Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies *NLM ID: 101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 100

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Review Article

LASER Assisted Dentistry: A Comprehensive Review

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ABSTRACT:
The word LASER stands for "Light Amplification by the Stimulated Emission of Radiation." Originally introduced to dentistry by Miaman in 1960, lasers have since found multiple applications in both hard and soft tissues. Recently, this advanced technology has been incorporated into dental practices with the goal of replacing traditional drilling methods. By utilizing lasers, we can offer a more comfortable first dental experience, making it a valuable preventive and therapeutic approach. Lasers are particularly effective for detecting and removing cavities, performing vital pulp therapy, lowering the risk of infections and inflammation, and promoting hemostasis. Additionally, because of their minimally invasive nature, laser treatments are generally well-received by children and those with dental anxieties. This literature review aims to shed light on the various types of lasers available and their applications in the field of dentistry.
Keywords: Laser, Application, Dentistry

Received: 13 June, 2025 Accepted: 28 June, 2025 Published: 10 July, 2025

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This article may be cited as: Hazari P, Sidral SY, Palekar SS, Rajan M, Rajan S, Mahindrakar R. LASER Assisted Dentistry: A Comprehensive Review. J Adv Med Dent Scie Res 2025; 13(7):70-74.

INTRODUCTION TO LASER ASSISTED DENTISTRY

Dental lasers are devices that utilize focused light to perform a variety of dental procedures with precision and efficiency. Defined simply, a laser (Light Amplification by Stimulated Emission of Radiation) emits a beam of light that can interact with tissues in different ways, depending on the wavelength and energy of the laser. In dentistry, lasers are employed for soft and hard tissue procedures, providing an alternative to conventional dental tools.[1]

The history of laser dentistry dates back to the early 1960s, when the first laser was developed by physicist Theodore Maiman. It was the ruby laser, primarily utilized in research and limited medical applications. In the late 1980s, advancements led to the approval of the first dental laser by the FDA. The Erbium:YAG laser, introduced in 1997, represented a significant breakthrough, specifically designed for dental hard tissue applications. Over the years, various types of lasers, including the diode, Nd:YAG, and CO2 lasers, have gained traction in dental practices, each tailored to specific applications in oral health care.[2-4]

Importance and Growth of Laser Technology in Dentistry: The importance of laser technology in dentistry cannot be overstated. Lasers have

transformed various dental procedures by offering several benefits over traditional techniques:[5,6]

1. Minimally Invasive: Lasers allow for more conservative treatment options, preserving healthy tissues while effectively targeting diseased or damaged areas. This results in less trauma during procedures.
2. Reduced Pain and Anxiety: The precision of lasers often results in less pain for patients, reducing the need for anesthesia and minimizing discomfort. This can also alleviate dental anxiety, encouraging more individuals to seek care.
3. Faster Healing and Recovery: The use of lasers typically promotes faster tissue healing and reduces inflammation due to their ability to sterilize the area being treated. This leads to shorter recovery times.
4. Lower Risk of Infection: Lasers' ability to coagulate blood vessels and sterilize tissues during procedures significantly lowers the risk of post-operative infections.
5. Expanded Treatment Options: The versatility of lasers enables their use in a wide range of applications, including cavity preparation, gum reshaping, and teeth whitening, among others.

As public awareness of these benefits has grown, so has the adoption of laser technology in dental practices. Research indicates an increasing trend towards integrating laser technology into routine dental care, with many dental schools incorporating laser education into their curricula. This shift reflects a broader recognition of the efficacy and value lasers bring to dental treatments.

This comprehensive review aims to provide an in-depth exploration of laser-assisted dentistry, consolidating existing knowledge while shedding light on emerging trends and future directions.

Types of Lasers Used in Dentistry: The application of lasers in dentistry has revolutionized many traditional procedures, allowing for increased precision, reduced discomfort, and improved healing times. The overview of the various types of lasers used in dental practice, categorized by their applications in hard and soft tissue procedures as well as diagnostic functions.[7,8]

Hard Tissue Lasers: Hard tissue lasers, such as the Erbium:YAG (Er:YAG) and Erbium:Chromium doped Yttrium Scandium Gallium Garnet (Er:Cr:YSGG) lasers, are effective in treating dental hard tissues, primarily enamel, dentin, and bone.

Erbium:YAG Laser: The Er:YAG laser operates at a wavelength of 2940 nm, which is highly absorbed by water and hydroxyapatite, making it particularly effective for hard tissue applications. This laser allows for precise cutting and is commonly utilized in:

a) Cavity Preparation: The Er:YAG laser can efficiently remove decayed tooth structure without the need for traditional dental drills. The laser's precision minimizes damage to surrounding healthy tissue and reduces the vibrations and noise typically associated with drilling, contributing to a more comfortable patient experience.

b) Bone Surgery: This laser is also effective in performing osteotomies and bone resurfacing procedures due to its ability to achieve precise cuts and coagulate blood vessels. The minimally invasive nature of the treatment reduces post-operative pain and promotes faster healing.

