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Laser Techniques in Modern Dentistry – A Literature Review

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ABSTRACT

Laser technology has a significant impact on our lives in numerous ways. Its contributions to the fields of medicine and dentistry are significantly impacting patient care and well-being. Gingivectomy, pulpotomy, frenectomy, cavities, cysts, tumors, ulcers, and other soft and hard tissue procedures have all been transformed by laser technology, which has also transformed dental care. It has become a fascinating technology in dentistry, and it is used in various clinical practices for multiple procedures. Because of their significant absorption in haemoglobin, near-infrared (NIR) wavelengths have proven excellent for multiple soft tissue treatments. This article provides a comprehensive overview of NIR lasers and their applications in dentistry, focusing on how these tools may precisely cut, coagulate, ablate, or vaporize particular tissues while improving efficiency, specificity, comfort, and ease of use.

Keywords: Pulp; Caries; Calculus; Diode; Laser

INTRODUCTION

Laser is a term used to refer to "the light amplification by stimulated emission of radiation" [1]. Light moves in waves at a steady speed. This energy is fundamentally measured in photons. A photon's wave properties are its wavelength and amplitude. Measuring a wave's amplitude from its zero-axis to its peak gives its vertical height. The horizontal space between a wave's two adjacent components is called its wavelength [2]. The introduction of laser technology in dentistry was intended to simplify and alleviate discomfort during procedures. Lasers might be used as a supplement or replacement for traditional medicine due to their bactericidal, detoxifying, haemostatic, and ablation capabilities. This is due to the limited adverse effects, discomfort, and improved visualization and healing [3]. With a focus on postoperative wound healing, this review compiles the most recent pertinent research on using lasers in dentistry as a less invasive treatment option [4].

HISTORY

A synthetic ruby laser was the first laser that Theodore Maiman presented [5]. In 1964, Sognnaes observed that enamel fuses and cater like glass when exposed to 500–200J/cm^2 shatter laser radiation [6]. Early research focused on ruby lasers, initially disregarded due to their high energy requirements and potential for thermal damage to the pulp and adjacent tissues. However, in 1964, introducing carbon dioxide lasers marked a significant advancement in dental technology. The excimer laser was used to create a wavelength adequate for the clinical preparation of dental hard tissue within the ultraviolet range. Ablation and technological difficulties restricted excimer laser

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clinical use. Late in 1965, the first laser radiation was used on a crucial tooth. The operation was painless, and the crown was unharmed [7]. An attempt was made in 1961 to use a high-power infrared (CO_2) laser to close the apical foramen in vitro [8]. Er: YAG lasers prepared enamel and dentin cavities without harm in 1989. Er.YAG may generate powdery ablation craters, according to the study, Er; YAG lasers prepare air rotors and cavities. [9].

The first ruby laser was constructed by Maiman in 1960 after Charles H [10]. Townes introduced MASER in 1951, and Albert Einstein proposed the stimulated emission of radiation theory in 1917. Gordon Gould coined the term "laser" in 1957 [11]. Helium-neon (HeNe) was the first gas laser described by Javan, Bennett, and Herriott in 1961. In 1964, Sognnaes reported that enamel was catered, and glass-like fusion occurred when enamel was exposed to laser energy at a rate of 500-200 J/cm^2 [12]. Ruby lasers were the primary focus of all early research. The ruby laser was quickly rejected due to its high energy demands for dental hard tissue treatments and potential to cause significant thermal damage to the pulp and surrounding tissues, whereas the Nd: YAG laser was mostly disregarded [13]. In 1964, the carbon dioxide laser was introduced, using the excimer laser to create a suitable wavelength for dental hard tissue clinical preparation in the ultraviolet range [14]. Excimer lasers have shown little clinical application due to ablation and technological issues. Goldman et al. exposed a crucial tooth to laser radiation for the first time later in 1965. The operation was painless, and only superficial crown damage was seen [15]. Er: Zharkova introduced YAG lasers in 1974, which were demonstrated in 1989 to prepare dentin and enamel cavities without significant side effects [16]. When Er.YAG is used to prepare cavities, it may result in ablation craters with a powdery surface. When it comes to creating cavities, an investigation into the effectiveness of Er: YAG lasers found that they are on par with air rotors [17]. Lasering the mouth cavity to remove cavities and prepare them for soft tissue surgery, such as sulcular debridement and osseous surgery, was authorized by the US Food and Drug Administration (FDA) in 1997 [18].

