Clinical assessment of Erbium:YAG laser and CO_2 laser in cavity preparation – An original research

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ABSTRACT

Background: Dental lasers have gained increasing attention in restorative dentistry as minimally invasive alternatives to conventional rotary instruments. Among the commonly used lasers, the Erbium:Yttrium Aluminum Garnet (Er:YAG) laser and Carbon Dioxide (CO_2) laser have shown promising results in hard tissue procedures. These laser systems are known to reduce patient discomfort, minimize vibration and noise, and potentially improve clinical outcomes during cavity preparation.

Aim: To clinically evaluate and compare the effectiveness of Er:YAG laser and CO_2 laser in cavity preparation.

Materials and Methods: This randomized clinical study included 100 patients requiring cavity preparation for dental caries. Participants were randomly divided into two groups: Group A (n=50) underwent cavity preparation using the Er:YAG laser, while Group B (n=50) received treatment with the CO_2 laser. Clinical parameters evaluated included time required for cavity preparation, pain perception using Visual Analog Scale (VAS), need for local anesthesia, and postoperative sensitivity. All cavities were restored with composite resin following standardized bonding procedures. Statistical analysis was performed using STATA software, applying independent t-test and chi-square test with significance set at $p < 0.05$.

Results: The results showed that the Er:YAG laser required significantly less preparation time (6.12 ± 1.35 min) compared to the CO_2 laser (7.48 ± 1.62 min) ($p = 0.001$). Pain perception scores were also significantly lower in the Er:YAG group (2.1 ± 0.9) compared with the CO_2 group (3.4 ± 1.2) ($p = 0.002$). Fewer patients required local anesthesia in the Er:YAG group (16%) than in the CO_2 group (34%). Postoperative sensitivity was also lower among patients treated with the Er:YAG laser.

Conclusion: Both laser systems were effective for cavity preparation; however, the Er:YAG laser demonstrated better clinical performance in terms of efficiency, reduced pain, and improved patient comfort. The findings suggest that Er:YAG laser may serve as a more effective and patient-friendly alternative for cavity preparation in restorative dentistry.

Keywords: Er:YAG laser, CO_2 laser, cavity preparation, dental caries, restorative dentistry.

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Introduction

Dental caries remains one of the most prevalent chronic diseases affecting individuals worldwide. It is characterized by the progressive demineralization and destruction of the tooth structure due to the metabolic activity of oral microorganisms [1]. Conventional cavity preparation has traditionally been performed using mechanical rotary instruments such as high-speed and low-speed handpieces equipped with burs. While these methods are effective for removing carious tissue, they are often associated with several drawbacks including patient discomfort, vibration, noise, heat generation, and the need for local anesthesia. These limitations have encouraged researchers and clinicians to explore alternative technologies that can improve patient comfort and clinical outcomes in restorative dentistry [2].

In recent decades, laser technology has emerged as a promising tool in various dental procedures including cavity preparation, caries removal, soft tissue surgery, periodontal therapy, and endodontic treatment [3]. The use of lasers in dentistry offers several potential advantages such as minimal invasiveness, reduced pain perception, improved precision, decreased bleeding, and better patient acceptance. Laser-assisted cavity preparation has particularly gained attention because it can selectively remove diseased tooth structure while preserving healthy tissues. Furthermore, lasers may reduce the risk of microcracks and thermal damage that are sometimes associated with conventional rotary instruments [4].

Among the different types of dental lasers available today, the Erbium: Yttrium Aluminum Garnet (Er:YAG) laser has gained significant popularity for hard tissue applications [5]. The Er:YAG laser operates at a wavelength of 2940 nm, which corresponds to the peak absorption of water and hydroxyapatite, the major components of dental hard tissues. Because of this high absorption, the Er:YAG laser can efficiently ablate enamel and dentin through a process known as thermomechanical ablation. In this process, the rapid absorption of laser energy by water molecules within the tooth structure causes micro-explosions that result in the removal of dental tissue [6]. This mechanism allows for precise cutting with minimal thermal damage to surrounding tissues. Additionally, the Er:YAG laser produces less vibration and noise compared to traditional drills, which can help reduce dental anxiety among patients [7].

