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# An in vitro investigation to assess the impact of an erbium-doped Yettriumaluminium garnet laser on the push out bond strength of fiber post-cemented with resin cement

***Dayanand Huddar[1*], Raghavendra Adaki[2], Shruti Umesh Pardeshi[3], Hombesh MN[4], Sunil Vadavadagi[5], Sumit J Deshpande[6]***

*[1*]Professor; Department of Prosthodontics, Bharati Vidyapeeth Dental College and Hospital, Sangli*

*[2]Head of Department, Department of Prosthodontics, Bharati Vidyapeeth Dental College and Hospital, Sangli*

*[3]Post Graduate; Department of Prosthodontics, Bharati Vidyapeeth Dental College and Hospital, Sangli*

*[4]Professor; Department of Prosthodontics, College of Dental Sciences, Davangere*

*[5]Professor; Department of Prosthodontics, SJM Dental college and Hospital, Chitradurga*

*[6]Professor and Head of Department, Department of Prosthodontics, Al Badar Rural Dental College and Hospital, Kalaburagi*

**Abstract**

Investigating the impact of the Er-YAG laser on the bond strength of fiber posts bonded with resin cement is the aim of this work.Three different post space irrigants were used (Normal Saline, warm Sodium Hypochlorite + EDTA, Sodium hypochlorite + Er-YAG laser) to irrigate the post space preparation followed by fiber post cementation with acrylic resin. Push out bond strength was checked at coronal and apical region. This in-vitro study shows that Er-YAG laser along with NaOCl has the best smear layer removing capacity. Samples which were exposed to Er-YAG laser and irrigated with 5.25% NaOCl shows highest bond strength whereas Samples irrigated with 0.9% Normal saline shows lowest bond strength and samples treated with 5.25% warm NaOCl and 17% EDTA shows bond strength slightly more than the samples irrigated with 0.9% normal saline.

**Keywords:**Normal Saline, Sodium Hypochlorite, EDTA, Er-YAG laser, Push out Bond Strength.

**Full length article** **Corresponding Author*, e-mail:drdayanandhuddar@rediffmail.com

## 1. Introduction

The quantity of tooth structure that remains after endodontic treatment directly affects the teeth's ability to be restored [1]. When these teeth have traditional restorations, the significant root fracture rate is made possible by the extremely thin walls caused by the loss of cervical root dentin and insufficient coronal remnant [2]. For a pulpless tooth to continue functioning as a vital component of the oral masticatory apparatus indefinitely, a satisfactory post endodontic restoration must be combined with a successful endodontic procedure. Before beginning final restorative procedures, an endodontically treated tooth must be assessed to see whether it can be restored, is not reversible, or can be restored with successful retreatment.For a tooth that has undergone endodontic therapy, many treatment alternatives include:

1. Endodontic retreatment: surgical or non-surgical methods.
2. Periodontal retreatment (need to stabilizethe tooth).
3. Observing (period to evaluate healing progress).
4. Extraction (unrestorable).

In the event that none of the previously listed issues arise, an intraarticular post restorative procedure may be started [3].In many cases, endodontically treated teeth require the placement of intra-radicular posts for restoration. Deboning causes fiber posts to fail all the time. Drilling during post-preparation produces a layer of smear that contains root canal sealant and leftover gutta-percha. The dentine-resin interface's binding strength is directly impacted by this smear layer that covers the dentin surface of the root canal. because the smear layer prevents resin cement from etching the root canal dentin. By eliminating the smear layer, radiation utilized for post space may have an impact on the cement's strong bond with root canal dentin. Additionally, following the application of resin cement during the root canal treatment, different root areas may display varied bond strength.The goal of this study is to compare how different root regions' push-out bond strengths to fiberpost-cemented acrylic cement are affected by the Er-YAG laser.

## 2. Material and method

Thirty-nine extracted non-carious permanent premolars were used for the study. The teeth were collected and stored in artificial saliva during the experimental period and randomly divided into 3 groups of 13 each based on different irrigating protocols:

- Group A- 0.9% Normal saline.
- Group B- 5.25% warm NaOCl + 17% EDTA.
- Group C- Er-YAG laser + 5.25% NaOCl.

