin bonding. Hence, this study aimed to evaluate and compare the influence of different disinfection protocols on the micro-tensile bond strength of FSFRRCs to root canal-treated dentin, thereby contributing valuable insights toward optimizing adhesive strategies for durable endodontic restorations.

The present study evaluated the effect of different disinfectants such as 2% CHX, 5.25% NaOCl, 17% EDTA and PDT on micro-tensile bond strength of FSFRRCs to root dentin, and the findings indicate that the 2% CHX and 5.25% NaOCl groups resulted in relatively lower dentin micro-tensile bond strength, whereas the 17% EDTA and Test groups preserved or improved dentin micro-tensile bond strength to a greater extent.

Based on these findings, the null hypothesis was rejected, as significant differences in micro tensile bond strength were observed among the groups. These results highlight the influence of disinfection protocols on dentin integrity, which may directly affect the bonding performance of FSFRRCs.

In the present study, single-rooted mandibular premolars were selected for micro-tensile bond strength evaluation due to their consistent canal morphology, structural uniformity, and routine extraction for orthodontic or periodontal reasons, making them suitable for *in vitro* research. This choice aligns with ISO/TS 11405:2015 guidelines, which recommends premolars from individuals aged 16-40 years for adhesion studies as they exhibit relatively stable dentin characteristics and avoid extreme age-related changes. However exact donor ages could not be confirmed in the present study which is a potential limitation given age-related changes in dentin. This was mitigated through strict inclusion criteria, radiographic evaluation, and standardized storage protocols to minimize variability and ensure reliable results[11].

Following extraction, all teeth were disinfected in 0.5% chloramine T and stored in distilled water at 4°C, in accordance with ISO/TS 11405:2015. This protocol helps preserve dentin integrity by maintaining collagen stability and moisture. All samples were tested within six months to ensure reliable bond strength evaluation [11, 12].

During instrumentation, a standardized 1% NaOCl solution was used as the primary irrigant to ensure uniform baseline conditions across all groups. This avoided premature dentin alterations that could bias the results. Using higher concentrations, such as 5.25% NaOCl, in early phases might have compromised dentin properties and confounded the effects of final disinfectants. Marending *et al*. demonstrated that NaOCl's impact on dentin is concentration-dependent, with 1% showing minimal effects on chemical and mechanical integrity compared to higher concentrations [13].

This study utilized flowable short fiber-reinforced resin composite (FSFRRC) as an intraradicular restorative alternative to traditional posts, which often require additional dentin removal. FSFRRC's micrometer-scale, randomly oriented glass fibers within a flowable resin matrix enhance fracture resistance by interrupting crack propagation and mimicking dentin's

stress distribution. This approach offers internal reinforcement with minimal tooth structure loss, promoting a more biomimetic and conservative restoration [4, 8].

In the present study, micro-tensile bond strength (μTBS) testing was employed to evaluate the bonding performance of flowable short fiber-reinforced resin composite (FSFRRC) to root dentin following various disinfection protocols. While clinical trials provide long-term data, *in vitro* μTBS testing offers immediate, controlled insight into adhesive performance during early material development.

Compared to traditional shear and tensile tests-which are often affected by uneven stress distribution due to larger bonded areas-the μTBS method, introduced by Sano *et al*. in 1994, provides more accurate and sensitive measurements. By sectioning specimens into smaller sticks, stress is more uniformly distributed at the bonded interface, reducing the influence of substrate defects [14, 15].

Although μTBS testing can be prone to premature failures due to the fragility of small specimens, it remains a valuable tool for detecting subtle differences in bond strength. In this study, dumbbell-shaped specimens were used to localize stress at the adhesive interface, minimize cohesive failures, and reduce structural flaws such as voids or bubbles. Standardized specimen preparation, verified using digital calipers and magnification, ensured reproducibility and dimensional accuracy [16].

Careful control of variables-including tooth selection, age range, storage conditions, standardized irrigation, and bond strength testing-enhanced the internal validity and reliability of this study. This allowed a focused investigation into how different disinfection protocols influence the bonding performance of flowable short fiber-reinforced composites in endodontically treated teeth.

Each disinfectant, with its distinct chemical properties and mechanism of action, alters dentin composition and surface energy, thereby impacting its interaction with adhesive systems and composite resins.

Sodium hypochlorite, a halogenated compound, remains the most widely used endodontic irrigant due to its strong antimicrobial action and tissue-dissolving properties. However, various mechanisms have been proposed to explain its detrimental impact on dentin bond strength [17].

In the present study, canals irrigated with 5.25% NaOCl showed lower mean μTBS values (10.34 MPa). This was statistically significant when compared to the PDT (11.70 MPa) and EDTA (11.40 MPa) groups, while no significant difference was observed in comparison to the CHX group (10.24 MPa).