Another important laser system used in dentistry is the Carbon Dioxide (CO_2) laser. The CO_2 laser typically operates at a wavelength of 10,600 nm and is highly absorbed by water and hydroxyapatite as well [8]. This property makes it particularly useful in both soft tissue and certain hard tissue procedures. The CO_2 laser has been widely utilized for soft tissue surgeries due to its excellent cutting ability and hemostatic properties [9]. However, advancements in laser technology and improved delivery systems have expanded its application to hard tissue procedures, including cavity preparation and caries removal. The ability of the CO_2 laser to sterilize the operative field and reduce bacterial load may further enhance the success of restorative procedures [10].

Laser-assisted cavity preparation also offers several biological advantages. Studies have shown that laser-prepared cavities may exhibit improved resistance to acid dissolution and reduced microleakage when compared with conventionally prepared cavities [11]. Laser irradiation can alter the chemical composition of enamel and dentin, increasing their resistance to future caries development [12]. In addition, the absence of smear layer formation during laser preparation may improve the bonding strength of restorative materials. These properties suggest that laser technology may contribute not only to more comfortable treatment but also to improved long-term outcomes in restorative dentistry [13].

Despite these potential benefits, the clinical adoption of lasers in cavity preparation is still evolving. Several factors influence their widespread use, including the cost of equipment, the need for specialized training, and variability in clinical outcomes reported in the literature. While both Er:YAG and CO_2 lasers have demonstrated promising results in laboratory and clinical studies, differences in their mechanisms of action, efficiency, cutting speed, thermal effects, and patient perception remain areas of ongoing research. Some studies have reported that the Er:YAG laser provides superior efficiency in hard tissue ablation, while others suggest that the CO_2 laser may offer advantages in terms of surface modification and bacterial reduction. However, direct clinical comparisons between these two laser systems in cavity preparation are relatively limited [14].

Furthermore, the evaluation of laser-based cavity preparation should consider multiple clinical parameters including procedure time, patient comfort, need for anesthesia, surface morphology of the prepared cavity, and overall clinical effectiveness. Understanding these parameters is essential for determining whether laser technology can serve as a reliable alternative or adjunct to conventional rotary instrumentation. As patient expectations for minimally invasive and painless dental procedures continue to increase, the demand for advanced technologies such as dental lasers is likely to grow [15].

Given the increasing interest in laser-assisted dentistry and the need for evidence-based evaluation of different laser systems, clinical studies comparing the effectiveness of various lasers are essential. Such studies can provide valuable insights into their practical advantages, limitations, and overall clinical applicability in routine restorative procedures. Therefore, this study is important to determine the clinical effectiveness and comparative performance of Er:YAG laser and CO_2 laser in cavity preparation.

Methodology

Study Design and Setting

This study was designed as a randomized controlled clinical trial to evaluate the clinical effectiveness of Er:YAG laser and CO_2 laser in cavity preparation. The study was conducted in the Department of Conservative Dentistry and Endodontics of a dental teaching hospital over a period of 6 months. Ethical approval was obtained from the Institutional Ethical Committee prior to the commencement of the study, and all participants provided written informed consent before enrollment.

Sample Size

A total of 100 patients requiring cavity preparation for dental caries were included in the study. The sample size was determined based on previous similar clinical studies and to ensure adequate statistical power for detecting significant differences between the two groups.

Inclusion Criteria

Patients were selected based on the following criteria:

- Patients aged between 18 and 50 years.
- Patients presenting with occlusal or occluso-proximal carious lesions requiring restorative treatment.
- Teeth with vital pulp confirmed by clinical examination and pulp vitality tests.
- Patients who were willing to participate and provided written informed consent.

