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Review Article

Laser Dentistry: A Painless Revolution in Oral Care

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Abstract

The use of laser technology in dentistry has revolutionized various diagnostic and therapeutic procedures, offering significant advantages over traditional methods. This paper provides an overview of the applications, benefits, and limitations of laser use in dental practice. Lasers in dentistry can be categorized based on their applications in soft tissue and hard tissue procedures. Soft tissue lasers are utilized for periodontal therapy, oral surgery, and aesthetic procedures, promoting haemostasis and reducing post-operative pain and swelling. Hard tissue lasers, including those used for cavity preparation and caries removal, offer precision and minimal thermal damage to surrounding tissues. The paper discusses the mechanisms of action, types of lasers commonly used in dental practices, and their specific clinical applications. Furthermore, it examines the cost-effectiveness, safety considerations, and patient acceptance associated with laser dentistry. Despite the high initial investment and the need for specialized training, the integration of laser technology in dentistry promises enhanced clinical outcomes, greater patient comfort, and expanded treatment possibilities. Continued advancements and research in laser technology are expected to further solidify its role as a cornerstone in modern dental care.

***Keywords**: Laser; Wavelength; Treatment; Anaesthesia; Tissue; Procedure; Light; Bleeding; Healing*

Introduction

The introduction of lasers in dentistry represents a significant technological advancement that has transformed various aspects of dental practice. Laser technology, which utilizes focused light beams to perform precise surgical and therapeutic procedures, has been adopted to enhance both the efficacy and comfort of dental treatments. The use of lasers in dentistry began in the late 20th century and has since evolved, offering numerous benefits over traditional methods, such as reduced pain, minimized bleeding, and faster healing times.

Lasers are now employed in a variety of dental procedures, including cavity detection, tooth whitening, soft tissue management, and hard tissue preparation. Different types of lasers, such as diode, Nd, and Er, are used depending on the specific dental application, each providing unique advantages in terms of precision and versatility.

This review article aims to explore the current state of laser technology in dentistry, examining its applications, benefits, limitations, and future prospects. By analysing recent advancements and clinical outcomes, this review seeks to provide a comprehensive understanding of how lasers are reshaping dental practices and improving patient care.

History

Since its introduction, the use of lasers in dentistry has advanced dramatically, improving patient comfort and precision throughout a range of dental treatments [1].

Initial development

- 1960: Theodore Maiman created the first functional laser, a ruby laser.
- 1964: Dr. Leon Goldman experimented with lasers for dental purposes, leading the way in the use of lasers in medicine.

Dentistry: An Introduction-1989: The FDA granted approval for the Nd-YAG laser, the first laser created especially for dental applications. Soft tissue operations were its main application.

Developments in the nineties-1990s: Dental applications have grown as a result of the invention and introduction of several laser types, such as CO_2 lasers, Er-YAG lasers, and diode lasers. With the use of these lasers, operations on both hard and soft tissue application.

1997: A major turning point in laser dentistry was reached when the FDA authorized the use of the Er-YAG laser on hard tissues, including teeth and bone.

21st century developments-2000s: Laser technology advanced to enable for more accurate and controlled procedures, making lasers more versatile and sophisticated. This featured enhancements to distribution systems, power settings, and wavelength specificity.

2004: The Waterlase system, developed by BIOLASE, was introduced. It combined laser light and a water spray to conduct a greater variety of dental treatments with less discomfort and anaesthetic.

Contemporary uses-2010s-present: The field of laser dentistry has expanded its applications and become more widely used as a result of ongoing innovation. Dental lasers of today are utilized for biopsies, cavity preparation, gum disease therapy, tooth whitening, and more. Thanks to improvements in safety measures and laser-tissue interaction, the technology is now more user-friendly [1].

With continuous research and development aimed at enhancing efficacy, efficiency, and LASER patient outcomes, laser dentistry is still evolving.

Dental laser classification [2]:

i. According to the wavelength (nanometers)

a. UV (ultraviolet) range - 140 to 400 nm
b. VS (visible spectrum) - 400 to 700 nm
c. IR (infrared) range - more than 700 nm.