The reduced bond strength observed with 5.25% NaOCl irrigation may be attributed to its oxidative effects on the dentin matrix. Studies by Gomes *et al*. [17] and Zhang *et al*.[18] suggest that NaOCl oxidizes demineralized collagen, generating protein-derived radicals that interfere with resin polymerization by competing with vinyl free radicals. As a result, bonding to oxidized dentin is significantly weakened.

Weston *et al* [19]. reported that NaOCl significantly reduces resin-dentin bond strength ($p < 0.05$), primarily due to the removal of the organic matrix, which compromises hybrid layer formation. Similarly, Nikaido *et al*. [20] highlighted that residual irrigants or their byproducts may contaminate dentin and hinder resin infiltration and polymerization-even when penetration appears complete.

Additionally, NaOCl has been shown to reduce dentin's mechanical properties, including elastic modulus, flexural strength, and microhardness, further impairing micromechanical bonding [21].

Clinically, this compromised adhesion can be mitigated by applying antioxidants such as ascorbic acid, sodium ascorbate, rosmarinic acid, green tea extract, or proanthocyanidins prior to bonding. These agents neutralize residual NaOCl via redox reactions, enhance polymerization, and stabilize the resin-dentin interface.

Morris *et al*. [22] found sodium ascorbate to be more effective than ascorbic acid in restoring bond strength, as it promotes polymerization and reverses the inhibitory effects of NaOCl. Consequently, antioxidant rinses have been widely recommended to counteract NaOCl's oxidizing effects and improve resin adhesion

Chlorhexidine (2%) is widely used in endodontics for its antimicrobial efficacy, substantivity, and ability to inhibit matrix metalloproteinases (MMPs), potentially preserving the collagen network and improving long-term bond durability (49). However, in the present study, the CHX group recorded the lowest mean μTBS value (10.24 MPa), significantly lower than both the EDTA (11.40 MPa) and PDT (11.70 MPa) groups, while showing no significant difference compared to the NaOCl group (10.34 MPa).

Although some studies, such as those by Hebling *et al*. [23], support CHX's role in stabilizing the hybrid layer through MMP inhibition, findings remain inconsistent. Kul *et al*. and Angeloni *et al*. [24, 25] found no effect on bond strength with CHX pretreatment, whereas Di Hipólito *et al*. reported reduced bond strength, and Durski *et al*. noted improved results both immediately and long-term [26].

One proposed explanation is that CHX does not remove the smear layer, possibly hindering adhesive infiltration and hybrid layer formation. Campos *et al*. also reported that CHX concentrations above 0.12% may adversely affect bonding when used prior to self-etch adhesives. Martinho *et al*. and Hiraishi *et al*. further confirmed CHX's potential to reduce bond strength and promote nanoleakage.

These conflicting findings may stem from variations in adhesive systems, CHX concentrations, and dentin conditions. Thus, while CHX remains valued for its antimicrobial action and potential to preserve the hybrid layer, its direct influence on bond strength remains controversial and technique-sensitive.

EDTA (17%) is a chelating agent that effectively removes the inorganic component of the smear layer, exposing collagen fibrils and opening dentinal tubules to enhance resin tag penetration and micromechanical bonding. In this study, the EDTA group demonstrated higher μTBS values (11.40 MPa) than both the CHX (10.24 MPa) and NaOCl (10.34 MPa) groups, with statistically significant differences. No significant difference was observed between the EDTA and PDT (11.70 MPa) groups, indicating comparable bonding performance.

The superior performance of EDTA is likely due to its ability to promote hybrid layer formation and increase surface roughness. However, prolonged or excessive use may cause dentin erosion and loss of calcium, potentially compromising bond strength.

Gu *et al*. and Gracia *et al* [27] confirmed that EDTA improves adhesive penetration and enhances bond strength of self-adhesive resin cements. Kul *et al* [25]. also reported that the combination of NaOCl and EDTA significantly increased push-out bond strength by effectively removing the smear layer. Similarly, Torabinejad *et al*. found that alternating EDTA with NaOCl improves smear layer removal, particularly in the coronal and middle thirds of the canal. However, they also cautioned that such irrigation regimens, depending on concentration and exposure time, may weaken root dentin [28].

These findings support the use of EDTA for optimizing adhesion but underscore the importance of controlled application to avoid adverse effects

In this study, photodynamic therapy (PDT) was utilized as a final disinfection protocol in post space preparation. A 660 nm diode laser was used to activate Toluidine Blue O (TBO), a photosensitizer with optimal absorption in the red region of the visible light spectrum. Upon activation, TBO generates reactive oxygen species (ROS), such as singlet oxygen and free radicals, which cause oxidative damage to microbial cells, offering broad-spectrum antimicrobial action [9].