Exclusion Criteria

Patients were excluded from the study if they met any of the following conditions:

- Teeth with pulpal involvement or periapical pathology.
- Patients with systemic diseases that could affect oral health or healing.
- Pregnant or lactating women.
- Patients with extensive tooth destruction requiring indirect restorations.
- Patients with a history of hypersensitivity to dental procedures.

Group Allocation

The 100 patients included in the study were randomly divided into two equal groups using a simple randomization technique:

- **Group A (n = 50):** Cavity preparation using Er:YAG laser
- **Group B (n = 50):** Cavity preparation using CO_2 laser

Randomization was performed using computer-generated random numbers to ensure unbiased allocation of participants.

Clinical Procedure

All patients underwent a detailed clinical examination and radiographic evaluation prior to the procedure. The treatment area was isolated using cotton rolls and saliva ejectors to maintain a dry operative field.

For **Group A**, cavity preparation was performed using the Er:YAG laser system according to the manufacturer's recommended parameters for hard tissue ablation. The laser beam was directed onto the carious lesion with continuous water spray to prevent thermal damage and to facilitate efficient tissue removal. The operator carefully removed the infected dentin while preserving healthy tooth structure.

For **Group B**, cavity preparation was carried out using the CO_2 laser system with appropriate settings suitable for dental hard tissue preparation. The laser was applied in a controlled manner to remove carious tissue while ensuring minimal thermal effects on the surrounding structures.

All procedures were performed by the same experienced clinician to minimize operator variability. Local anesthesia was administered only when patients reported discomfort during the procedure.

Outcome Measures

Several clinical parameters were evaluated and recorded during and after the procedure, including:

- **Time required for cavity preparation** (measured in minutes)
- **Patient pain perception**, assessed using the Visual Analog Scale (VAS)
- **Need for local anesthesia** during the procedure
- **Surface characteristics of the prepared cavity**
- **Patient comfort and acceptance of the procedure**

Restorative Procedure

Following cavity preparation, all cavities were restored using a standardized restorative material (light-cured composite resin). The bonding protocol was performed according to the manufacturer's instructions to ensure consistency in restoration placement.

Follow-Up

Patients were followed up after 1 week and 1 month to evaluate postoperative sensitivity, restoration integrity, and any complications associated with the procedure.

Statistical Analysis

The collected data were entered into a spreadsheet and analyzed using statistical software. Descriptive statistics such as mean and standard deviation were calculated for quantitative variables, while frequency and percentages were used for categorical variables.

Comparative analysis between the two groups was performed using the independent t-test for continuous variables and the chi-square test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Results

A total of **100 patients** participated in the study and were randomly allocated into two groups: **Group A (Er:YAG laser, n = 50)** and **Group B (CO_2 laser, n = 50)**. All participants completed the study and were included in the final statistical analysis. The outcomes evaluated included demographic distribution, time required for cavity preparation, pain perception, requirement of local anesthesia, and postoperative sensitivity.

Demographic Characteristics

The demographic characteristics of the participants were comparable between the two groups. The mean age of participants in Group A was **31.8 ± 7.2 years**, while in Group B it was **32.4 ± 6.9 years**, with no statistically significant difference between the groups (**p > 0.05**). Gender distribution was also similar between the two groups.

Table 1: Demographic Distribution of Participants

Variable	Er:YAG Laser (n=50)	CO_2 Laser (n=50)	p-value
Mean Age (years)	31.8 ± 7.2	32.4 ± 6.9	0.68
Male	28 (56%)	27 (54%)	0.84
Female	22 (44%)	23 (46%)	0.84

The statistical analysis showed **no significant difference in baseline characteristics between the groups**, confirming the comparability of the study population.

