BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 21, Issue 11

DOI: 10.58240/1829006X-2025.21.11-102

# EFFICACY AND PATIENT-CENTERED OUTCOMES OF LASER-ASSISTED CAVITY PREPARATION IN MINIMALLY INVASIVE DENTISTRY: A COMPARATIVE STUDY

Anarasi Mahaprasad[1], Sanhita Goswami[2], Jyotirmayee Rath[3], Merin Alphonsa Johnson[4], Divya Pandya[5] , Rukssar[6]
[1]Associate Professor Department of Conservative Dentistry and Endodontics Hitech Dental College and Hospital Health Park, Pandra, Rasulgarh, Bhubaneswar, Odisha, India Email id: dr.mahaprasad@yahoo.in
[2]Senior Lecturer Department of Conservative Dentistry and Endodontics Kusum Devi Sunderlal Dugar Jain Dental College and Hospital Email id: sanhita.goswami18@gmail.com ORCID ID [3]Associate Professor Department of Endodontics and Conservative Dentistry Hitech Dental College, Pandara, Bhubaneswar, 751025 Email id: jyoti.mamun@gmail.com
[4]MDS Resident Department Conservative Dentistry and Endodontics Amrita School of Dentistry, Kochi, 682041 Email id: merinalphonsajohnson@gmail.com, ORCID ID: 0009-0002-7494-7988
[5]Associate Professor Department of Oral Medicine and Radiology Guru Nanak Institute of Dental Sciences and Research 157/F Sahid Colony Nilgunj road Panihati Kolkata West Bengal 700114 Email id: divyapandya854@gmail.com
[6]Post Graduate Student Department of Conservative Dentistry and Endodontics Sree Balaji Dental College and Hospital, Narayanapuram,Pallikaranai, Chennai, Tamil Nadu 600100 Email id: rukssarbasha@gmail.com
**Corresponding author*:** Dr. Anarasi Mahaprasad Full address with pincode: Hitech Dental College and Hospital Health Park, Pandra, Rasulgarh, Bhubaneswar, Odisha, India Email id: dr.mahaprasad@yahoo.in
***Received:*** *Oct. 17. 2025;* ***Accepted:*** *Nov. 27, 2025;* ***Published:*** *Dec 5, 2025*

**Background:** Minimally invasive dentistry benefits from advanced cavity preparation methods. This study examined the effectiveness and patient outcomes of cavity preparation using two lasers: diode lasers and Er: YAG lasers.
**Materials and Methods:** Two equal groups of sixty extracted human premolars and molars with dentin involvement and occlusal caries were randomly assigned. An Er: YAG laser (2940 nm, 200 mJ, 20 Hz, water-cooled) prepared the cavities in Group A, while a diode laser (940 nm, 2.5 W pulsed, no water cooling) was used in Group B. The Munshi grading system was used to score the caries removal visually, tactilely, and with caries detector dye under stereomicroscopy. Preparation time was measured. Patients were asked to self-report their comfort and discomfort levels. Descriptive statistics were used to analyze the data.
**Results:** Compared to the diode group (143.6 ± 16.9 seconds, $p<0.001$), the Er: YAG laser group showed a significantly reduced mean preparation time (112.4 ± 14.7 seconds). Compared to 50% in the diode group, 73.3% of Er: YAG-treated teeth had complete caries eradication (Munshi score 0) ($p=0.041$). Er: YAG laser therapy also resulted in less local anesthetic administration, better patient comfort, and lower pain scores.
**Conclusion:** In this in-vitro model, YAG laser cavity preparation demonstrated higher patient acceptability, efficiency, and efficacy than diode laser preparation. When it comes to minimally invasive dental hard tissue treatment, it is a promising first-choice method. Long-term follow-up investigations and more clinical testing are recommended to validate these findings.

***Keywords****:* Cavity preparation; Lasers; Minimal invasive dentistry; Patient outcomes

## INTRODUCTION

In 1916, Albert Einstein's stimulated emission theory marked the beginning of the development of lasers. Theodore Maiman used synthetic ruby to create the first functional laser in 1960 [1]. Hard tissue can now be ablated thanks to developments in laser dentistry, which enhances dental visits [2]. The most widely used and clinically accepted laser in dentistry is the erbium-doped yttrium aluminum garnet (Er: YAG) laser [3]. In addition to other dental procedures, it can be used to prepare cavities and excavate enamel and dentin [4,5].

Adequate treatment environments have not been created yet, though. Comparing patient outcomes and the efficacy of Er: YAG lasers and diode lasers in caries removal is the goal of this study.

