BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 21, Issue 8

DOI:10.58240/1829006X-2025.21.8-154

ORIGINAL ARTICALE

LASER DENTISTRY:ADVANCEMENTS, CLINICAL APPLICATIONS AND FUTURE PROSPECTS

Seethalakshmi Chiranjeevi[1], Pooraninagalakshmi J[2], Navneet Gurm[3], D G Madhuri[4], Anitha Subbappa[5], Preeti Patil[6]

[1]Reader, Department of Oral Medicine and Radiology, Sree Balaji Dental College and Hospital, Pallikaranai, Chennai Email ID:seethamds@gmail.com

[2].Department: conservative dentistry and endodontics, Designation: senior lecturer, College address with pincode: Sree Balaji Dental College and Hospital, narayanapuram , Pallikaranai- 600100
Email ID:pooranijana@gmail.com

[3] Designation- general dentist Department- Endodontist College address - National dental college and hospital, dera bassi , SAS Nagar, punjab , india - 140201 Email ID:navgurm7@gmail.com

[4].Designation - POST GRADUATE Dept- PROSTHODONTICS College address - Sree Balaji Dental College & Hospital, Velachery Main Road, Narayanapuram, Pallikaranai, Chennai - 600 100. Tamilnadu, India Email ID:geethsmadhuri@gmail.com

[5]Reader Department: Dept of Periodontology College address: JSS Dental college and Hospital, JSSAHER, Shivarathreeswaranagara, Mysuru-570015 Email ID: dr.anithas@jssuni.edu.in

[6]. Reader Dept: Oral Medicine and Radiology College address: Dayananda Sagar College of Dental Sciences, shavige Malleshwara Hills, kumaraswamy layout, Bangalore 560111 Email ID: preetipatil@dscds.edu.in

Corresponding Author: Reader, Department of Oral Medicine and Radiology, Sree Balaji Dental College and Hospital, Pallikaranai, Chennai Email ID:seethamds@gmail.com

***Received:** Jun 28. 2025;* ***Accepted:** Jul. 29, 2025;* ***Published:** Sep 4,2025*

ABSTRACT

Laser technology has changed dental practice through accuracy, minimal invasiveness, and greater patient comfort. It is applied in different procedures, including the removal of cavities, reshaping the gums, and the treatment of periodontal disease. Advantages include less pain, quicker healing, and reduced use of anesthesia. Recent advances in technology, such as erbium and diode lasers, have enhanced the outcome of treating hard and soft tissues. Though there are challenges like being expensive and requiring special training, the future of laser dentistry looks bright, with a lot of possibilities for further application in preventive treatments, early disease diagnosis, and more effective treatments, leading to improved patient experiences and improved quality of care.

Keywords: Hard tissue lasers; Lasers; Soft tissue lasers.

INTRODUCTION

The word "laser" is an acronym for "Light Amplification by Stimulated Emission of Radiation." Technology produces intense beams of light that can be used to precisely cut, mold, or dissect tissue. Laser therapy, a key component of modern dental practice, has its origins in hypotheses proposed by Albert Einstein in 1917 and was experimentally confirmed by Theodore Maiman in 1960.

Although lasers were introduced into medicine during the mid-20th century, their use in dentistry gained popularity in the 1980s, with broader application becoming feasible in the 1990s after advancements improved their accuracy and reduced patient discomfort[1]. Since then, laser technology has profoundly transformed dentistry, enabling precise, effective, and non-invasive treatments for a wide range of oral conditions. It has evolved significantly, leading to numerous applications in both therapeutic and diagnostic dentistry[2]. The ability of laser beams to stimulate cells at a biological level has allowed their integration across all branches of dentistry.

Today, laser treatments are valued for their ease of use, effectiveness, patient comfort, and improved performance compared to traditional methods. Thus, this review comprehensively explores the latest advancements in laser technologies, highlights current and emerging clinical applications, and examines future trends that are poised to shape the trajectory of laser dentistry.

Principles of Laser Technology in Dentistry

Lasers work by changing light energy into heat by means of photothermal reactions. The basic elements of a laser system are a gain medium (solid-state, gas, or liquid), a pumping source (electrical or optical), and an optical feedback cavity or resonator. The pumping mechanism excites photons to generate energy, and the optical resonator, constructed of parallel mirrors, multiples this energy into a focused beam. Laser light is distinguished by being monochromatic, coherent, and collimated [3, 4].