Erbium:Cr:YSGG Laser: The Er:Cr:YSGG laser operates at a wavelength of 2780 nm and has similar properties to the Er:YAG laser, but with some distinctions that enhance its versatility across different applications. Key applications include:

a) Cavity Preparation: Like the Er:YAG, the Er:Cr:YSGG laser offers efficient cavity preparation. It is especially useful for removing tough decay while preserving surrounding tooth structures, leading to minimal discomfort and greater patient satisfaction.

b) Bone Surgery: This laser can also be applied in surgical procedures involving bone. Its unique absorption wavelengths enable effective interaction with both bone and soft tissues, making it suitable for procedures such as bone cutting and reshaping in implantology.

Soft Tissue Lasers: Soft tissue lasers are specifically designed for procedures involving oral soft tissues. The most common types are diode lasers and Nd:YAG lasers.

Diode Lasers: Diode lasers operate at wavelengths ranging from 810 nm to 980 nm. They are highly effective in soft tissue procedures due to their versatility and ease of use:

a) Periodontal Treatments: Diode lasers are commonly used in various periodontal therapies, such as gingival reshaping, gum disease treatment, and pocket reduction procedures. The laser's precision allows for targeted treatment, minimizing damage to adjacent healthy tissue and promoting a quicker recovery.

b) Soft Tissue Surgeries: These lasers are highly effective in frenectomies, biopsy procedures, and the removal of soft tissue lesions. The coagulating properties of diode lasers help control bleeding during surgery, further reducing post-operative complications.

Nd:YAG Lasers: Nd:YAG lasers operate at a wavelength of 1064 nm and can be used for both soft tissue and certain hard tissue applications:

a) Periodontal Treatments: Nd:YAG lasers are effective in treating periodontal disease by ablating diseased tissue and promoting the

regeneration of healthy tissues. Their ability to disinfect the surgical area reduces the risk of infections post-treatment.

b) **Soft Tissue Surgeries:** Similar to diode lasers, Nd:YAG lasers can be utilized in surgeries involving soft tissues, such as excising tumors or lesions. They provide precise cutting, minimize bleeding, and promote faster healing.

Diagnostic Lasers: The use of lasers extends beyond treatment applications and includes diagnostic functions. Diagnostic lasers are employed to enhance cavity detection and diagnostic accuracy.

a) **Caries Detection Lasers:**Dental diagnostic lasers, such as the DIAGNOdent, enable dentists to detect caries or cavities in their earliest stages. These devices primarily utilize a semiconductor laser to illuminate tooth surfaces, measuring fluorescence in the enamel. When the laser light shines on a tooth, healthy enamel reflects the light differently than decayed tissue. This allows for:

b) **Early Detection:** Cavities that are not visible through traditional examination can be identified, enabling timely intervention and minimizing the need for more invasive treatment.

c) **Increased Accuracy:** The laser's measurement capabilities provide a more objective analysis compared to visual assessments, allowing dental professionals to make better-informed decisions regarding treatment plans.

Mechanism of Action of LASER: Lasers (Light Amplification by Stimulated Emission of Radiation) have revolutionized dental practices by providing precise, efficient, and less invasive treatment options. At the core of their application in dentistry is the interaction between laser light and biological tissues, allowing for various therapeutic benefits.

The Basic Principles of Laser Operation:A laser generates a coherent beam of light through a process that involves the excitation of atoms or molecules in a gain medium (solid, liquid, or gas). Upon excitation, these entities emit photons, which are reflected back and forth through mirrors, amplifying the light until it is emitted as a concentrated beam.Lasers can be classified based on their wavelength, mode of operation, and the state of the gain medium.

Types of Lasers Used in Dentistry:Common dental lasers include diode lasers, Nd:YAG lasers, Er:YAG lasers, and CO2 lasers, each having specific applications based on their properties and wavelengths.

Interaction of Laser Light with Biological Tissues: The interaction of laser light with biological tissues is critical for understanding its effectiveness in dental treatments. This interaction can be categorized into several mechanisms:

Absorption: The efficacy of a laser in treating dental tissues is determined by how well the laser wavelength is absorbed by the target tissue.Different chromophores (molecules that absorb light) within the tissues, such as water, hemoglobin, and melanin, interact with specific wavelengths.

For instance, dental hard tissues (enamel and dentin) are more responsive to certain wavelengths (e.g., Er:YAG lasers), while soft tissues (gingiva, mucosa) can be effectively treated with wavelengths absorbed by hemoglobin and water.

