LASERS IN DENTISTRY

Abstract

This comprehensive review explores the remarkable evolution and significant contributions of laser technology to dentistry in the 21st century. Lasers, with their precise and minimally invasive attributes, have revolutionized various aspects of dental clinical practice. The chapter begins with a historical perspective, tracing the roots of laser technology to Albert Einstein's groundbreaking work. It categorizes dental lasers into hard and soft types, delving into their mechanisms, applications, and the importance of wavelength selection.

The mechanisms of laser-induced tissue damage, including thermal, chemical, photoacoustic, and photoelectric effects, are discussed, shedding light on the diverse interactions between lasers and biological tissues. The chapter emphasizes the crucial role of safety precautions during laser procedures. Safety measures, such as protective eyewear and correct laser handpiece positioning, are highlighted to prevent accidental exposure during laser procedures.

Highlighting the wide array of applications, the chapter covers the use of lasers in oral surgery, periodontology, endodontics, cosmetic dentistry, and more. It underscores the advantages of lasers, including precise cutting, reduced discomfort, and diminished reliance on anesthetics.

The chapter also delves into dosage parameters, offering a formula for calculating exposure time during laser treatments and emphasizing the convenience of modern laser equipment in automating this process.

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In conclusion, this chapter establishes that lasers have not only transformed dental practice but also paved the way for future advancements. While discussing the advantages, the review acknowledges the challenges, including device costs and the need for additional education. It underscores the importance of selecting the right laser type and wavelength for specific clinical needs.

As lasers continue to play an ever-expanding role in dentistry, their precise and minimally invasive capabilities promise to further enhance patient care, making them a cornerstone of the dental practices of the future.

I. INTRODUCTION

Lasers have considerably contributed to dentistry and other clinical fields in a precise and effective way. The word LASER stands for "Light Amplification by Stimulated Emission of Radiation". The discovery of lasers has led to a significant increase in the efficiency and comfort of dental treatment.

II. HISTORY

Albert Einstein, in 1917, explained the photoelectric amplification which set the foundation for the invention of the laser. In 1959, laser was first introduced to the people.

Albert Einstein recognized that a natural process like the emission of radiation promoted laser.

Lasers possess the ability to amplify the intensity of light to create focused, high-intensity beams with effective wavelengths.

In the 1960s, Miaman introduced lasers to dentistry which marked the beginning of research on the diverse applications of lasers in dental procedures.

Since 1963, Leon Goldman, a trailblazer in the field of laser medicine, extensively documented the biomedical facets of lasers and recorded his observations regarding laser dentistry, focusing primarily on the impact of lasers on dental caries, teeth, and oral tissues.

Dental Lasers: 1993- Nd YAG, 1994- CO_2 Laser, 1996- Laser welder, 1998- Er-YAG Laser.

III. TYPES OF LASERS

Two scenarios exist within the realm of lasers in dentistry. On one hand, there are hard lasers, such as Carbon dioxide (CO_2), Neodymium Yttrium Aluminum Garnet (Nd: YAG), and Er: YAG, which offer versatility for both hard and soft tissue applications but come with limitations due to their high costs and the potential risk of thermal injury to tooth pulp. On the other hand, there are cold or soft lasers, primarily based on semiconductor diode devices. These compact and cost-effective devices are primarily used for various applications and are generally referred to as low-level laser therapy (LLLT) or 'biostimulation'.

The excimer laser is a unique form of gas discharge that is generated when noble gases like argon, krypton, and xenon are combined with reactive gases. Low-Level Laser Therapy (LLLT) has gained acceptance in the field of clinical dentistry, primarily due to its therapeutic benefits, including biostimulation, regenerative potential and anti-inflammatory effects, which are achieved due to low heat.

IV. WAVELENGTH

The properties of a laser are dependent upon its wavelength which has an impact on both the clinical uses and design of the laser.

Wavelengths commonly employed in the fields of medicine and dentistry, typically span from 193 to 10,600 nanometers (nm), covering a wide spectrum that extends from ultraviolet to the far infrared range.

The diode laser which utilizes flexible quartz fiber falls within the wavelength range of 635 to 950 nanometers (nm). With a power output ranging from 2 to 10 watts (W), it is primarily absorbed by pigmented soft tissues and serves as an effective haemostatic agent.

