

Lasers in Periodontal Therapy

Greeshma Matharasi*, Sreehita Dantuluri, Fatima Al Farooqui

Department of Periodontics, Sri Balaji Dental College, Hyderabad, Telangana, India.

Abstract

Lasers have become an integral tool in modern periodontal therapy, offering a range of benefits over traditional methods. This review article provides a comprehensive overview of the application of laser technology in the treatment of periodontal diseases. It begins by discussing the fundamental principles of laser operation and the various types of lasers used in dentistry. Emerging trends and future directions in laser-assisted periodontal therapy are discussed, emphasizing ongoing research and technological advancements aimed at improving patient outcomes. By synthesizing current research findings and clinical experiences, this review aims to provide dental professionals with a thorough understanding of the benefits and limitations of laser technology in periodontal therapy, ultimately contributing to the optimization of patient care.

Keywords: Laser, Periodontal therapy, Soft tissue.

INTRODUCTION

Periodontal disease consists of a group of inflammatory diseases inhibited by bacteria that colonize the teeth and infect their surrounding tissues. Bacteria and their products contaminate the root surface and make it biologically incompatible for soft tissue attachment. It is well established that a clean root surface is mandatory for the stability of fragile attachment between the root surface and the gingival flap by maturing the fibrin clot. Scaling and root planing are the traditional methods of controlling subgingival microflora for the management of periodontal diseases. The objectives of subgingival debridement are to eliminate not only the adherent and unattached bacterial plaque but also deposits of calculus. Scalers and curettes have been used traditionally to achieve a clean and smooth root surface that is biologically compatible with soft tissue attachment. Lasers are the most recent introduction in the treatment of periodontal diseases. They are used for the removal of calculus and root surface detoxification, removal of the lining epithelium of the diseased pocket wall, and for their antimicrobial effect on the pocket microbiota.^[1]

HISTORICAL BACKGROUND

In 1917, Albert Einstein laid the foundation for the invention of the laser and its predecessor, “the Maser,” by theorizing that photoelectric amplification could emit a single frequency, or stimulated emission. The term LASER is an acronym for “Light Amplification by the Stimulated Emission of Radiation”

and was first introduced to the public in 1959, in an article by a Columbia university graduate student, Gordon Gould. Theodore Maiman, built the first functioning laser, by using a mixture of helium and neon. In 1961, a laser generated from crystals of yttrium-aluminum-garnet treated with 1–3% neodymium (Nd: YAG) was developed. In 1962, the argon laser was developed. In 1964, Patel at Bell laboratories developed the CO₂ laser. Nowadays diode lasers are being extensively used in the field of dentistry.

PROPERTIES OF LASER

1. **Light:** Light is a form of energy in the form of electromagnetic radiation, related to radio waves, radar, microwaves, infrared, ultraviolet, and X-rays. The basic unit of radiant energy is the photon. Light is defined by amplitude (height of wave oscillation) and wavelength (distance between wave points), with frequency measuring the number of cycles per second.
2. **Emission:** Two types of emission are observed.
 - a. **Spontaneous emission:** In 1913, Niels Bohr, a Danish physicist, developed his model of an atom, applying the quantum principle of Planck. He proposed distinct

Address for correspondence: Dr. Greeshma Matharasi,
Department of Periodontics, Sri Balaji Dental College, Hyderabad,
Telangana, India.
Email: dr.m.greeshma26@gmail.com

Received: Apr. 06, 2024; **Accepted:** May. 20, 2024; **Published:** Jul. 20, 2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Matharasi G, Dantuluri S, Al Farooqui F. Lasers in Periodontal Therapy. J Res Adv Dent 2024;15(5):1-5.

Access this article online

Website:
www.jrad.co.in

DOI:
<https://doi.org/10.53064/jrad.2024.15.5.548>

energy orbits or levels of energy around the nucleus of that atom. Bohr found that an electron could jump to a higher (and unstable) level by absorbing a photon and then the electron would return to a lower (more stable) level while releasing a photon. He termed this spontaneous emission.