The interaction between laser light and mucosal tissues includes processes like absorption, transmission, reflection, and scattering. As target tissues absorb laser energy, it increases the temperature, creating photochemical effects according to the water content of the tissues. At temperatures up to 100°C, ablation is produced, so water in the tissues vaporises; those over 200°C may cause dehydration and carbonisation. The precise wavelength of the laser, delivery system (e.g., fiber optic cable, hollow waveguide, articulated arm), and cooling system (water or air) are essential for controlling interaction and avoiding thermal damage. Knowledge of these principles enables clinicians to choose the correct laser for the intended treatment effect [5].

Types of Lasers

Dental lasers are categorized in accordance with their lasing medium, wavelengths, tissue appropriateness, and active medium type (Figure 1). The various types of lasers work at different wavelengths, each of which is appropriate for a particular dental treatment.

Erbium (Er) Lasers	Carbon Dioxide (CO2) Lasers	Diode Lasers	Neodymium (Nd) Lasers
They absorb well in water and hydroxyapatite, so they are used for both hard tissue and soft tissue applications, including cavity preparation, bone remodeling, and periodontal therapy. Er: YAG lasers are efficient in removing calculus and debridement of infected root canals. Er: YAG at 2940 nm and Er,Cr: YSGG at 2780 nm.	Mainly employed in soft tissue surgery such as gingivectomy and excision of oral lesions. They also exhibit strong absorption with hydroxyapatite for the prevention of caries. 966 nm, or 10,600 nm.	These can be used for oral surgery, endodontic procedures, aesthetic remediations, and soft tissue therapies. Diode lasers are safer for soft tissue because they generate less heat than some other lasers. Blue-violet diode lasers (450 nm and 405 nm) are also employed. Ranging from 445 nm to 1064 nm, commonly 635 nm, 670 nm, 810 nm, 830 nm, 980 nm, 1064 nm.	Used in the management of soft tissues, root canal treatment, and decontamination of peri-implantitis sites because of their strong antimicrobial effects and deeper penetration of tissues. Nd:YAG at 1064 nm
Excimer Lasers	**Argon Lasers**	**Helium-Neon (He-Ne) Lasers**	**Potassium Titanyl Phosphate Lasers**
Useful for disinfecting root canals and eliminating infected hard tissues with minimal thermal effects. 308 nm.	Used in minor surgery, curing resins, and tooth whitening. 488–515 nm.	Applications include caries detection and diagnosis, wound healing, and reduction of pain, especially in soft tissue treatments. 633 nm.	Application for hard tissue treatments, bleaching, and TMJ surgery. 532 n

Figure 1. Types of Lasers.

Technological Advancements in Lasers

Advances in laser technology over the recent past have greatly enhanced the effectiveness and safety of laser-assisted dental treatments. There has been a main emphasis on the integration of lasers with digital dentistry, merging them with 3D scanning, CAD/CAM systems, and artificial intelligence (AI) to augment accuracy, efficiency, and customized treatment planning. One of the notable technological breakthroughs is variable square pulse (VSP)

Seethalakshmi Chiranjeevi, Pooraninagalakshmi J, Navneet Gurm, D G Madhuri,Anitha Subbappa Designation, Preeti Patil Designation Laser Dentistry: Advancements, Clinical Applications and Future Prospects.Bulletin of Stomatology and Maxillofacial Surgery.2025;21(8).154-158 doi:10.58240/1829006X-2025.21.8-154

Technology offers practitioners more control over the and degree of laser treatment beyond what is possible with regular scalpels or drills[6]. Building on this innovation, the quantum square pulse (QSP) Mode is an exclusive mode that breaks up a longer laser pulse into multiple short "pulse quanta"[7]. This efficiently provides short, high-finesse pulses, minimizing unwanted effects such as scattering in debris clouds in hard tissue ablation, resulting in sharper, cleaner margins and increased bond strength. It also accelerates the speed of cavity preparation by up to 1.75 times and reduces noise levels, providing greater patient comfort. The precision of laser treatments is further enhanced by digitally controlled handpieces (e.g., Fotona's X-Runner®), which enable automatic laser beam guidance with adjustable spot size and shape, enhancing accuracy and speed, particularly for large hard and soft tissue removal and surface treatments[8]. The X-Runner is capable of operating in high-density scanning (HDS) mode for even smoother finishes and deeper ablation. At the forefront of laser innovation is the LightWalker system, an extensive dental laser system from Fotona providing pain-reducing treatment of soft and hard tissues, accelerated healing, bloodless and sutureless surgery of soft tissues, efficient periodontal treatments, and endodontic and cosmetic treatments in safety. It includes a green pilot beam for better visibility during surgery and a new straight-tip handpiece to support superior ergonomics. Beyond cutting and ablating tissue, lasers are also playing a vital role in therapeutic and regenerative applications. Photobiomodulation (PBM), formerly known as low-level laser therapy/LLLT, utilizes low-level lasers to drive cellular activity without producing notable heat, fostering tissue repair, pain relief, and inflammation regulation[9]. It is especially valuable for post-surgical recuperation, bone remodelling, and treating ailments such as mucositis and temporomandibular joint disease. In addition, Photodynamic therapy (PDT) uses laser-activated dyes to specifically kill pathogens and undesirable eukaryotic cells in infected tissues, providing a non-invasive treatment for oral infections and lesions, such as precancerous and cancerous conditions[10] Together, these technologies have the goal of making dental procedures quicker, less intrusive, more comfortable, and with better results.