LASER DEVICE COMPONENTS

The laser cavity at the laser's focus point consists of a pumping mechanism, an active medium, and an optical resonator. The active medium comprises one or more chemical elements, compounds, or molecules [19]. The name of a laser is usually derived from the gas that acts as its active medium; for instance, a CO_2 laser. Solid crystal (Nd: YAG, Er: YAG) in the case of a diode laser, a solid-state semiconductor (d) liquid (not utilized in dentistry). Pumping transfers energy into the active medium. Two mirrors on either side of the laser cavity reflect waves back and forth, functioning as optical resonators [20].

LASER IN PERIODONTICS

Gingivectomy, genioplasty, scaling, and root planning are only a few of the operations that make use of lasers, which vary in their indications, manner of action, and absorption characteristics. Shorter wavelength laser energy delivery systems use compact, flexible bare glass fibre optic systems. Er; YAG, Nd; YAG, and CO_2 lasers are commonly utilized for removing hyperplastic gingival tissues due to their minimal postoperative discomfort and absence of scarring [21]-[23]. Antibacterial characteristics, root surface concernment and plaque removal, and water cooling make the YAG laser ideal for

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immunocompromised patients. Water (such as CO_2, Er: YAG) absorbs the laser wavelength, making it impossible to go through regular glass fibres. Accordingly, special fibers with articulated arms or semi-flexible hollow waveguides transfer wavelengths, while the erbium laser cools hard tissues using a water spray [24]. Compared to traditional periodontal surgery, lasers reduced plaque index, haemorrhage index, pocket depth, and reattachment. Laser-tissue interaction: Laser light energy interacts with target tissue via absorption, transmission, reflection, and diffraction [25],[26]. The beam's first interaction with the target tissue involves reflection off the surface, which can be fatal if aimed at the eye. To prevent transmission, which is the second tissue contact of laser energy without impacting the target tissue, everyone in the laser treatment room is required to wear protective eyewear that is specific to the wavelength of the laser [27]. Transmission depends on laser light wavelength. The final tissue contact where laser light decreases energy is scattering. Heat transmission at the surgery site may cause tissue damage [28]. Tissue properties, such as pigmentation and water content, as well as the wavelength of the laser, determine how much energy tissue can absorb [29].

LASER WAVELENGTH PROPERTIES

Lasers in dentistry have different wavelengths. Any laser energy release produces a monochromatic beam. Laser light waves are coherent therefore photon waves have the same frequency and amplitude. Some of the equipment emits laser beams that are collimated. However, the beams generated by optical fibers deviate. The emission mode of dental laser systems allows them to emit light energy continuously or intermittently. The pulsed mode can be divided into gated and free-running phases, with three distinct emission modes: continuous-wave mode, gated-pulse mode, and free-running pulsed mode or true-pulsed mode [30]. Table 1 provides a summary of the lasers with their wavelengths.

Table 1: Characteristics of Laser Wavelength Used in Clinical Dentistry In the current review

Laser type	Construction	Wavelength (nm)
Argon	Gas laser	488,515
KTP	Solid state	532
Helium-neon	Gas laser	633
Diode	Semiconductor	635,670,830
Nd: YAG	Solid state	1064
Er, Cr: YSGG	Solid state	2780
CO_2	Gas laser	9600

PENETRATION DEPTH OF LASER

Four main interactions in living tissue impact a laser's effectiveness; the amount of absorption is directly related to the wavelength of the laser. Deep-penetrating lasers, such as neodymium-doped yttrium-aluminium-garnet (Nd: YAG) and diode lasers, have a lower water absorption coefficient than superficially absorbed lasers, such as carbon dioxide (CO_2), Er: YAG, and Er, Cr: YAG lasers. Light from lasers is only absorbed at the surface layer; they do not penetrate or disperse deeply [31],[32].

DISINFECTION AND DETOXIFICATION EFFECTS

Lasers' photothermal action may kill bacteria. Devitalization or inactivation occurs when they are subjected to laser light because they denature and evaporate. Due to the bactericidal properties of laser treatment, they may potentially create a sterilized region during surgery, which not only reduces the danger of infection but also aids in the healing of wounds after surgery. The use of the Nd: YAG laser is worth considering to eliminate periodontal disease-causing pigmented bacteria, such as Prophy Aeromonas gingival, due to the laser's ability to specifically absorb these germs.