Most lasers operate in one or more of these wavelength regions.

ii. Broad classification

a. Hard laser (for surgical work)

i. CO_2 lasers (CO_2 gas)
ii. Nd:YAG lasers (Yttrium-aluminium-garnet crystals dotted with neodymium)
iii. Argon laser (Argon ions)

b. Soft laser (for biostimulation and analgesia)

i. He-Ne lasers
ii. Diode lasers
iii. According to the delivery system

a. Articulated arm (mirror type)
b. Hollow waveguide
c. Fiber optic cable

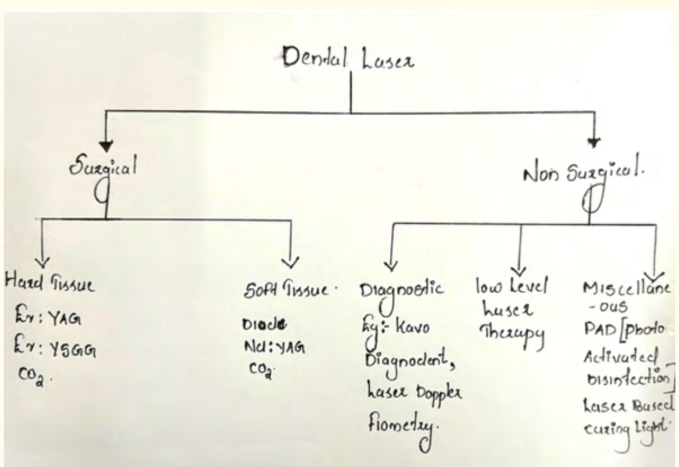
iv. According to the type of active medium used: Gas, solid, semi-conductor or dye lasers
v. According to type of lasing medium: E.g. Erbium: Yttrium Aluminium Garnet

vi. According to pumping scheme

a. Optically pumped laser
b. Electrically pumped laser.

vii. According to operation mode:

a. Continuous wave lasers
b. Pulsed lasers.



Figure

Types of laser

There are several ways to categorize lasers used in dentistry practices: The selection of a lasing medium, such as gas or solid, the suitability of different types of tissue for application (hard or soft tissue lasers), the range of wavelengths and the inherent risks involved with laser application are all taken into consideration.

Argon laser

The laser uses ionized argon gas as its active medium, emitting light at two wavelengths (488 nm and 514 nm) in dentistry. These wavelengths are well-absorbed in enamel and dentin, making them useful for cutting and shaping gingival tissues. Argon lasers are useful for treating vascular abnormalities and periodontics due to their bactericidal properties.

Diode laser

Diode lasers, with wavelengths of 800 nm for aluminium and 900 nm for indium, gallium, and arsenic, are used in soft tissue surgical procedures like gingivoplasty and sulcular debridement. These portable, compact devices promote fibroblastic growth and allow for safer surgery due to the tissue's inability to absorb these wavelength.

Nd-YAG laser

Soft-tissue operations using Nd-YAG laser treatments, with a wavelength of 1064 nm, provide good haemostasis and a clean working field. This laser is recommended for gingival and sulcular debridement operations, early cavity elimination, and pulpal analgesia. However, it operates less efficiently than Er: YAG or Er: chromium (Cr):YSGG lasers.

Erbium laser

Erbium lasers, with a 2780 nm active medium and a 2940 nm active medium, are used to remove dental cavities. The laser's erbium crystals, Cr-YSGG and YAG, provide precise, clean margins and minimize pulpal injury. The laser's lower depth of penetration also makes it analgesic, making it a preferred choice for caries removal. It also aids in removing endotoxins from root surfaces.

CO_2 laser

A laser, a gas discharge with a wavelength of 10,600 nm, is used to treat wounds by slicing and coagulating soft tissue. This laser wavelength creates a clean working field, allowing for penetration depth and minimal post-operative discomfort. However, wound healing can be slowed due to the gas discharge, and the surgeon may experience loss of touch sensation. Despite these drawbacks, with proper technique, tissue ablation can be precisely performed, ensuring a clean working field for the treatment of wounds [3].