Clinical Applications

Laser technology is significant in the field of dentistry. It enhances the performance of dental interventions on both hard and soft tissues with greater control and accuracy compared to conventional techniques[11]. Lasers gained popularity in dental procedures during the 1990s due to their advantages, such as high precision and minimal pain following surgery[12]. Lasers can make intensityp recise incisions, inflicting less trauma to the surrounding areas and enabling faster healing and less swelling [11]. They also minimize the requirement of local anaesthetic in certain procedures, increasing comfort for patients by eliminating the vibration and noise of conventional dental equipment. In soft and hard tissue surgeries, lasers minimize blood loss and pain, enhancing the patient's experience [13]. Lasers also maintain the surgical field free from blood and dampness, reducing the post-operative risk of infection [12]. These advantages render laser technology a superior alternative to conventional techniques for most dental procedures, more efficient and comfortable in contemporary dentistry.

Lasers in Soft Tissue Surgery

Soft tissue lasers in surgery are gaining widespread use because of their advantages over traditional surgical methods. Dental lasers act upon soft tissues owing to the selective absorption of their wavelength by hemoglobin and water. Lasers are ideal for cutting, vaporizing, and coagulating soft tissues, hence providing adequate control of bleeding with minimal pain post-surgery [13].The laser beam cuts, coagulates, and precisely removes soft gingival tissues. Controlled energy minimizes bleeding through the congealing of blood vessels, and this reduces healing time. Ablation of diseased tissue and protection of the surrounding tissues are ensured by precise cutting edges.

Lasers applied in soft tissue surgery can be utilized in operations such as gingivectomies, frenectomies, excision of mucosal lesions, and gingival tissue reshaping. In a gingivectomy, the laser can extirpate excessive hypertrophied gingival tissue with little bleeding since it can instantly coagulate small vessels. The operation is also less painful for the patient, uses less local anesthesia, and produces faster healing[14]. One of the principal benefits of soft-tissue laser surgery is quicker healing. The laser cauterizes nerve endings and blood vessels as it cuts, virtually eliminating post-surgery pain and infection risk. Patients who have undergone treatment with laser, unlike traditional surgery, suffer fewer complications and recover quickly[14].

Lasers in Dentistry Hard Tissue Surgery

Hard tissue lasers, especially erbium-based lasers such as Er: YAG and Er,Cr: YSGG, have been very promising in dental procedures concerned with bone and tooth structures. Erbium-based lasers are more effective in treatments like the removal of dental caries, preparation of cavities, gingivectomies, bone lesions, and periodontal surgery[15,16]. Er: YAG laser, at 2940 nm, is highly absorbed by water and therefore optimum for accurate and minimally invasive soft tissue and hard tissue cutting [17]. The lasers, such as the Nd: YAG, with a wavelength of 1064 nm, travel deeper and are best used for

Seethalakshmi Chiranjeevi, Pooraninagalakshmi J, Navneet Gurm, D G Madhuri,Anitha Subbappa Designation, Preeti Patil Designation Laser Dentistry: Advancements, Clinical Applications and Future Prospects.Bulletin of Stomatology and Maxillofacial Surgery.2025;21(8).154-158 doi:10.58240/1829006X-2025.21.8-154

decontamination of subgingival tissues because they have a high preference for pigmented tissues and hemoglobin[13]. Moreover, laser dosimetry, encompassing factors like spot size, energy output, and wavelength, plays an important role in deciding the interaction of the laser with tissues and achieving optimal outcomes[16,18,19]. Some clinical applications of hard tissue lasers are dental fissure sealing, treatment of caries, endodontic disinfection, and even tooth whitening with the use of chemical agents [15,16,18-20].