The PDT group exhibited the highest mean μTBS (11.70 MPa), significantly outperforming the NaOCl (10.34 MPa) and CHX (10.24 MPa) groups. Although bond strength was slightly higher than the EDTA group (11.40 MPa), the difference was not statistically significant, suggesting that both PDT and EDTA provide similarly favorable conditions for adhesion.

The enhanced bond strength in the PDT group aligns with previous studies. Gök *et al*. reported that ROS generated during PDT promote collagen cross-linking, stabilizing the dentin matrix and improving its resistance to enzymatic degradation. Hashemikamangar *et al*. observed laser-induced morphological changes such as open dentinal tubules and a modified smear layer, which contribute to improved bond stability. Additionally, diode laser irradiation has been shown to increase surface energy and enhance substrate receptivity for adhesive penetration and resin tag formation [29].

Overall, the findings support PDT as an effective, biocompatible disinfection method that not only offers antimicrobial benefits but also positively influences the bonding performance of adhesive materials in endodontically treated teeth.

Although the *in vitro* design of this study enabled strict control over variables and standardized procedures, it does not fully replicate clinical conditions. Factors such as moisture control, variability in dentin anatomy, and operator technique can significantly influence in vivo bonding outcomes. Additionally, micro-tensile bond testing is

associated with a higher risk of premature failures due to the fragility of small specimens. The long-term performance of FSFRRC under functional loading was also not assessed in this study.

Future research should explore the synergistic effects of sequential irrigants (e.g., NaOCl followed by EDTA), the impact of antioxidant rinses, and the performance of newer adhesive systems. Longitudinal in vivo studies are particularly important to validate the clinical efficacy and durability of FSFRRC restorations following different disinfection protocols.

Conclusions

The findings of this study carry important clinical implications. FSFRRC offers a promising alternative to traditional post-and-core systems, particularly for restoring structurally compromised teeth. However, its success depends on achieving a reliable bond to radicular dentin.

This study highlights the critical role of canal disinfectant selection before FSFRRC placement. PDT stands out for its effective disinfection and minimal impact on dentin. EDTA is beneficial for smear layer removal but should be used with caution to avoid erosion. While NaOCl is essential for initial cleaning, its adverse effects on bonding may necessitate the use of neutralizing agents. CHX, though less effective in enhancing bond strength, may help preserve the hybrid layer over time.