Time Required for Cavity Preparation

The **mean time required for cavity preparation** using the Er:YAG laser was **6.12 ± 1.35 minutes**, while the CO_2 laser required **7.48 ± 1.62 minutes**. Statistical analysis using the independent t-test revealed a **significant difference between the groups (p = 0.001)**.

Table 2: Time Required for Cavity Preparation

Group	Mean Time (minutes)	Standard Deviation	p-value
Er:YAG Laser	6.12	1.35	
CO_2 Laser	7.48	1.62	**0.001***

*Statistically significant (p < 0.05)

These findings indicate that **Er:YAG laser required significantly less time for cavity preparation compared to the CO_2 laser**.

Pain Perception During Procedure

Pain perception was assessed using the **Visual Analog Scale (VAS)** ranging from 0 (no pain) to 10 (severe pain). Patients treated with the Er:YAG laser reported significantly lower pain scores compared to those treated with the CO_2 laser.

Table 3: Pain Perception (VAS Score)

Group	Mean VAS Score	Standard Deviation	p-value
Er:YAG Laser	2.1	0.9	
CO_2 Laser	3.4	1.2	**0.002***

Patients in the **Er:YAG laser group experienced significantly less discomfort** during the procedure compared to the CO_2 laser group.

Requirement of Local Anesthesia

The need for local anesthesia during cavity preparation was also evaluated. Fewer patients in the Er:YAG group required anesthesia compared to the CO_2 laser group.

Table 4: Requirement of Local Anesthesia

Group	Required Anesthesia	Did Not Require	p-value
Er:YAG Laser	8 (16%)	42 (84%)	
CO_2 Laser	17 (34%)	33 (66%)	**0.03***

The difference between the groups was statistically significant (**p = 0.03**), indicating that **Er:YAG laser procedures were associated with reduced need for anesthesia**.

Postoperative Sensitivity

Postoperative sensitivity was assessed one week after treatment. Patients treated with Er:YAG laser reported lower incidence of sensitivity.

Table 5: Postoperative Sensitivity

Group	Sensitivity Present	No Sensitivity	p-value
Er:YAG Laser	6 (12%)	44 (88%)	
CO_2 Laser	14 (28%)	36 (72%)	**0.04***

The results demonstrated that **postoperative sensitivity was significantly lower in the Er:YAG laser group** compared to the CO_2 laser group.

STATA Statistical Findings

Statistical analysis was performed using **STATA version 16.0**. The independent t-test showed a statistically significant reduction in **procedure time (p**

= 0.001) and **pain perception (p = 0.002)** in the Er:YAG laser group compared to the CO_2 laser group. The chi-square test demonstrated significant differences in **requirement of anesthesia (p = 0.03)** and **postoperative sensitivity (p = 0.04)** between the two groups.

Overall, the STATA analysis confirmed that **Er:YAG laser demonstrated superior clinical performance compared to CO_2 laser in cavity preparation**, particularly in terms of reduced treatment time, lower pain perception, decreased need for anesthesia, and reduced postoperative sensitivity.

Discussion

The present study evaluated the **clinical effectiveness of Er:YAG laser and CO_2 laser in cavity preparation** with respect to procedure time, pain perception, requirement of anesthesia, and postoperative sensitivity. The results demonstrated that **Er:YAG laser showed superior clinical performance**, with significantly lower pain scores, reduced need for anesthesia, shorter preparation time, and decreased postoperative sensitivity compared with the CO_2 laser. These findings support the growing body of evidence that laser technology can be an effective and minimally invasive alternative to conventional cavity preparation methods.

One of the most important findings of the present study was the **reduced pain perception in patients treated with the Er:YAG laser**. This result is consistent with the clinical pilot study conducted by **Keller et al. (1997) [16]**, who evaluated the clinical applicability of the Er:YAG laser for caries removal and cavity preparation. Their study reported that most patients experienced **little or no pain during laser treatment**, and local anesthesia was rarely required. The authors concluded that Er:YAG laser cavity preparation could be performed with **minimal patient discomfort and without pulpal damage**.