- b. Stimulated emission: In 1916 Albert Einstein postulated the theory of lasers. Using Bohr's model, he postulated that during the process of spontaneous emission, an additional photon, if present in the field of the already excited atom with the same excitation level, would stimulate a release of two quanta. These would be identical in phase, direction, and wavelength. In addition, these emission photons would share monochromatic and coherent properties thus a laser is born.^[2]
3. Amplification: Amplification is part of a process that occurs inside the laser. Once stimulated emission occurs, the process should theoretically continue as more photons enter the field both to excite the atoms and to interact with the excited photons returning to their ground state. As Bohr implied, there can be several potential levels of energy available in most atoms.^[2]
4. Radiation: Radiation is categorized into seven classes based on wavelength: Gamma rays, X-rays, ultraviolet, visible, infrared, microwaves, and radiofrequency waves. These can be broadly divided into ionizing (gamma-rays, X-rays, ultraviolet) and nonionizing (others) radiation. The visible spectrum, perceived by the human eye, ranges from approximately 380 nm (violet) to 750 nm (red).^[2]

EMISSION MODES

Dental laser devices can emit light energy inconstant on or pulsed on and off. The pulsed lasers can be further divided into gated and free-running modes for delivering energy to the target tissue. Thus three different emission modes are described, as follows:

1. Continuous-wave mode, in which the beam is emitted at only one power level continuously as long as the operator depresses the foot switch.
2. Gated-pulse mode: The laser is in an on-and-off mode at periods. The duration of the on and off timer is in microseconds.
3. Free-running pulsed mode sometimes referred to as true pulsed mode. This emission is unique in that large peak energies of laser light are emitted usually for microseconds, followed by a relatively long time in which the laser is off. Free-running pulsed devices cannot have a continuous-wave or gated-pulse output.^[2]

COMPONENTS OF LASER

- A. Active medium: The active medium is at the center or core of the laser, termed the optical cavity. The atoms

(or molecules) of that material absorb photonic energy and then begin to spontaneously emit.

- B. Pumping mechanism: Surrounding this optical cavity with its active medium is an excitation source, known as the pumping mechanism. Pumping is used to transfer energy into the optical cavity, and that energy must be of sufficient quantity and duration so that the occupation of a higher energy level exceeds that of a lower level. This condition is called a population inversion and it allows amplification to occur.
- C. Resonator: The resonator, sometimes known as the optical cavity or optical resonator, is the laser component surrounding the active medium. In most lasers, there are two mirrors one at each end of the optical cavity, placed parallel to each other, or in the case of a semiconductor, either a cleaved and polished surface exists at the end of the wafer or there is a reflection within the wafer.^[3]

LASER DELIVERY SYSTEMS

Laser energy can be delivered to the surgical site by various means that should be ergonomic and precise. There are three general modalities:

1. Optical fiber: An optical glass fiber usually made of quartz-silica. This glass core conducts the laser beam along its length. A thin polyamide coating surrounds the core to contain the light, and a pliable thicker jacket covers both to protect the integrity of the system.
2. Hollow waveguide: A hollow waveguide is a jacketed flexible tube. The internal surface has a reflective coating like silver iodide to allow the beam's transmission. A series of protective jackets complete the system.
3. An articulated arm: An articulated arm consists of a series of reflective hollow tubes with pivoting internally mirrored joints along its length. The arm has a counterweight to provide ease of movement. The laser emission port is coupled with the first tube, and a handpiece and optional tip are added to the operative end of the distal tube.^[3]

LASER EFFECTS ON TISSUE

The light energy produced by a laser can have four different interactions with a target tissue: Reflection, transmission, scattering, and absorption.

1. Reflection is simply the beam being redirected off the surface, with no effect on the target tissue.
2. Absorption: The second interaction with tissue is absorption. Absorption of the laser energy by the intended target tissue usually is the most desirable effect. The amount of energy absorbed by the tissue depends on that tissue's characteristics, such as pigmentation and water content, and the laser wavelength.
3. Transmission: The third effect is the transmission of the laser energy directly through the tissue, with no effect on the target tissue. This effect also is highly dependent on the wavelength of laser light.