Advantages of the Use of Lasers in Dentistry

Dental lasers possess several significant benefits compared to traditional equipment. One of the most important advantages is pain reduction during treatment, which makes procedures more tolerable for patients. Lasers also provide perfect hemostasis, maintaining a dry field for surgery, which increases control and visualization during surgery [15]. Their antimicrobial nature enables decontamination of the surgical site, greatly diminishing the chance of infection after surgery [18,19]. Additionally, laser procedures are generally less invasive, resulting in quicker recovery and reduced swelling and bleeding, which increases overall patient satisfaction [20]. In endodontic and cosmetic treatments, lasers enhance sealant retention, ease access to the canals, and enable efficient disinfection, all contributing to clinical effectiveness as well as aesthetic performance [18,20].

Disadvantages of Laser Technology

While lasers have their strengths, they have significant disadvantages that can influence their widespread use. The prohibitive expense of the equipment is also a significant impediment, as sophisticated units such as erbium and CO_2 lasers range from USD 10,000 to 80,000, excluding service or calibration costs [21] In addition, there is specialized training involved to operate dental lasers safely and effectively, which may include pricey certification courses and a steep learning curve [22]. These aspects prevent small or solo practices from investing in the technology unless there is a high volume of patients[21]. Even then, the cost of treatment per case is higher with the use of lasers, and this can be an off-put for patients, particularly in low- and middle-income areas[20].

Limitations of Laser Application in Dental Practice

Several clinical limitations also limit the extensive use of lasers in dentistry. Lasers are not practical for the removal of all types of restorative materials, such as amalgam or ceramic crowns, nor are they always efficient for treating extremely deep caries or severe tooth decay[18,23]. In bone operations or extensive periodontal treatments, their short depth of penetration may not be consistent or effective enough [24]. Additionally, laser procedures are occasionally slower than conventional techniques, particularly in cavity preparation, as observed by Coluzzi et al., which impacts clinic efficiency[25]. Another essential issue is the potential for thermal damage when improperly using the laser; excessive power or improper wavelengths can result in permanent tissue damage, especially with prolonged or extensive procedures[26].Last but not least, though lasers augment oral disinfection, particularly against periodontal microorganisms, this advantage has not yet fully replaced traditional chemical agents and mechanical debridement[20].

Future Prospects and Emerging Trends

The future of laser dentistry is bright, with the constant development of technology and research[27]. With technology becoming less costly and more readily available, one can only expect that there will be increasingly more dental clinicians who use laser-based treatments. New laser dentistry trends are convergence with digital dentistry: Using lasers as part of digital tools, like 3D scanning and CAD/CAM (Computer-Aided Design and Computer-Aided Manufacturing) systems, can be used for more efficient and accurate treatments. Scientists are investigating the creation of new lasers with various wavelengths to enhance their application in dental treatments. These advances will allow for more versatile treatments with even greater precision and efficiency. More comfort for the patient: As laser technology advances, treatments will become more comfortable for patients. As technology improves, lasers in the future will be quicker, less invasive, and even shorter in length and less painful.

CONCLUSION

Laser technology has revolutionized the field of dentistry, providing unmatched precision, reduced invasiveness, and improved patient comfort. From daily cavity extraction and gum recontouring to advanced treatment of periodontal diseases, implant placement, and sophisticated diagnostic procedures, lasers offer new ways to address typical dental issues. Although there are still issues, mainly in relation to the high capital expense of equipment, the requirement for specialized training, and standardization of procedures, continued developments in laser technology are constantly resolving these hurdles. The future of laser dentistry is highly optimistic, with studies concentrated on widening the scope of conditions that can be treated, enhancing accuracy, and combining with digital systems and artificial intelligence. As technology advances and becomes more mainstream, lasers will increasingly be at the forefront of delivering dental care, establishing new benchmarks for accuracy, patient comfort, and overall success of treatments in oral health. The revolutionary potential of lasers is why they are so crucial to contemporary dental practice, with the potential to deliver safer, more predictable, and functionally and aesthetically better results for patients.

DECLARATIONS

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable.

Competing interests

The authors declare no conflict of interest.

Funding

This research received no external funding.