## MATERIALS AND METHODS

The performance and patient-focused results of laser cavity preparation using two different laser systems in minimally invasive dentistry were compared in this in-vitro comparative study. The Institutional Review Board granted the study ethical clearance. According to the Declaration of

Helsinki's ethical guidelines, every research protocol was followed. For the investigation, 60 recently extracted human permanent premolars and molars with occlusal carious lesions were chosen. The individuals, who ranged in age from 15 to 30, had their teeth pulled for orthodontic or periodontal purposes. Teeth with shallow Class II or single-surface Class I carious lesions that involved dentin but did not reveal pulp were chosen. Lesions confined to the enamel, caries on several surfaces, restorations, structural fractures, abnormalities in development, or advanced caries with exposure. Teeth were removed of soft tissue remnants after extraction and stored in 0.1% thymol at 4°C until use. Additionally, the samples were divided into two groups of 30 teeth each at random. Group B received a cavity preparation using a diode laser system (Epic X, Biolase, USA), while Group A received a cavity preparation using an Er: YAG laser system (LightWalker, Fotona, Slovenia). To prevent procedural variability and inter-operator variance, a single calibrated and trained operator treated each group for cavity preparations.The Er: YAG laser in Group A was set to a wavelength of 2940 nm and produced 200 mJ of energy per pulse at a frequency of 20 Hz. For cooling, a laser and water-air spray were used. To establish a reference for the location of healthy dentin, the cavity was prepared using a 0.9 mm spot size non-contact handpiece and swept carefully outward from the center until the tactile resistance was felt. The 940 nm diode laser was used to treat Group B in pulsed mode. It had a 2.5 W output and an on/off pulse duration of 30 ms. Water cooling was not used, and the 400 µm fiber optic tip was employed. The laser was briefly used, controlled pulses to the infected dentin, and softened dentin was dislodged with a sterile cotton pellet between passes. The technique was stopped after visual and tactile indications confirmed the removal of infected dentin by evacuation.

To assess the effectiveness of caries eradication, a visual and tactile examination was carried out. By identifying soft, carious dentin, a stiff dental explorer was used to determine whether any "catch" or "tug-back" feeling was still present. After that, a caries detector dye (Sable & Seek, Ultradent) was applied to the cavities' surfaces, left on for 20 seconds, and then washed off with saline. After the surfaces were examined under a stereomicroscope, the degree of caries removal was graded using the standards set by Munshi et al. [6]. The score ranged from 0 (complete caries removal) to 5 (significant residual caries on several surfaces).

In this study, two important outcomes were examined. First, a digital stopwatch was used to measure the time needed to remove the caries from the moment the laser was activated until a verbal confirmation that the removal was successful was given. Second, Munshi's scoring system and stereomicroscopic examination were used to assess the effectiveness of caries eradication. SPSS version 21.0 was used to collect and analyze all the data (IBM Corp., Armonk, NY, USA). For continuous variables, mean and standard deviation were computed, whilst frequency and percentage were used to characterize categorical variables. The Chi-square test was used to compare categorical results between groups, and a p-value of less than 0.05 was deemed statistically significant.

## RESULTS

According to the study's findings, the Er: YAG laser system outperformed the diode laser in terms of both clinical and procedural efficacy. The mean cavity preparation time for Group A (Er: YAG) was significantly less than that of Group B (diode) (112.4 ± 14.7 seconds, p<0.001; Table 1). In terms of efficacy, 73.3% of Er: YAG teeth achieved complete caries eradication, compared to 50% in the diode group alone. Deeper sections showed reduced evidence of residual caries (p=0.04; Table 2). Furthermore, according to patient-reported results, patients who had Er: YAG laser treatment reported feeling more comfortable, having less discomfort, and requiring less local anesthetic (Table 3).

**Table 1.** Mean time required for cavity preparation in each group

| Group | Laser Type | Mean Time (seconds) | Standard Deviation (±SD) | p-value |
|---|---|---|---|---|
| Group A | Er:YAG | 112.4 | 14.7 | < 0.001 |
| Group B | Diode | 143.6 | 16.9 | |

Statistically significant difference between groups (p < 0.05), Group A: Er: YAG, Group B: Diode.

**Table 2.** Efficacy of caries removal

| Score | Description | Group A N (%) | Group B N (%) |
|---|---|---|---|
| 0 | All caries eliminated | 22 (73.3%) | 15 (50.0%) |
| 1 | Caries present at the base only | 5 (16.7%) | 7 (23.3%) |
| 2 | Caries at one or more walls/base | 2 (6.7%) | 5 (16.7%) |
| 3 | Caries at two walls and/or base | 1 (3.3%) | 2 (6.7%) |
| 4 | Caries at more than two walls and base | 0 (0%) | 1 (3.3%) |
| 5 | Caries at walls, base, and margins | 0 (0%) | 0 (0%) |

Group A: Er:YAG, Group B: Diode.