4. Scattering: The fourth tissue interaction is the scattering of the laser light, which weakens the intended energy. Scattering is the predominant event with use of the near-infrared lasers in healthy soft tissue.^[3]

Biologically, five types of effects can be seen when the laser beam photons enter a tissue. The following photobiologic effects are possible with use of a dental laser:^[3]

1. Fluorescence
2. Photothermal effect
3. Photodisruptive effect
4. Photochemical effect
5. Photobiomodulation.

ADVANTAGES OF LASERS IN PERIODONTAL THERAPY

1. Effective and efficient soft and hard tissue ablation with greater hemostasis, bactericidal effect, minimal wound contraction, and minimal collateral damages with reduced use of local anesthesia
2. Lasers are the most useful for the removal of hemorrhagic lesions
3. Bloodless operative field, thus better visibility
4. They have high patient acceptance
5. Many procedures can be done with only topical anesthesia
6. Better healing and less scarring
7. Less time-consuming.^[4]

DISADVANTAGES OF LASERS IN PERIODONTAL THERAPY^[4]

1. The laser light interacts with target tissues not only in the contact irradiation mode but also in the non-contact irradiation mode
2. The Laser beam may be reflected off shiny metal surfaces of dental instruments, such as retractors or mouth mirrors, which can cause accidental irradiation to the adjacent tissues
3. High-speed evacuation is necessary to capture the Laser plume, which is a biohazard
4. Er: YAG and CO₂ lasers may cause melting or ablation of tooth structure if they come in contact with tooth structure
5. The cost of the laser apparatus is high.

EFFECTS OF LASERS ON PERIODONTAL THERAPY

1. Pain relief: laser therapy interrupts pain signals from injured body parts to the brain, decreasing nerve sensitivity and significantly reducing the perception of pain. It also boosts the production and release of endorphins and enkephalins, which are the body's natural pain relievers.
2. Inflammation reduction: laser therapy causes vasodilation, the enlargement of small arteries and lymph vessels, enhancing the clearance of inflammation, swelling,

and edema from injury sites and promoting lymphatic drainage, which aids the healing process.

Accelerated tissue repair and cell growth: Therapeutic lasers emit photons that deeply penetrate body tissues, stimulating the production centers of cells. This increases cellular energy, enabling cells to absorb nutrients and expel waste products more efficiently.

3. Wound healing:
 - a. Improved blood flow: laser therapy significantly enhances the formation of new capillaries within damaged tissues
 - b. Reduced scar tissue formation: By accelerating the healing process, improving blood flow, and effectively removing waste products, laser therapy minimizes the formation of scar tissue following cuts, burns, and surgery, resulting in less scar tissue overall.^[3]

TYPES OF LASERS USED IN PERIODONTICS

1. Carbon dioxide laser: With the CO₂ laser, the rapid rise in intracellular temperature and pressure leads to cellular rupture, as well as the release of vapor and cellular debris, termed the laser plume.^[5]
2. Neodymium: Yag laser: A Nd: YAG laser device, designed and promoted for oral and dental applications, can deliver up to 3 watts of power in either a pulsed (20 pulses per second) or non-pulsed mode, utilizing a specially designed handpiece with contact or non-contact probes. It received Food and Drug Administration (FDA) clearance for oral soft tissue in 1990. However, the FDA has not permitted the manufacturer of any laser to state that it can sterilize the field or that it is painless. Because of concerns about the claims for the use of the Nd: YAG laser on dental hard tissues, the FDA convened an expert panel in July 1990 to review submitted data. The panel concluded that the data were not yet sufficient to substantiate claims of efficacy on hard tissues. To date this has not been revisited by the FDA for the Nd: YAG laser.^[5]
3. Erbium: Yag laser: The primary emphasis of utilizing lasers only on soft tissues was changed in 1997 with FDA safety clearance for the use of the Erbium: YAG laser on hard tissues such as enamel, cementum, and bone. The Er: YAG laser has a wavelength of 2940 nm, which is ideal for absorption by hydroxyapatite and water, making it more efficient in ablating enamel and dentin than any previously introduced laser. The Erbium: YAG laser utilizes a fiber optic delivery system with an accompanying helium neon laser as an aiming beam, since the wavelength is invisible. It is essential to use a water spray to wet the surface during laser radiation to achieve maximum efficiency of tissue removal with minimal heat generation. The surface is left with an acid-etched appearance microscopically, which enhances the bond strength when used on enamel for cavity preparation.^[5]