Principles of laser

Lasers are based on the fundamental idea of stimulated radiation emission, where atoms or molecules in a material release energy when they fall back to a lower energy state in the form of photons. This release, known as coherent light, is produced by incoming photons of a particular wavelength. To function, the laser medium's population needs to be flipped, indicating more excited atoms or molecules than lower energy states. The optical cavity, formed by two mirrors at either end of the laser medium, amplify light by allowing photons to travel through the mirrors numerous times, ensuring coherent, directed laser light. Laser light is typically monochromatic, with only one colour or wavelength due to the laser medium's unique energy levels and the optical cavity's construction. The laser's highly collimated light beam remains narrow across a considerable distance due to its coherent nature. A gain medium, composed of gas, liquid, or solid, stimulates light emission to increase its intensity [4].

Mechanism of laser action

Lasers are utilized in dentistry for various operations, such as gum surgery, teeth whitening, and cavity preparation. The laser generation process involves the stimulated emission of radiation, which generates a concentrated beam of light with a specific wavelength. This light interacts with teeth tissues, affecting their properties. Different laser wavelengths are absorbed by different tissues, such as soft tissue, dentin, and enamel. Some lasers are better suited for soft tissue treatments, while others are better at cutting hard tissues like enamel. The energy of the absorbed laser light is transformed into heat.

The dental laser uses a hollow wave guide, focusing lenses, cooling system, and fiberoptic cable to direct light toward the desired tissue. The action is based on the Amdt-Schutz principle, which indicates that the impact will decrease or cease if the stimulus is increased or decreased above the ideal dosage. Laser light has one wavelength and is monochromatic. The laser system requires energy from a pumping mechanism, which is more drawn to particular light wavelengths. The wavelength determines the depth of penetration and absorption in the target tissue. Some lasers can pierce tissue more deeply than others, while others have limited penetration [5].

Soft tissue application

- Gingival contouring
- Frenectomy
- Biopsy and lesion removal
- Pain relief
- Recurrent aphthous healing
- Haemostasis.

Gingival contouring

A dental technique called laser gingival contouring is performed to modify the gum tissue's shape. Through the use of diode laser, extra or irregular gum tissue can be removed, enhancing the gums' appearance and functionality. Following are some advantages of laser gingival contouring:

- Precision: The gum line may be adjusted with extreme accuracy thanks to lasers.
- Minimal bleeding: By cauterizing while it cuts, the laser lessens bleeding and speeds up healing.
- Decreased discomfort: In comparison to conventional surgical techniques, patients frequently report less discomfort.
- Faster recovery: Because the surrounding tissues are not as severely damaged during the process, recovery timeframes are usually shorter [4].

Frenectomy

A frenectomy is a dental procedure that involves removing or modifying the frenulum, a small fold of tissue connecting the lip or tongue to the gum or floor of the mouth. Laser dentistry uses a laser instead of traditional surgical tools, offering several benefits such as precision, reduced bleeding, less pain and discomfort, lower infection risk, and faster healing. Laser frenectomies are often used for conditions like tongue- or lip-tie, which can impair speech, feeding, and oral hygiene. A clinical trial suggests that Nd-YAG lasers are a feasible substitute for scalpels in frenectomy procedures due to their lower pain and discomfort after surgery, better patient tolerance, and less intraoperative bleeding compared to scalpels [4].

Biopsy and oral lesion removal

Laser dentistry is increasingly popular for biopsy and oral lesion excision due to its precision and minimally invasive nature. It offers fine-grained control over tissue removal, minimizing harm to adjacent tissues. Lasers also cause less bleeding, less pain and oedema, and faster healing due to their coagulating qualities. Depending on the location and nature of the lesion, lasers can eradicate leukoplakia, fibromas, and papillomas. The accuracy of laser cuts often reduces the need for sutures, facilitating quicker recovery. Laser light also minimizes scarring, achieving better cosmetic outcomes. Compared to conventional techniques, laser dentistry is minimally invasive, requiring less physical intervention, enhancing comfort, and sterilizing the area by heating the region. Patients find the procedures less intimidating, and postoperative problems are less common. Overall, laser dentistry offers better cosmetic outcomes and reduced infection risk [6].