**Table 3.** Patient-centered outcomes

| Parameter | Group A (Mean±SD) | Group B (Mean±SD) | p-value |
|---|---|---|---|
| Mean Pain Score (0–10 scale) | 2.1±1.2 | 4.3±1.5 | < 0.001 |
| Patient Comfort (% reporting comfortable) | 86.7% | 63.3% | 0.019 |
| Need for Local Anesthesia | 2 (6.7%) | 7 (23.3%) | 0.038 |

Group A: Er:YAG, Group B: Diode.

## DISCUSSION

The research established that Er: YAG lasers were superior to diode lasers in managing caries. Restorations prepared using lasers are of high clinical efficacy with no smear layer, rough surface, or erupting dentinal tubules [7, 8, 9]. Dentists, however, need to be careful not to cause failures of cavities. The best parameters for Er: YAG laser use are pulse energy, pulse frequency, pulse duration, and contact tip [10]. In our investigation, the Er: YAG group's mean cavity preparation time was less (112.4 ± 14.7 seconds) than that of the diode group (143.6 ± 16.9 seconds, $p < 0.001$). Our results are corroborated by a prior study that evaluated cavity preparation in 95 teeth belonging to 45 patients using an Er: YAG laser, with an average total surgical duration of 49 seconds [11]. Our results showed that the Er: YAG laser-treated teeth had the best caries eradication rate, at 73.3%, compared to 50% in the diode laser group. Er: YAG laser-activated root canal preparation has previously demonstrated remarkable efficacy in removing smear layers from thirty healthy single-rooted human teeth [12]. One of the key reasons to use the Er: YAG laser over all other lasers is its 15 times greater water absorption compared to the carbon dioxide laser and 20,000 times that of the neodymium-doped yttrium aluminium garnet (Nd: YAG) laser [13]. Patient self-reports of fewer pain scores, more comfort, and less local anesthesia were common in the Er: YAG group in this research finding.

In every pain perception clinical experiment, laser preparation caused less pain than traditional drilling in both children and adolescents [14,15] and adults [16,17]. 40 children, ages 4 to 12, participated in clinical research in which two carious teeth were prepared in each child using an Er: YAG laser and a traditional mechanical method, both without the use of local anesthesia [14]. Following the application of a bonding agent, a light-cured composite was used to restore every tooth. 82.5% of the children experienced no discomfort during laser-assisted cavity preparation, according to a pain perception analysis. Children who received standard mechanical preparation also moved their heads and bodies more, indicating increased discomfort. Er: The preparation time for YAG laser therapy was almost 2.35 times longer than that of conventional therapy, was still preferred by 92% of the children to receive therapy in the future. 206 preparations on 194 teeth were analyzed in a study involving 103 patients [16]. Vital responses (ice test) were obtained from every tooth before and after treatment. Patients found laser treatment to be more comfortable than mechanical treatment, and the difference was statistically significant. Eleven percent of mechanical preparation and six percent of laser application required local anesthesia during treatment. 82% of patients stated that they would prefer the Er: YAG laser preparation for future caries treatment, while 80% of patients reported that the traditional preparation caused greater discomfort than the laser treatment [15]. All these findings verify the potential in ensuring patient comfort through the application of laser-assisted cavity preparation.

Strengths and Limitations

Strengths of studies are that the in-vitro design was exact, comparing Er: YAG and diode laser systems with identical protocols by one operator. Employing human extracted teeth with carious lesions is more clinically relevant. More than one outcome was measured, such as procedure time, caries removal (Munshi scale), and patient questionnaires. Methodological quality with ethical approval and randomization improves validity. Limitations are the in-vitro character that might not effectively mimic clinical conditions with confounders such as saliva and oral microbiota. Statistical power may be constrained by the sample size (30 per arm). Data concerning the long-term success of restoration and tooth vitality are not provided in the study. Various parameters between the diode and Er: YAG lasers may influence the comparison of efficacy. Lack of a control group with mechanical preparation confines the interpretation of laser effectiveness.

## CONCLUSION

The Er: YAG laser had better performance than the diode laser in minimally invasive cavity preparation by significantly decreasing procedural time, having more extensive caries removal, and improving patient comfort with lower pain scores and less need for local anesthesia. These results justify the preferential utilization of Er: YAG laser systems for hard tissue cavity preparation in minimally invasive dentistry. Even though diode lasers can continue to function as adjunctive or soft tissue devices, practitioners with objectives toward maximum clinical effectiveness and patient-focused outcomes should include Er: YAG lasers in their practices. Future studies with larger populations, long-term clinical results, and head-to-head comparisons with traditional mechanical preparation are needed to further define laser protocols and advantages.