Similarly, the findings of the present study align with the randomized clinical trial by **Liu et al. (2006) [17]**, who assessed the clinical efficiency and patient acceptance of Er:YAG laser cavity preparation in children. Their study found that **over 80% of patients reported no pain during laser treatment**, and the majority preferred laser therapy over conventional mechanical preparation. The authors highlighted that laser technology significantly improves patient comfort and acceptance, particularly in anxious or pediatric patients.

Another important observation in the present study was the **reduced postoperative sensitivity associated with Er:YAG laser cavity preparation**. This finding may be explained by the absence of smear layer formation and the minimal thermal damage produced by laser ablation. A study conducted by **Shigetani et al. (2002) [18]** investigated the marginal leakage of composite restorations in cavities prepared using Er:YAG laser irradiation. The authors observed that the **laser-prepared surfaces exhibited open dentinal tubules and lacked smear layer formation**, which may improve bonding and reduce postoperative complications. Their results suggested that laser cavity preparation can be a reliable method for restorative procedures with acceptable marginal sealing ability.

The present study also demonstrated that the **Er:YAG laser required less time for cavity preparation compared with the CO_2 laser**, indicating greater efficiency for hard tissue ablation. These findings are supported by the research conducted by **Al-Batayneh et al. (2014) [19]**, who evaluated the efficiency and thermal effects of Er:YAG laser during cavity preparation in both primary and permanent teeth. Their study reported that the **Er:YAG laser effectively removed carious tissue without causing significant temperature rise in the pulp**, confirming its safety and efficiency in dental hard tissue preparation.

Furthermore, the results of the present study are consistent with the systematic evaluation conducted by **Li et al. (2019)**, [20] who performed a meta-analysis on the use of Er:YAG laser for caries removal and cavity preparation. The authors concluded that Er:YAG laser technology provides **effective caries removal with improved patient comfort and reduced need for anesthesia**, supporting its clinical application in restorative dentistry.

In addition to clinical comfort, the **surface morphology of laser-prepared cavities** has also been investigated in previous studies. For example, **Freitas et al. (2007)** [21] evaluated the morphological characteristics of cavities prepared by Er:YAG laser using scanning electron microscopy. Their findings showed that laser-prepared surfaces exhibit **irregular microretentive patterns without smear layer**, which may enhance the bonding of restorative materials and improve long-term restoration success.

Although the present study demonstrated favorable outcomes for Er:YAG laser cavity preparation, it is

important to consider certain limitations reported in previous literature. Some studies have indicated that laser preparation may occasionally require slightly longer preparation time compared to conventional rotary instruments, depending on the energy parameters used and the size of the lesion. However, the advantages of improved patient comfort, reduced vibration and noise, and minimally invasive tissue removal may outweigh these limitations.

Overall, the findings of the present study are consistent with previous research demonstrating the **clinical effectiveness and patient-centered benefits of Er:YAG laser technology in restorative dentistry**. The results suggest that Er:YAG laser cavity preparation offers significant advantages over CO_2 laser in terms of efficiency, patient comfort, and postoperative outcomes. These findings support the increasing adoption of laser-assisted techniques in modern minimally invasive dentistry and highlight the potential of Er:YAG laser as a valuable tool for cavity preparation in clinical practice.

Limitations of the Study

Despite the valuable findings obtained in the present study, certain limitations should be considered. The study was conducted with a relatively **small sample size of 100 patients** from a single clinical center, which may limit the generalizability of the results to a larger population. The **follow-up period was relatively short**, as postoperative outcomes were assessed only up to one month; therefore, long-term outcomes such as restoration durability, secondary caries, and long-term pulpal response could not be evaluated. In addition, the study focused only on **occlusal and occluso-proximal cavities**, which may not represent the performance of lasers in other types of lesions or deeper cavities. Operator experience and laser parameter settings could also influence treatment outcomes, and minor variations in these factors may affect the results. Furthermore, the study compared only **two laser systems (Er:YAG and CO_2 laser)** without including conventional rotary instruments as a control group, which could have provided a broader comparison of cavity preparation techniques. Therefore, further multicenter studies with larger sample sizes and longer follow-up periods are recommended to validate and expand upon these findings.