4. Diode laser: The diode laser has also been introduced over the past few years for dental use, obtaining FDA safety clearance. Has a wavelength of 819 nm. This energy level is absorbed by pigmentation in the soft tissues and makes the diode laser an excellent hemostatic agent. It is used for soft tissue removal in a contact mode, giving a tactile sensation similar to electrocautery.^[5]

APPLICATIONS OF THE LASERS IN PERIODONTAL THERAPY

1. Non-surgical periodontal therapy
2. Gingival soft-tissue procedures
3. Hard-tissue procedures
4. Surgical periodontal therapy
5. Photobiomodulation therapy
6. Antimicrobial photodynamic therapy (PDT).

NON-SURGICAL PERIODONTAL THERAPY

Lasers have solved the limitation of mechanical instrumentation as the beam can reach the deepest pockets and grooves. Periodontopathogens are deactivated at 50°C. For bacterial reduction and coagulation, soft-tissue lasers, such as argon, diode laser, 9 and Nd: YAG are a good choice for inflamed tissues and pigmented bacteria.^[6]

Gingival soft-tissue procedures

Lasers such as diode, CO₂, Nd: YAG, Er: YAG, and Er, Cr: YSGG are being extensively used in periodontal treatments including gingival soft tissue procedures such as gingivoplasty, gingivectomy, frenectomy, benign tumors or epulis elimination, irradiation of aphthous ulcers, gingival depigmentation, coagulation of free graft donor sites, second-stage exposure of dental implants, and crown lengthening procedures.^[6]

Removal of the pocket epithelium

Lasers are also used for soft tissue periodontal applications. The Nd: YAG was the first laser wavelength to be compared to the scalpel for treating periodontal pockets and controlling bacteremia and gingival bleeding. There are advantages in the post-surgical outcomes with the removal of pocket epithelium.^[7]

Root surface modifications

Root surface modification using CO₂, Nd: YAG, Er: YAG, and diode laser has been studied by many authors with conflicting results and is related to the energy density and laser wavelength selection. *In vitro* studies have shown better fibroblast adherence with Er: YAG laser irradiation than mechanical scaling alone, whereas conflicting results were seen with Nd: YAG laser.^[6]

Low-level laser in periodontology

1. Photobiomodulation therapy
2. Antimicrobial PDT.

Photobiomodulation

Photobiomodulation can be used in periodontal surgical treatment to encourage gingival and mucous tissue repair;

speed up bone tissue healing and lessen periodontal surgical post-operative discomfort.^[8,9]

Antimicrobial PDT

PDT, also known as photo radiation, phototherapy, or photochemotherapy, is a new treatment modality that has been developing rapidly within various medical specialties since the 1960s. In this treatment modality, there is a powerful laser-initiated photochemical reaction, involving the use of photoactive dye also called photosensitizer like (Methylene Blue or ortho-Toluidine Blue) activated by light of a specific wavelength in the presence of oxygen.

Laser and implants

Gingival enlargement is relatively common around implants when they are loaded with removable prosthesis. Lasers can be used for hyperplasia removal as well as in the treatment of peri-implantitis. Er: YAG laser, due to its bactericidal and decontamination effect, can be used in the maintenance of implants. It has a high bactericidal effect without heat generation around implants.^[3]

LASER-ASSISTED NEW ATTACHMENT PROCEDURE (LANAP)

It was observed that LANAP could initiate regeneration of the affected periodontal tissues in human beings, and new connective tissue attachment mediated by cementum could be seen.