V. CHARACTERISTICS OF LASER

The outcome of laser interactions with biological tissues depends on various attributes of the laser system, including

1. Wavelength
2. Pulse duration
3. Pulse energy
4. Repetition rate
5. Beam spot size
6. Delivery method
7. Laser beam properties
8. Optical properties of the tissue, like the refractive index, scattering coefficient (μs), absorption coefficient (μa), and anisotropy factor.

VI. MECHANISM OF ACTION

Laser-induced damage to biological tissues can occur through four distinct mechanisms

1. **Thermal Mechanisms:** The primary cause of damage from laser irradiation is tissue absorption, leading to heating. Heat can extend beyond the initial target area, resulting in characteristic burns and tissue damage through the denaturation of proteins.

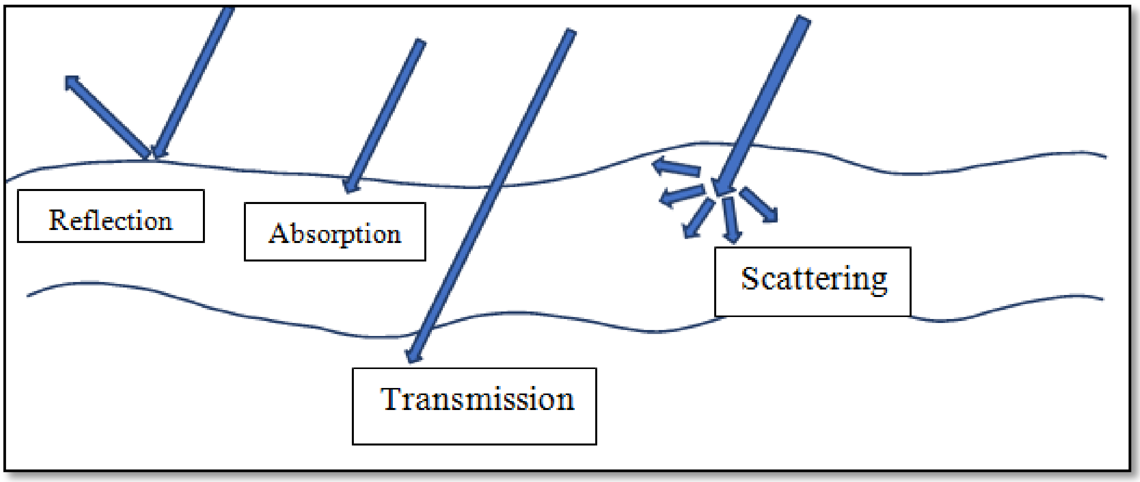
2. **Chemical Mechanisms:** Absorbed laser radiation can trigger chemical reactions, often leading to oxidation and cell death. These reactions typically have a low damage threshold, and they can continue even after the cessation of laser radiation.

3. **Photoacoustic Mechanisms:** When radiation is absorbed and converted into heat over a short duration, it can cause the heated volume to expand rapidly. This generates an acoustic wave that propagates through the tissue and interacts with other tissues in distant areas.

4. **Photoelectric Mechanisms:** High-power-density lasers can operate on biological tissue, causing damage through photoelectric effects.

VII. INTERACTION OF LASERS ON TISSUE

When we aim the laser towards the tissue to execute a specific task, the interaction with biological interference will occur as reflection, transmission, scattering or absorption.



Lasers target the different chromospheres in the tissue which selectively absorbs the laser as heat and yields a desirable response with the principle of selective photothermolysis.

VIII. LASERS IN DIFFERENT FIELD OF DENTISTRY

Type of Laser	Wavelength	Used in
Carbon Dioxide Lasers	10,600 nm	Superficial lesions, resurfacing of the skin and removal of sialoliths, Aphthous ulcers, Herpetic lesions, Coagulation of bleeding areas, Removal of granulation tissues, Excision of epulis, Inflammatory hyperplasia, Mucoceles and ranulas and Pigmented lesions, Premalignant lesions like leukoplakia, Sublingual keratosis
Nd: YAG Lasers	1,064 nm	Pigmented lesions, Sialoliths and verrucous carcinoma.
Ho: YAG	2,100 nm	Excisional biopsy
Er: YAG	2944 nm	Hard tissues and skin resurfacing
Argon Lasers	488,514 nm	Treatment of pigmented lesions and vascular anomalies
Diode Lasers	620 to 900 nm	Oral soft tissue lesions.