Figure 1 indicates armamentarium used for the study. All the teeth were decoronated below the CEJ using a diamond disk and copious water spray. Root canal preparation was done using rotary files till F2. The root canals were irrigated between each instrumentation using normal saline. Sodium hypochlorite is not used during biomechanical preparation. Then, obturation of the root canals was done using 6% GP with “Lateral condensation technique”. Following root canal preparation and obturation, the specimens were stored in artificial saliva (ICPA, Wet mouth) and was closed for 7 days at 37°C in an incubator. After 7 days of storage, the root canal filling was removed and post spaces were created using the assorted drill (Figure 2). The post space preparation was done in such a way that at least 5mm of the obturated gutta percha remained in the canal. In Group A, the dentinal walls of all the post spaces are irrigated with 0.9% Normal saline 1ml/min.In Group B, all the 13 samples are irrigated with 17% EDTA and 5.25% warm NaOCl1ml/min. In Group C, the dentinal walls of the post gaps were exposed to an Er-YAG laser (Doctor Smile, Lambda Scientific) for 15 seconds after being dried with paper points. The laser's specifications included a 2.940 nm wavelength emission, 1.5W output, and 400μm fiber optic tips (Figure 3). Following a 15-second thermal rest, the process was carried out four times, resulting in a 60-second exposure period overall. All of the samples received a final irrigation with distilled water, and absorbent paper points were used to dry the canals. Following a 15-second etch with 37% phosphoric acid, distilled water was used to rinse the canal walls. The walls of the canals were coated with self-adhesive resin cement (Luxa core Z, Dual, Germany) in accordance with the manufacturer's specifications. After applying a small amount of finger pressure to seat the fiber post, the light-emitting diode was used to polymerize the resin cement. After this process, each specimen was preserved for 24 hours at 37°C in artificial saliva. Following incubation, a diamond disc was used to section the specimens horizontally. A computerized caliper was used to measure the thickness of each slice (Figure 4). Three sections with approximate thicknesses of 2mm each were prepared: coronal, middle, and apical. Subsequently, a universal testing machine (Figure 5) was utilizedto test the coronal and apical parts. A diamond metallic plugger was used to push out the material from the apical to the coronal direction until the post was dislodged (Figure 6). The universal testing machine's software computed push-out bond strength using the formula L/A mPa.

## 3. Results

Samples which were exposed to Er-YAG laser and irrigated with 5.25% NaOCl shows highest bond strength whereas Samples irrigated with 0.9% Normal saline shows lowest bond strength and samples treated with 5.25% warm NaOCl and 17% EDTA shows bond strength slightly more than the samples irrigated with 0.9% normal saline.

### *3.1. Coronal Section*

Mean Bond strength of coronal section of Group A samples irrigated with 0.9% Normal saline shows lowest bond strength of 8.2723 MPa (SD± 4.12075) whereas Group C samples exposed to Er-YAG laser and irrigated with 5.25% NaOCl shows highest bond strength of 23.5115 MPa (SD±7.52300). Group B Samples treated with 5.25% NaOCl shows bond strength 9.1023 MPa (SD±6.39178) slightly higher than bond strength of Group A samples (0.9% Normal saline)

### *3.2. Apical Section*

Mean Bond strength of Apical section of Group A samples irrigated with 0.9% Normal saline shows lowest bond strength of 4.4038 MPa (SD±3.51989) whereas Group C samples exposed to Er-YAG laser and irrigated with 5.25% NaOCl shows highest bond strength of 8.2631 MPa (SD±9.83326). Group B Samples treated with 5.25% NaOCl shows bond strength 7.8138 MPa (SD±6.87383) slightly higher than bond strength of Group A samples (0.9% Normal saline. For each of the three test groups, descriptive statistics such as the mean and SDs values were computed. ANNOVA and Tukey HSD tests were used to compare means.Coronal portion Group C showed a statistically significant difference in the mean measurement recorded with other tested groups ($P<0.05$).The mean amount of bond strength and the comparison of means are presented in Table 1 to Table 5.