LASER-ASSISTED PERI-IMPLANTITIS PROCEDURE (LAPIP)

The LAPIP Protocol McCarthy brought forth the concept of LAPIP, "Laser Assisted Peri-Implantitis Procedure" as a modification of LANAP which could be used in diseased implants. Laser removes inflamed pocket tissue, disrupts biofilms, and decontaminates the root/implant surface. A decrease in inflammation and a laser-induced hemostasis further decontaminates the tissue creating a durable blood clot to close the system.^[10]

LASER SAFETY

General safety requirements for laser use in dental clinics include posting laser warning signs outside the clinic, using barriers within the operator, and wearing protective eyewear to guard against reflected or accidental direct laser exposure. High-volume suction is necessary to evacuate the plume generated from tissue ablation. Studies have examined the thermal effects of lasers on the periodontal ligament and surrounding bone, indicating that periodontal tissues remain undamaged if the temperature increase is kept below 5°C. A temperature increase threshold of 7°C is generally considered the maximum biologically acceptable limit to prevent periodontal damage.^[3]

PRECAUTIONS DURING LASER SURGERY

1. Use glasses for eye protection (patient, operator, and assistants)
2. Prevent inadvertent irradiation (action in noncontact mode)
3. Protect the patient's eyes, throat, and oral tissues outside the target site
4. Use wet gauze packs to avoid reflection from shiny metal surfaces
5. Ensure adequate high-speed evacuation to capture the laser plume.

RECENT ADVANCES

1. The waterlase system is a revolutionary dental device that uses laser-energized water to cut or ablate soft and hard tissue
2. Periowave™, a photodynamic disinfection system, utilizes nontoxic dye (photosensitizer) in combination with low-intensity lasers enabling singlet oxygen molecules to destroy bacteria.^[3]

CONCLUSION

Laser technology for dental applications has reached a high state of refinement and continues to improve. Advances in laser-based photochemical reactions promise targeted applications for cells, pathogens, or molecules. Combining diagnostic and therapeutic laser techniques is another area of growth. Over the next decade, specific laser technologies are expected to become essential in dental practice.

While conventional periodontal therapy remains the primary treatment for periodontal diseases, it often fails to fully access and disinfect periodontal defects. Lasers enhance disinfection of hard-to-reach diseased root surfaces and epithelium, making them a valuable adjunct to traditional therapy. Future advancements are anticipated in both soft and hard tissue lasers.

REFERENCES

1. Bains VK, Gupta S, Bains R. Lasers in periodontics: An overview. *J Oral Health Community Dent* 2010;4:29-34.
2. Convissar AR. Laser fundamentals. In: *Principles and Practice of Laser Dentistry*. 2nd ed. St Louis Missouri: Elsevier; 2016. p. 12-26.
3. Elavarasu S, Naveen D, Thangavelu A. Lasers in periodontics. *J Pharm Bioallied Sci* 2012;4:S260-3.
4. Ishikawa I, Aoki A, Takasaki AA, Mizutani K, Sasaki KM, Izumi Y, *et al.* Application of lasers in periodontics: True innovation or myth? *Periodontol* 2000 2009;50:90-126.
5. Cobb CM. Lasers in periodontics: A review of the literature. *J Periodontol* 2006;77:545-64.
6. Narang S, Maytreeye R, Singh N, Khare K, Jain P. Clinical application of soft tissue lasers in periodontics. *J Orofac Res* 2015;5:94-8.
7. Jassim SD. *Laser Applications in Periodontology*. Public Health in Developing Countries-Challenges and Opportunities. London: IntechOpen; 2019.
8. Abu-Ta'a M, Karamah R. Laser and its application in periodontology: A review of literature. *Open J Stomatol* 2022;12:305-20.
9. Woodruff LD, Bounkeo JM, Brannon WM, Dawes KS, Barham CD, Waddell DL, *et al.* The efficacy of laser therapy in wound repair: A meta-analysis of the literature. *Photomed Laser Surg* 2004;22:241-7.
10. Jha A, Gupta V, Adinarayan R. LANAP, Periodontics and beyond: A review. *J Lasers Med Sci* 2018;9:76-81.