Conclusion

Within the limitations of this study, both **Er:YAG laser and CO_2 laser** were effective for cavity preparation in restorative dentistry. However, the **Er:YAG laser demonstrated superior clinical performance**, showing shorter preparation time, lower pain perception, and reduced need for local anesthesia. Patients treated with the Er:YAG laser also experienced **less postoperative sensitivity** compared with the CO_2 laser group. These findings suggest that the Er:YAG laser may be a **more efficient and patient-friendly alternative** for cavity preparation. Further long-term clinical studies are recommended to confirm these results and evaluate long-term restorative outcomes.

References

1. Rathee M, Sapra A. Dental Caries. [Updated 2023 Jun 21]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK551699/
2. Krishnaveni L, Dash JK, Baliarsingh RR, Ray P, Khwairakpam M, Das S. Comparative Evaluation of Caries Removal Efficacy of Ceramic Bur, Polymer Smart Bur, and Conventional Tungsten Carbide Bur in Primary Molars: A Clinical Study. Int J Clin Pediatr Dent. 2025 Oct;18(10):1222-1227. doi: 10.5005/jp-journals-10005-3286. Epub 2025 Oct 18. PMID: 41211356; PMCID: PMC12592874.
3. Al Asmari D, Alenezi A. Laser Technology in Periodontal Treatment: Benefits, Risks, and Future Directions-A Mini Review. J Clin Med. 2025 Mar 14;14(6):1962. doi: 10.3390/jcm14061962. PMID: 40142770; PMCID: PMC11943112.
4. Anukriti Kumari., et al. "Dental Curing Light : Sustainability, Environmental and Cancer Responsibility". Acta Scientific Cancer Biology 8.6 (2024): 04-11. https://actascientific.com/ASCB/ASCB-08-0491.php
5. Nazemisalman B, Farsadeghi M, Sokhansanj M. Types of Lasers and Their Applications in Pediatric Dentistry. J Lasers Med Sci. 2015 Summer;6(3):96-101. doi: 10.15171/jlms.2015.01. Epub 2015 Jun 28. PMID: 26464775; PMCID: PMC4599202.
6. Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. Natl J Maxillofac Surg. 2012 Jul;3(2):124-32.

doi: 10.4103/0975-5950.111342. PMID: 23833485; PMCID: PMC3700144.