Pain relief

Laser dentistry has gained popularity due to its ability to reduce pain and discomfort during dental procedures. It offers precision by removing decaying tissue or reshaping gums, reducing the need for anaesthetics. Lasers also reduce bleeding and swelling by cauterizing as they cut, reducing postoperative discomfort. Faster healing times are achieved due to less bleeding and tissue damage. Laser procedures are less invasive than older treatments, reducing overall pain and suffering. Additionally, laser dentistry reduces the risk of infection by sterilizing the tissue, reducing the chance of bacterial infections. Patients report feeling more at ease during and after the treatment [4].

Recurrent aphthous healing

Laser dentistry is a promising method for treating recurrent aphthous ulcers, which are uncomfortable lesions that develop inside the mouth. Laser treatment offers immediate discomfort relief by desensitizing nerve endings surrounding the ulcer. It also reduces healing time by promoting tissue regeneration and reducing inflammation. Regular laser treatment may lead to fewer recurrences, as it lowers the bacterial load and prevents infections that could impede the healing process. Laser dentistry is non-invasive, usually requiring no anaesthesia, making it a comfortable alternative for patients. Additionally, lasers can help reduce inflammation around the ulcer, hastening the cure of symptoms. Overall, laser dentistry offers a safe and efficient method for treating recurrent aphthous ulcers, improving patient comfort and accelerating healing [7].

Haemostasis

Laser dentistry offers several advantages for achieving haemostasis in dental procedures. It provides immediate coagulation, precision, reduced need for sutures, and minimized postoperative bleeding. Laser energy targets specific regions, limiting tissue damage and bleeding risk. It also reduces postoperative bleeding, improving visibility and effectiveness. The laser's heat sterilizes surrounding tissue, reducing postoperative infections and bleeding. Additionally, laser dentistry enhances patient comfort by reducing bleeding and the need for stitches. Overall, laser dentistry enhances dental operations' accuracy and efficiency while controlling bleeding, improving patient outcomes [7].

Hard tissue application

- Cavity detection and removal
- Tooth preparation for filling
- Enamel and dentin procedures
- Treatment of tooth sensitivity
- Root canal treatment
- Bone surgery.

Cavity detection and removal

- **Detection:** Cavities can be found early with lasers, which can also detect degradation before X-rays show them.
- **Removal:** While maintaining the integrity of the tooth's healthy structure, lasers can accurately eliminate dental decay. Drills are not necessary, and this can be completed with little discomfort [4].

Tooth preparation for filling

Using lasers, the tooth surface is made ready for fillings by generating a sterile, dry atmosphere that improves the bonding of composite fillings [4].

Enamel and dentin procedures

- **Etching:** In order to improve the adherence of restorative materials, lasers can etch dentin and enamel for bonding treatment.
- **Reshaping**: To prepare the teeth for veneers and crowns or for aesthetic reasons, lasers can reshape dentin or enamel.

Treatment for tooth sensitivity

By sealing tubules on the root surface with lasers, tooth sensitivity to hot and cold stimuli is decreased.

Root canal treatment

By eliminating germs and debris, lasers can help clean and shape the root canals more efficiently, increasing the procedure's success rate [4].

Bone surgery

Lasers are utilized in bone-related surgeries such crown lengthening, contour remodeling, and specific kinds of bone grafting. Compared to more traditional approaches, this can be done with greater precision and less trauma [8].

Advantages

- Provides bactericidal and detoxification effect.
- Less discomfort than conventional methods.
- Minimally invasive.
- No need for sutures.
- Easier tissue ablation than conventional scalpel.
- Improved visualization at surgical site.
- Less post-operative tissue edema and swelling [9].

Disadvantages

- A heavy financial load.
- Possible surface damage to teeth and roots.
- Possible harm to the dental pulp and underlying bone [10].

Conclusion

Laser technology revolutionizes dental practices, offering improved precision, pain reduction, and faster healing times. However, challenges include high upfront costs, specialized training, and applicability constraints. However, advancements in laser technology could improve patient outcomes, comfort, and clinical precision.

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