## 4. Discussion

It is a standard procedure to restore teeth that have undergone endodontic treatment using glass fiber posts. Failure at the Post-cement–Dentine interface is crucial because it primarily affects the clinical effectiveness of restorative treatment by strengthening the link between the post and the root canal surface.

The smear layer produced by post-space preparation reduces the adaptability of filling materials as well as their penetration into the dentinal tubules. It is advised to use resin-bonded luting cement to encourage mechanical adherence between the material's monomer and dentin'scollagen fibers, leading to the creation of a hybrid layer.Inthis way, the elimination of the smear layer and the ensuing dentinal tubule opening improve the adhesive cement's ability to penetrate tubules and strengthen the connection.The most widely used irrigant is hypochlorite because of its many benefits. Moreover, the smear layer can be broken down more quickly by boiling hypochlorite than by a solution at ambient temperature. The endodontic smear layer is removed with an Er-YAG laser in a recent approach known as the "PIPS Technique." PIPS, or photon-induced photoacoustic streaming, is a process that relies on the bubble cavitation mechanism. Strong shockwaves that are produced in this situation when bubbles in a fluid collapse might remove the smear layer from the nearby walls.Thesmear layer in the canal is removed by the Er-YAG laser activating the solution by causing bubbles to rupture powerfully and quickly, sending shockwaves throughout the fluid [4-5]. Because of the high surface tension and inadequate mechanical cleansing action during conventional syringe needle irrigation, the irrigating solution may not have been able to get deep into the apical region of the root canal. Studies conducted in the past and present have demonstrated that laser-activated irrigations, such as Er:YAG laser irradiation employing PIPS activated irrigation, are more efficient than conventional irrigation at eliminating dentine debris from the apical portion of the root canal [6]. It was demonstrated that when the irrigant was triggered by the Er:YAG laser, the smear layer was eliminated more successfully in coronal regions than in the apical region. This can be explained by the fact that the dentine in the coronal part of the root canal is more exposed to irrigation solutions because the coronal portions of the root canal may have a bigger diameter, which could result in a higher volume of irrigation solution flowing in the canal.The study's findings demonstrate that Er-YAG combined with heated NaOClis effective in eliminating smear layers and provides the strongest connection, making it superior for cleaning dentinal walls. Push-out bond strength values were higher in the post-space wall pretreatment group using an Er-YAG laser system than in the non-lased group[7]. Depending on the type of luting agent used, further antimicrobial treatment of the root canal with either a gaseous ozone or an Er:YAG laser may have an impact on the retention of adhesively luted fiber posts [8]. The binding strength between fiber posts and resin core material may vary depending on the kind of post and surface treatment; 1 W and 1.5W Er,Cr:YSGG laser application enhanced adhesion at the post/core interface[9]. Because these teeth have little coronal dentin left, the use of a post during restoration of severely damaged endodontically treated teeth is frequently necessary to ensure adequate core retention[10-11]. Dependingon the power used, YAG laser irradiation strengthened the connection between fiber-reinforced posts and composite resin cores[12]. We draw the conclusion that retention of the post-core system cemented with both resin and zinc phosphate cement was favored by the prior treatment of dentine walls with 1% NaClO+17% EDTA, or Er:YAG laser + water[13]. Regardless of the various levels, there were no statistically significant differences between the groups[14]. The two primary lasers used to treat dental materials' surfaces are Nd:YAG and Er:YAG.However; Er, Cr:YSGG has lately drawn interest from physicians. Er:YAG and Er,Cr:YSGG lasers are fundamentally similar, with the exception of a few minor variations in energy, pulse length, and wavelength range [15].