7. Gachinamath V, Varma AS, Gangavati R, Huded P. Non-Invasive Laser Technologies for Early Detection of Oral Cancer and Dental Diseases. Oral Sphere J. Dent. Health Sci. 2026;2(2):120-125. doi: 10.63150/osjdhs.2026.18
8. Zhang OL, Yin IX, Yu OY, Luk K, Niu JY, Chu CH. Advanced Lasers and Their Applications in Dentistry. Dent J (Basel). 2025 Jan 16;13(1):37. doi: 10.3390/dj13010037. PMID: 39851613; PMCID: PMC11763962.
9. Garg N, Verma S, Chadha M, Rastogi P. Use of carbon dioxide laser in oral soft tissue procedures. Natl J Maxillofac Surg. 2015 Jan-Jun;6(1):84-8. doi: 10.4103/0975-5950.168218. PMID: 26668460; PMCID: PMC4668740.
10. Binrayes A. An Update on the Use of Lasers in Prosthodontics. Cureus. 2024 Mar 30;16(3):e57282. doi: 10.7759/cureus.57282. PMID: 38690478; PMCID: PMC11058581.
11. Zhang Y, Chen W, Zhang J, Li Y. Does Er,Cr:YSGG reduce the microleakage of restorations when used for cavity preparation? A systematic review and meta-analysis. BMC Oral Health. 2020 Oct 6;20(1):269. doi: 10.1186/s12903-020-01252-x. PMID: 33023550; PMCID: PMC7541249.
12. Feng Z, Yuan R, Cheng L, Fan H, Si M, Hao Z. Effect of Er:YAG Laser Irradiation on Preventing Enamel Caries: A Systematic Review and Meta-Analysis. Int Dent J. 2024 Aug;74(4):679-687. doi: 10.1016/j.identj.2024.01.022. Epub 2024 Feb 20. PMID: 38383278; PMCID: PMC11287166.
13. Świenc W, Kiryk J, Michalak M, Majchrzak Z, Laszczyńska M, Kiryk S, Grychowska-Gąsior N, Nawrot-Hadzik I, Matys J, Dobrzyński M. The Effect of Laser Surface Treatment on the Bond Strength of Adhesive Materials to Primary Teeth: A Systematic Review. Materials (Basel). 2025 Nov 18;18(22):5212. doi: 10.3390/ma18225212. PMID: 41304056; PMCID: PMC12654663.
14. Fiegler-Rudol J, Skaba D, Kawczyk-Krupka A, Wiench R. Antibacterial and Bactericidal Effects of the Er: YAG Laser on Oral Bacteria: A Systematic Review of Microbiological Evidence. J Funct Biomater. 2025 Jun 3;16(6):209. doi: 10.3390/jfb16060209. PMID: 40558896; PMCID: PMC12194413.
15. Dhayanidhi A, Mudiarasu N, Mathivanan A, Gopalkrishnan JR, Nagarajan SKK, Bharathan K. "Laser Dentistry"-The Need of the Hour: A Cross-sectional Study. J Pharm Bioallied Sci. 2020 Aug;12(Suppl 1):S295-S298. doi: 10.4103/jpbs.JPBS_89_20. Epub 2020 Aug 28. PMID: 33149474; PMCID: PMC7595529.
16. Keller U, Hibst R. Effects of Er:YAG laser in caries treatment: a clinical pilot study. Lasers Surg Med. 1997;20(1):32-8. doi: 10.1002/(sici)1096-9101(1997)20:1<32::aid-lsm5>3.0.co;2-#. PMID: 9041505.
17. Liu JF, Lai YL, Shu WY, Lee SY. Acceptance and efficiency of Er:YAG laser for cavity preparation in children. Photomed Laser Surg. 2006 Aug;24(4):489-93. doi: 10.1089/pho.2006.24.489. PMID: 16942429.
18. Shigetani Y, Tate Y, Okamoto A, Iwaku M, Abu-Bakr N. A study of cavity preparation by Er:YAG laser. Effects on the marginal leakage of composite resin restoration. Dent Mater J. 2002 Sep;21(3):238-49. doi: 10.4012/dmj.21.238. PMID: 12474951.
19. Al-Batayneh OB, Seow WK, Walsh LJ. Assessment of Er:YAG laser for cavity preparation in primary and permanent teeth: a scanning electron microscopy and thermographic study. Pediatr Dent. 2014 May-Jun;36(3):90-4. PMID: 24960377.
20. Li T, Zhang X, Shi H, Ma Z, Lv B, Xie M. Er:YAG laser application in caries removal and cavity preparation in children: a meta-analysis. Lasers Med Sci. 2019 Mar;34(2):273-280. doi: 10.1007/s10103-018-2582-x. Epub 2018 Jul 12. PMID: 30003427.
21. Freitas PM, Navarro RS, Barros JA, de Paula Eduardo C. The use of Er:YAG laser for cavity preparation: an SEM evaluation. Microsc Res Tech. 2007 Sep;70(9):803-8. doi: 10.1002/jemt.20470. PMID: 17576132.