REFERENCES

1. Parker S. Introduction, history of lasers and laser light production. Br Dent J. 2007;202(1):21-31.
2. Liaqat S, Qayyum H, Rafaqat Z, Qadir A, Fayyaz S, Khan A, et al. Laser as an innovative tool, its implications and advances in dentistry: A systematic review. Journal of Photochemistry and Photobiology. 2022;12:100148.
3. Romanos GE. Laser Fundamental Principles. Advanced Laser Surgery in Dentistry; Wiley Blackell: Hoboken, NJ, USA. 2021:3-11.
4. Herd RM, Dover JS, Arndt KA. Basic laser principles. Dermatologic clinics. 1997;15(3):355-72.
5. Khanin YI. Principles of laser dynamics: Newnes; 2012.
6. Nemeš K, Lukač M, Možina J. Variable square pulse vs conventional PFN pumping of Er: YAG laser. Optics & Laser Technology. 2012;44(3):664-8.
7. Gutknecht N, Lukac M, Marincek M, Perhavec T, Kazic M. A novel quantum square pulse (QSP) mode erbium dental laser. J LAHA. 2011;1:15-21.
8. Primc NM, Lukac M. Quantum square pulse mode ablation measurements with digitally controlled Er: YAG dental laser handpiece. J Laser Health Acad. 2013;1:1-5.
9. Rezende SB, Campos L, Palma LF, Tateno RY, Simões A, Macedo MC, et al. Photobiomodulation and antimicrobial photodynamic therapy for oral cytomegalovirus reactivation following acute graft-versus-host disease. Photodiagnosis and Photodynamic Therapy. 2020;32:101849.
10. Allison RR, Huang Z, Moghissi K. Tools of clinical Photodynamic Therapy (PDT): A Mini Compendium. Photodiagnosis and Photodynamic Therapy. 2024;46:104058.
11. Myers TD. The future of lasers in dentistry. Dental Clinics of North America. 2000;44(4):971-80.
12. Maiman TH. Stimulated optical radiation in ruby. nature. 1960;187(4736):493-4.
13. Romanos G, Nentwig G-H. Diode laser (980 nm) in oral and maxillofacial surgical procedures: clinical observations based on clinical applications. Journal of clinical laser medicine & surgery. 1999;17(5):193-7.
14. Kimura Y, Wilder-Smith P, Matsumoto K. Lasers in endodontics: a review. International endodontic journal. 2000;33(3):173-85.
15. Diaci J, Gaspirc B. Comparison of Er: YAG and Er, Cr: YSGG lasers used in dentistry. J laser health Acad. 2012;1(1):1-13.
16. Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. National journal of maxillofacial surgery. 2012;3(2):124-32.
17. Parker S. Laser-tissue interaction. British dental journal. 2007;202(2):73-81.
18. Malcangi G, Patano A, Trilli I, Piras F, Ciocia AM, Inchingolo AD, et al., editors. Therapeutic and adverse effects of lasers in dentistry: A systematic review. Photonics; 2023: MDPI.
19. Minamizato T. Slip-cast zirconia dental roots with tunnels drilled by laser process. The Journal of prosthetic dentistry. 1990;63(6):677-84.
20. Ting M, Alluri LSC, Sulewski JG, Suzuki JB, Paes Batista da Silva A. Laser treatment of peri-implantitis: A systematic review of radiographic outcomes. Dentistry journal. 2022;10(2):20.
21. Tzanakakis E-GC, Skoulas E, Pepelassi E, Koidis P, Tzoutzas IG. The use of lasers in dental materials: A review. Materials. 2021;14(12):3370.
22. Naidoo S, Mulder R. The use of laser-based technologies in dentistry: ethical issues and safety considerations: ethics case. South African Dental Journal. 2015;70(10):464-6.
23. Kumar M, Vyas T, Kewalia K, Barupal S. Laser in Dentistry-A Review. UNIVERSITY JOURNAL OF DENTAL SCIENCES. 2023;9(2).
24. Panova NK, Nikolova KT, Dikova TD. Application of lasers and laser processing technologies in modern dentistry: A review. Journal of Chemical Technology and Metallurgy. 2023;58(6):1116-27.
25. Agop-Forna D, Salceanu M, Topoliceanu C, Cretu C, Vasincu D, Forna N. Dental lasers in restorative dentistry: a review. Romanian journal of oral rehabilitation. 2021;13(2):7-17.
26. Alghamdi M, Halawani M, Alarawi H, Alzaidi A, Alhogail L, Alsobhi S, et al. The Use of Laser Technology in Dentistry: A Comprehensive Review. Migr Lett. 2022;19:577-86.
27. Sharma R, Pandit S. Laser technology in dentistry: Advancements, applications, and future trends.

Seethalakshmi Chiranjeevi, Pooraninagalakshmi J, Navneet Gurm, D G Madhuri,Anitha Subbappa Designation, Preeti Patil Designation Laser Dentistry: Advancements, Clinical Applications and Future Prospects.Bulletin of Stomatology and Maxillofacial Surgery.2025;21(8).154-158 doi:10.58240/1829006X-2025.21.8-154