**Table1:** Comparison of bond strength of coronal and apical portion with different irrigating materials.

| Group | | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| **Saline** | **Coronal** | 13 | 3.18 | 16.20 | 8.2723 | 4.12075 |
| | **Apical** | 13 | 1.04 | 15.00 | 4.4038 | 3.51989 |
| **NaOCL** | **Coronal** | 13 | 1.57 | 24.01 | 9.1023 | 6.39178 |
| | **Apical** | 13 | 1.71 | 20.66 | 7.8138 | 6.87383 |
| **Er-YAG+NaOCl** | **Coronal** | 13 | 5.67 | 32.17 | 23.5115 | 7.52300 |
| | **Apical** | 13 | 0.55 | 39.49 | 8.2631 | 9.83326 |

**Table 2:** Pair wisecomparison of bond strength of apical portion with different irrigating materials using Post Hoc Tukey test.

| | Pairwise comparison | | Mean Difference | P value |
|---|---|---|---|---|
| Apical | N. Saline | NaOCL | -3.41000 | .573 |
| | | Laser | -3.85923 | .468 |
| | NaOCL | Saline | 3.41000 | .573 |
| | | Laser | -.44923 | .998 |
| | Er-YAG | Saline | 3.85923 | .468 |
| | | NaOCL | .44923 | .998 |

**Table 3:** Pair wise comparison of bond strength of coronal portion with different irrigating materials using Post Hoc Tukey test.

| | Pairwise comparison | | Mean Difference | P value |
|---|---|---|---|---|
| Coronal | N. Saline | NaOCL | -.83000 | .986 |
| | | Laser | -15.23923* | .001* |
| | NaOCL | Saline | .83000 | .986 |
| | | Laser | -14.40923* | .001* |
| | Er-YAG | Saline | 15.23923* | .001* |
| | | NaOCL | 14.40923* | .001* |

*Statistically Significant p ≤ 0.05.

**Table 4:** Comparison of mean difference of bond strength of apical portion between three experimental groups using ANOVA test.

| | | N | Mean | Std. Deviation | F value | P value |
|---|---|---|---|---|---|---|
| Apical | N. Saline | 13 | 4.4038 | 3.51989 | 1.212 | 0.316 |
| | NaOCL | 13 | 7.8138 | 6.87383 | | |
| | Er-YAG | 13 | 8.2631 | 9.83326 | | |

**Table 5:** Comparison of mean difference of bond strength of coronal portion between three experimental groups using ANOVA test.

| | | N | Mean | Std. Deviation | F value | P value |
|---|---|---|---|---|---|---|
| Coronal | N. Saline | 13 | 8.2723 | 4.12075 | 16.961 | 0.001 |
| | NaOCL | 13 | 9.1023 | 6.39178 | | |
| | Er-YAG | 13 | 23.5115 | 7.52300 | | |

*Statistically Significant p ≤ 0.05.