In a recent study performed with an Er, Cr: YSGG laser, has found application in sinus grafting procedures also. The utilization of the erbium laser offers distinct advantages, such as creating precise and clean cuts in hard tissues. These benefits are attributed to the laser's interaction with water at the tissue interface.

Argon lasers, which work at wavelengths of 488 and 514 nanometers (nm), are easily absorbed by substances like haemoglobin and melanin. This characteristic makes them particularly valuable in the treatment of pigmented lesions and vascular anomalies. Interestingly, when combined with a 35% hydrogen peroxide (H_2O_2) solution and a suitable dye with an absorption coefficient appropriate for the light-H_2O_2 interaction, argon lasers appear to be an ideal tool for dental bleaching procedures due to minimal heat production.

He-Ne laser can be used for Radiation Mucositis.

The low-level laser can be used for Herpes lesions, aphthous ulcers and denture sores. Helium Cadmium Lasers can be used for Fluorescence examination.

Photodynamic therapy (PDT) plays a vital role in the minimal intervention protocol for treating dental caries, addressing both prevention and cure. This is achieved through the interaction of specific wavelengths of light with a non-toxic compound known as the photosensitizer (PS) in the presence of oxygen. This interaction leads to the production of reactive species, which have the capacity to induce the death of bacterial cells within dental biofilms.

Leveraging the diode laser technology and its underlying principles, the first commercially accessible device employing laser fluorescence was created, known as DIAGNOdent (LF; KaVo, Biberach, Germany). In more recent times, an updated version of this device has emerged, known as the DIAGNOdent pen (LFpen; KaVo) which employs similar principles to the original device in distinguishing between fluorescence between in healthy and carious tissues.

Dosage parameters in dental laser treatments are typically preset for most standard situations, and only experienced operators may find the need to make adjustments.

The formula for calculating the exposure time (t) during laser treatment is:

$$t\ (s) = D\ (J/cm^2) \times A\ (cm^2) / P\ (W)$$

Where

t represents the exposure time in seconds (s).
D is the optimum dose in joules per square centimeter (J/cm^2).
A is the area to be irradiated in square centimeter (cm^2).
P stands for laser power in watts (W).

This formula is useful for determining the duration the laser light should be active to deliver the desired dose to the treatment area.

Most laser equipment conveniently displays power and dose information on its screen. When these parameters are configured, the equipment automatically calculates the exposure time required for the treatment.

IX. PRECAUTIONS WHILE PERFORMING THE PROCEDURE

- Doors should be closed during the procedure.
- To wear safety goggles: by patient, operator, assistant
- Not to look directly into the laser beam
- Laser handpiece should be pointed only towards the area to be treated.
- Not to bend fiber optic cable.
- Laser machines should not be moved during the procedure.

X. ADVANTAGES AND DISADVANTAGES OF LASER

The benefits of employing lasers in dental procedures encompass reduced discomfort, diminished reliance on anesthetics, absence of risk of bacteremia, superior wound healing, absence of scar tissue formation, effective bleeding control, typically no requirement for sutures, fewer instrument and material usage, elimination of the need for autoclaving, and the capability to address both hard and soft tissues. While lasers can be utilized alongside traditional tools like scalpels, it's important to note that lasers are valuable tools but not a universal solution for all dental and medical needs.

Drawbacks associated with the use of lasers encompass the relatively high cost of laser devices, the requirement for additional education, especially in basic physics, as each wavelength possesses distinct properties and the necessity for implementing safety measures such as the use of goggles and other protective equipment.

In conclusion, laser technology stands out as a recent addition to medical technologies, offering remarkable benefits due to its minimal side effects, exceptional precision, and biocompatibility. Laser treatments in maxillofacial medicine have potential implications for quicker treatment and faster healing. However, it is crucial to carefully select the appropriate laser type and wavelength to effectively address the needs of both soft and hard tissues.

In the 21st century, lasers have made substantial contributions to dental clinical practice, and their significance is expected to grow even further in the future of dentistry.

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