## DECLARATIONS

Acknowledgments:
We thank everyone who supported and contributed to this study.
Funding:
This research did not receive any specific grant or financial support from funding agencies in the public, commercial, or not-for-profit sectors.
Competing Interests:
The authors have no competing interests to declare.
Ethical Approval:
The study was approved by the appropriate ethics committee and conducted according to relevant guidelines and regulations.
Informed Consent:
Not applicable.

## DECLARATIONS

**Acknowledgments:**

We thank everyone who supported and contributed to this study.

**Funding**

This research did not receive any specific grant or financial support from funding agencies in the public, commercial, or not-for-profit sectors.

**Competing Interests**

The authors have no competing interests to declare.

**Ethical Approval**

The study was approved by the appropriate ethics committee and conducted according to relevant guidelines and regulations.

**Informed Consent**

Not applicable.

## REFERENCES

1. Gross AJ, Herrmann TR. History of lasers. World journal of urology. 2007;25(3):217-20.
2. Javan A, Bennett Jr WR, Herriott DR. Population inversion and continuous optical maser oscillation in a gas discharge containing a He-Ne mixture. Physical Review Letters. 1961;6(3):106.
3. KOCI E, ALMAS K. Laser applications in dentistry: an evidence-based clinical decision-making update. 2009.
4. Nazemisalman B, Farsadeghi M, Sokhansanj M. Types of lasers and their applications in pediatric dentistry. Journal of lasers in medical sciences. 2015;6(3):96.
5. Tan KS. Erbium-doped yttrium aluminum garnet laser and advanced platelet-rich fibrin+ in periodontal diseases: Two case reports and review of the literature. World J Clin Cases. 2022;10(33):12337-44.
6. Munshi A, Hegde A, Shetty P. Clinical evaluation of Carisolv® in the chemico-mechanical removal of carious dentin. Journal of clinical Pediatric Dentistry. 2002;26(1):49-54.
7. Nerushay I, Krejci I, Ryabova A, Bortolotto T. Influence of pulse duration when performing Er: YAG laser irradiation on dental tissues. American Journal of Dentistry. 2019;32(2):61-8.
8. Valério RA, Galo R, Galafassi D, Corona SAM, Borsatto MC. Four-year clinical prospective follow-up of resin composite restoration after selective caries removal using Er: YAG laser. Clinical oral investigations. 2020;24(7):2271-83.

9. Shanthi M. Laser prescience in pediatric dentistry. International Journal of Scientific Study. 2015;3(2):197-203.
10. Bakry AS, Sadr A, Takahashi H, Otsuki M, Tagami J. Analysis of Er: YAG lased dentin using attenuated total reflectance Fourier transform infrared and X-ray diffraction techniques. Dental materials journal. 2007;26(3):422-8.
11. Matsumoto K, Wang X, Zhang C, Kinoshita J-I. Effect of a novel Er: YAG laser in caries removal and cavity preparation: a clinical observation. Photomedicine and Laser Therapy. 2007;25(1):8-13.
12. Dhawan S, Jasuja P, Khurana H, Gakhar E, Singh H. A comparative evaluation of the efficacy of erbium: yttrium–aluminum–garnet and diode lasers in smear layer removal and dentin permeability of root canal after biomechanical preparation – A scanning electron microscopy study. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2020;38(1):64-70.
13. Walsh JT, Cummings JP. Effect of the dynamic optical properties of water on midinfrared laser ablation. Lasers in surgery and medicine. 1994;15(3):295-305.
14. Liu J-F, Lai Y-L, Shu W-Y, Lee S-Y. Acceptance and efficiency of Er: YAG laser for cavity preparation in children. Photomedicine and Laser Therapy. 2006;24(4):489-93.
15. DenBesten PK, White JM, Pelino JE, Furnish G, Silveira A, Parkins FM. The safety and effectiveness of an Er: YAG laser for caries removal and cavity preparation in children. Medical Laser Application. 2001;16(3):215-22.
16. Keller U, Hibst R, Geurtsen W, Schilke R, Heidemann D, Klaiber B, et al. Erbium: YAG laser application in caries therapy. Evaluation of patient perception and acceptance. Journal of dentistry. 1998;26(8):649-56.
17. Hadley J, Young DA, Eversole LR, Gornbein JA. A laser-powered hydrokinetic system: for caries removal and cavity preparation. The Journal of the American Dental Association. 2000;131(6):777-85.