**Figure 1:** Armamentarium.

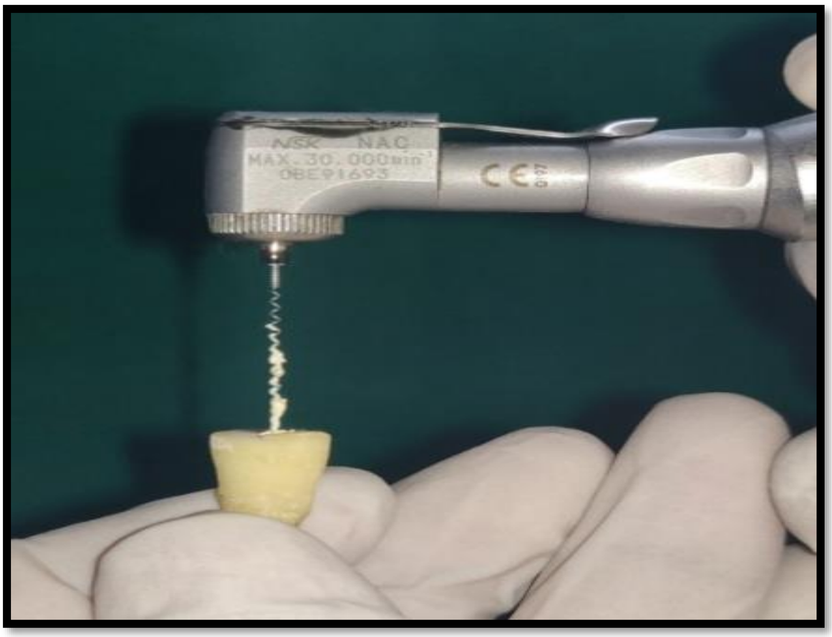


**Figure 2:** Post space preparation.

**Figure 3:** Irradiated with Er-YAG laser.


**Figure 4:** Measurement using vernier caliper.


**Figure 5:** Universal testing machine.

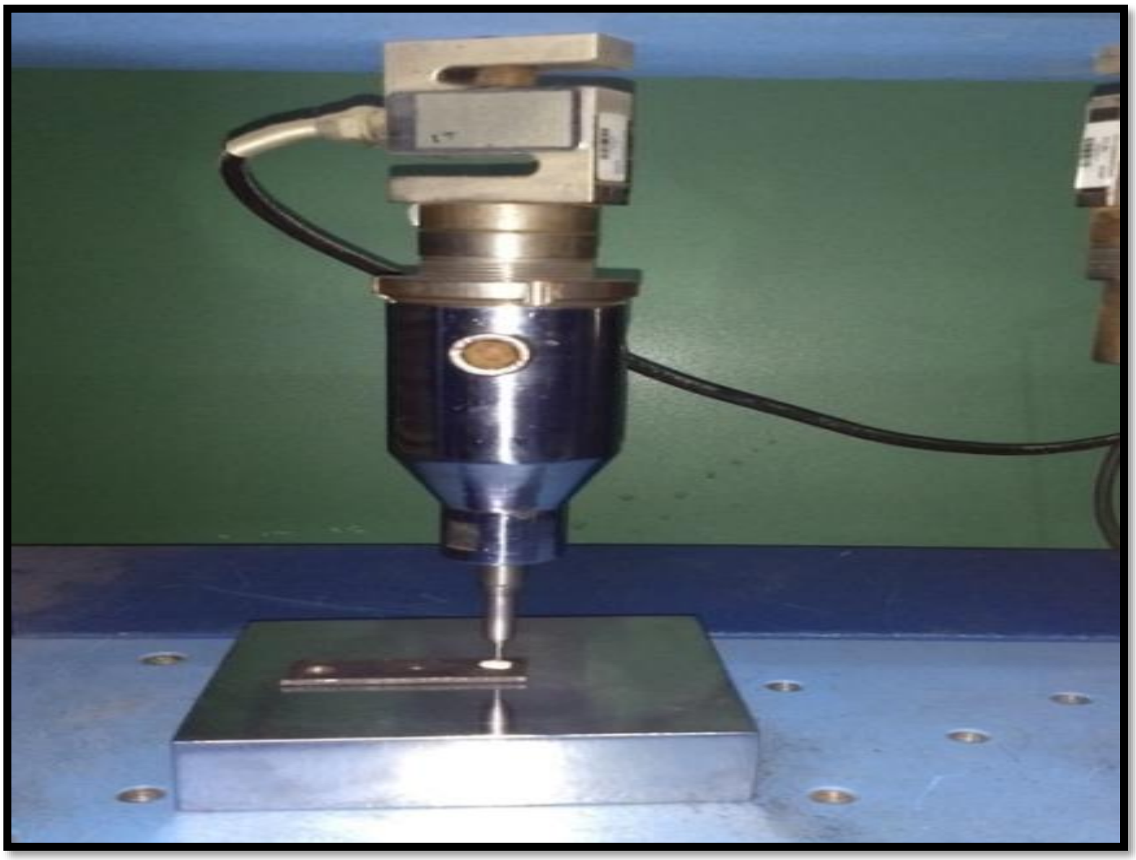

**Figure 6:** Pushout Bond Strength testing.

## 5. Conclusions

Samples which were exposed to Er-YAG laser and irrigated with 5.25% NaOCl shows highest bond strength whereas Samples irrigated with 0.9%. Normal saline shows lowest bond strength and samples treated with 5.25% warm NaOCl and 17% EDTA shows bond strength slightly more than the samples irrigated with 0.9% normal saline.'

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