BIO-STIMULATION

One property of laser treatment (photo biomodulation) is the bio-stimulation it induces in tissues and cells after irradiation. The mechanism of this therapy is still uncertain, but it is associated with a photochemical reaction that occurs within cells. The biological effects of laser irradiation include a reduction in inflammation, faster wound healing, and pain relief [33]

ADVANTAGES OF LASER

Laser offers several advantages, including bactericidal and detoxification effects, less discomfort, minimal invasiveness, no need for sutures, easier tissue ablation, better visualization at the surgical site due to hemostasis, and less postoperative tissue edema and swelling [34].

DISADVANTAGES OF LASER

The drawbacks of laser application include substantial financial expenditures, possible harm to tooth enamel and root surfaces, as well as injury to the underlying bone and dental pulp [35]. The risks and precautions for clinical use are summarized in Table 2.

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Table 2. Risks and precautions in clinical use of laser
In the current review

Before and during laser irradiation	**Visible or invisible light from the laser will cause severe damage and may cause blindness. Please note that the human eye does not see wavelengths outside the visible range, so protective glasses must be worn to protect against the laser.**
Risk of thermal injury	**When the temperature rises, enzyme activity decreases, as does the decomposition of proteins and collagen. Therefore, it is recommended to spray water constantly to reduce heat generation**
Risk of excessive tissue destruction due to heat	**When the temperature is more than 100 degrees Celsius, this leads to the destruction of gum tissue and leads to the eradication of the root surfaces**

CARIES DIAGNOSTICS

In the 1980s, a visual detection approach was developed to identify tooth tissue based on its natural green fluorescence [36],[37]. The technique differentiated between healthy tooth tissue, which fluoresces vibrantly green, and carious lesions, which fluoresce insufficiently, using an argon-ion laser (488nm) excitation wavelength. In early 1990, this method was improved upon by switching out the argon-ion laser of a xenon-based arc lamp for emission light that passed through a blue-transmitting filter. Quantitative light-induced fluorescence (QLF) is a method that uses digital imaging to quantify the observed green fluorescence loss, which is an indirect indication of mineral loss [38]. While red fluorescence is seen in calculus, plaque, and advanced caries, the 405 nm excitation wavelength of the QLF system allows the measurement and visualization of the inherent green fluorescence of dental tissues [39]. Using laser wavelengths between 650 and 800 nm, a hand-held device has been designed to detect dental caries by utilizing the significant red fluorescence phenomena in carious lesions [40]. The QLF method is best used in conjunction with other diagnostic procedures (tactile, visual, and radiographic) to reduce the possibility of false-positive results.

LASER IN ORTHODONTICS

The prospective advantage of lasers over conventional methods is the determining factor in applying lasers in orthodontics [41]. Phosphoric acid (37%) is applied to the enamel surface as a gel or solution in traditional acid etching techniques. The activity lasts between 15 and 60 seconds. After drying and cleaning, the enamel takes on a matte appearance. An alternative to phosphoric acid for enamel conditioning is using CO_2, Nd; YAG, Er; and YAG lasers, which are more successful. The surface must be coated with an accelerator for laser etching, and the region will be exposed to radiation until the accelerator evaporates. Ceramic brackets are frequently employed in orthodontic treatment for aesthetic purposes. However, enamel fractures can result when these brackets are detached from teeth. Consequently, thermal detachment of brackets using CO_2 and YAG lasers can prevent this. Data on changes during CO_2 and YAG laser bracket detachment were published by Strobl and Tocchio [42],[43].

CONCLUSION

In the past, dental treatment was problematic for patients due to their lack of awareness regarding the necessity of treatment and psychological factors, such as dread of pain. In the present day, the introduction of lasers has made dental treatments more comfortable and straightforward. In dentistry, lasers are becoming regular, maybe even routine, therapy. Before employing lasers, the practitioner must understand their scientific foundation and tissue effects and have sufficient equipment training and clinical experience. With the understanding of the essential characteristics for optimal therapy, lasers may be created, allowing dentists to care for patients with enhanced procedures and equipment. The laser is versatile in dental treatment and may often replace traditional methods.

Conflict of interests.

Non conflict of interest

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