Transmission: Beyond absorption, laser light can also penetrate and transmit through tissues. The depth of penetration is influenced by the laser wavelength and the tissue's properties.

For example, longer wavelengths may penetrate deeper into tissues, while shorter wavelengths may be absorbed more rapidly, affecting their overall therapeutic action.

Importance of Wavelength in Laser Effectiveness: The wavelength of a laser is perhaps one of the most crucial factors determining its effectiveness in dental applications:

Wavelength-Specific Absorption: Each tissue type has a unique absorption spectrum; thus, selecting the appropriate laser wavelength can enhance treatment efficacy.Shorter wavelengths (such as those used in lasers targeting soft tissues) are beneficial for procedures like gingival surgery, while longer wavelengths can be advantageous for hard tissue applications.

Thermal Effects: Different wavelengths can produce varying thermal effects, impacting cellular response.Higher absorption results in more localized heating, which can lead to tissue coagulation, and in some cases, ablation (removal of tissue) without damaging surrounding areas.

Safety Considerations: The choice of wavelength also involves considerations of safety and minimizing harm to adjacent tissues. Wavelengths that are selectively absorbed by the target tissue can minimize collateral damage to surrounding healthy tissue.

Application of Laser in Dentistry: Various application of Laser is summarized n Table 1.

Table 1:Application of Laser in Dentistry[1,2,9-11]	
Application	**Description**
Soft Tissue Surgery (Gingival Contouring, Frenectomy)	Using lasers for soft tissue procedures like gingivectomy reduces inflammation and promotes rapid healing.
Hard Tissue Surgery (Cavity Preparation, Bone Recontouring)	Lasers are used to remove caries and reshape bone; they are effective on hard tissues like enamel and dentin
Root Canal Therapy (Root Canal Laser Assisted Irrigation)	Sterilizing root canals with the laser to eliminate bacteria, improving endodontic treatment.
Teeth Whitening	Speeding up the whitening process by activating bleaching agents with the laser.
Pain Management and Biostimulation	Low-level laser therapy (LLLT) reduces pain and stimulates tissue after procedures.
Periodontal Treatments	Laser periodontal treatment to reduce periodontal pockets and stimulate tissue regeneration
Oral Lesions and Precancerous Conditions Treatment	Laser removal of oral lesions and treating precancerous conditions with minimal scarring.
Diagnosis	Dental Caries Pulp Vitality

Advantages of Laser in Dentistry[5,6]

1. No need for anesthesia or drilling.
2. Reduced blood loss and pain, with hemostatic and analgesic effects.
3. Decreased post-operative swelling.
4. Minimal scarring after surgery.
5. Sterilizes the treatment area.
6. Diminished caries activity due to laser exposure on tooth enamel.
7. Helps alleviate fear and anxiety in patients.
8. Beneficial for patients with medical conditions.

Disadvantages of Laser in Dentistry[5,6]

1. The laser beam can be harmful to both the patient and operator, potentially causing retinal burns from direct or reflected light.
2. Higher cost compared to traditional methods.
3. Requires qualified personnel to operate.
4. Ineffective for removing defective crowns or silver fillings.

Future Trends in Laser Dentistry: The continuous advancement of laser technology is paving the way for more efficient and precise treatments. New wavelengths and delivery systems are being developed to target dental tissues more effectively.Emerging laser systems are designed to be more user-friendly for practitioners while offering enhanced comfort for patients.

Potential for New Applications in Various Dental Specialties: Research is expanding the potential applications of lasers in specialties such as orthodontics, endodontics, and periodontics, promising to enhance treatment outcomes.For example, lasers are being tested for efficiency in root canal treatments and tooth whitening, showcasing their versatility and effectiveness across various dental procedures.

Ongoing Research and Clinical Trials: Numerous clinical trials are underway to validate the efficacy and safety of laser-assisted therapies in broader contexts. This includes exploring laser use in soft tissue surgeries and the treatment of oral diseases.
Findings from ongoing research are anticipated to contribute to developing standardized protocols for laser use in dentistry, further establishing its role in modern practice.

Summary of the Current State of Laser-Assisted Dentistry

1. Laser dentistry has emerged as an effective alternative to traditional methods, with significant benefits in terms of patient comfort, healing time, and treatment precision.
2. The integration of lasers into dental practices is becoming more common, with positive feedback from both practitioners and patients.
3. Consideration of Future Directions: As technology evolves, the possibilities for laser applications in dentistry will continue to expand. This evolution will likely enhance patient care and treatment options available to practitioners.Future advancements may lead to improved patient outcomes and a shift in standard practices within the dental field.

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