References

1. Trope M, Langer I, Maltz D, Tronstad L. Resistance to fracture of restored endodontically treated premolars. Endod Dent Traumatol. 1986 Feb;2(1):35-8.
2. Gutmann JL. The dentin-root complex: anatomic and biologic considerations in restoring endodontically treated teeth. J Prosthet Dent. 1992 Apr;67(4):458-67.
3. Maxwell EH, Braly BV, Eakle WS. Incompletely fractured teeth--a survey of endodontists. Oral Surg Oral Med Oral Pathol. 1986 Jan;61(1):113-7.
4. Selvaraj H, Krithikadatta J, Shrivastava D, Onazi MAA, Algarni HA, Munaga S, *et al*. Systematic review fracture resistance of endodontically treated posterior teeth restored with fiber reinforced composites- a systematic review. BMC Oral Health. 2023 Aug13;23(1):566.
5. Perel ML, Muroff FI. Clinical criteria for posts and cores. J Prosthet Dent. 1972 Oct;28(4):405-11.
6. Davies H, Ahmed SH, Edwards D. Metal vs fibre posts - which is clinically superior for the restoration of endodontically treated teeth? Evid Based Dent. 2021 Dec;22(4):162-3.
7. Ever X Flow a short-fibre reinforced flowable composite designed to replace dentine and reinforce restorations. Available from: https://www.gc.dental/india/products/operatory/composite restoratives/everx flow.
8. Sharma A, Amirtharaj LV, Sanjeev K, Mahalaxmi S. Fracture Resistance of Endodontically Treated Premolars Restored with Flowable Short Fibre-Reinforced Resin Composite-An *In vitro* Study. Eur Endod J. 2022;7(2):161.
9. Plotino G, Grande NM, Mercade M. Photodynamic therapy in endodontics. Int Endod J. 2019 Jun;52(6):760-74.
10. Mallmann A, Jacques LB, Valandro LF, Muench A. Microtensile bond strength of photoactivated and autopolymerized adhesive systems to root dentin using translucent and opaque fiber-reinforced composite posts. The Journal of Prosthetic Dentistry. 2007 Mar 1;97(3):165-72.
11. ISO/TS 11405:2015(en), Dentistry - Testing of adhesion to tooth structure [Internet]. [cited 2025 Jun 14]. Available from: https://www.iso.org/obp/ui/#iso:std:iso:ts:11405:ed-3:v1:en
12. Secilmis A, Dilber E, Gokmen F, Ozturk N, Telatar T. Effects of storage solutions on mineral contents of dentin. J Dent Sci. 2011 Dec 1;6(4):189-194.
13. Marending M, Luder HU, Brunner TJ, Knecht S, Stark WJ, Zehnder M. Effect of sodium hypochlorite on human root dentine--mechanical, chemical and structural evaluation. Int Endod J. 2007 Oct;40(10):786-793.
14. Pashley DH, Carvalho RM, Sano H, Nakajima M, Yoshiyama M, Shono Y, *et al*. The microtensile bond test: a review. J Adhes Dent. 1999;1(4):299-309.
15. Sano H, Shono T, Sonoda H, Takatsu T, Ciucchi B, Carvalho R, *et al*. Relationship between surface area for adhesion and tensile bond strength--evaluation of a micro-tensile bond test. Dent Mater Off Publ Acad Dent Mater. 1994 Jul;10(4):236-240.
16. Mallmann A, Jacques LB, Valandro LF, Mathias P, Muench A. Microtensile bond strength of light- and self-cured adhesive systems to intraradicular dentin using a translucent fiber post. Oper Dent. 2005;30(4):500-506.
17. Gomes BPFA, Aveiro E, Kishen A. Irrigants and irrigation activation systems in Endodontics. Braz Dent J. 2023;34(4):1-33.
18. Zhang K, Kim YK, Cadenaro M, Bryan TE, Sidow SJ, Loushine RJ, *et al*. Effects of different exposure times and concentrations of sodium hypochlorite/ethylenediaminetetraacetic acid on the structural integrity of mineralized dentin. J Endod. 2010 Jan;36(1):105-109.
19. Weston CH, Ito S, Wadgaonkar B, Pashley DH. Effects of time and concentration of sodium ascorbate on reversal of NaOCl-induced reduction in bond strengths. J Endod. 2007 Jul;33(7):879-881.
20. Nikaido T, Takano Y, Sasafuchi Y, Burrow MF, Tagami J. Bond strengths to endodontically-treated teeth. American Journal of Dentistry. 1999 Aug 1;12(4):177-180.
21. Sim TP, Knowles JC, Ng YL, Shelton J, Gulabivala K. Effect of sodium hypochlorite on mechanical properties of dentine and tooth surface strain. Int Endod J. 2001 Mar;34(2):120-132.
22. Morris MD, Lee KW, Agee KA, Bouillaguet S, Pashley DH. Effects of sodium hypochlorite and RC-prep on bond strengths of resin cement to endodontic surfaces. J Endod. 2001 Dec;27(12):753-737
23. Hebling J, Pashley DH, Tjäderhane L, Tay FR. Chlorhexidine arrests subclinical degradation of dentin hybrid layers in vivo. J Dent Res. 2005 Aug;84(8):741-6.
24. Angeloni V, Mazzoni A, Marchesi G, Cadenaro M, Comba A, Maravi T, *et al*. Role of Chlorhexidine on Long-term Bond Strength of Self-adhesive Composite Cements to Intraradicular Dentin. J Adhes Dent. 2017;19(4):341-348.
25. Kul E, Yeter KY, Aladag LI, Ayrancı LB. Effect of different post space irrigation procedures on the bond strength of a fiber post attached with a self-adhesive resin cement. J Prosthet Dent. 2016 May;115(5):601-605.
26. Di Hipólito V, Rodrigues FP, Piveta FB, Azevedo L da

C, Bruschi Alonso RC, Silikas N, *et al*. Effectiveness of self-adhesive luting cements in bonding to chlorhexidine-treated dentin. Dent Mater Off Publ Acad Dent Mater. 2012 May;28(5):495-501.
27. Garcia C, Ruales-Carrera E, Prates LHM, Volpato CAM. Effect of different irrigations on the bond strength of self-adhesive resin cement to root dentin. J Clin Exp Dent. 2018 Feb 1;10(2):e139-145.
28. Torabinejad M, Khademi AA, Babagoli J, Cho Y, Johnson WB, Bozhilov K, *et al*. A new solution for the removal of the smear layer. J Endod. 2003 Mar;29(3):170-175.
29. Hashemikamangar SS, Biglari P, Shahidi Z, Chiniforush N. Effect of photodynamic therapy with two photosensitizers on the microtensile bond strength of a universal adhesive to affected dentin. Photodiagnosis Photodyn Ther. 2024 Aug 1;48:104249

How to Cite This Article
Bhavana S. Comparative evaluation of micro tensile bond strength of root dentin treated with different canal disinfectants and photodyanamic therapy when bonded to flowable short fiber reinforced resin composite: An *in vitro* study. International Journal of Applied Dental Sciences. 2025; 11(3): 438-445.