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Review Article

A Review of the Use of Lasers in Contemporary Dental Practices

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ABSTRACT

Laser, which stands for Light Amplification by Stimulated Emission of Radiation, has been used in various soft and hard tissue dental procedures since Maiman first applied it in 1960. Its role in modern dentistry is increasingly recognized, offering both supplementary and alternative methods to conventional techniques. This review examines the applications of lasers in dental treatments of both soft and hard tissue. Lasers, which were initially considered an advanced technology with limited practical applications, are now an integral part of clinical practice. Albert Einstein's (1917) prediction about photoelectric amplification leading to a single frequency, or stimulated emission, laid the foundation for the laser and its earlier versions. A review of research on non-alcoholic fatty liver disease examined the incidence, causes, and treatment strategies by examining databases such as Cochrane, Medline, Embase, Pubmed, and NCBI. With extensive advances over the years, laser technology has become well-established in soft tissue surgery, resin curing, cavity preparation, and caries detection. Despite these advancements, there is potential for further progress, and like laser abrasion, the integration of different technologies could lead to new dental treatments and procedures.

Keywords: Resin curing, Lasers, Dental application, Photostimulation, Photosensitization

Introduction

Over the past decade, there has been extensive research on the clinical applications of lasers in dentistry [1, 2]. In parallel, global organizations advocating for laser dentistry have emerged. The role of lasers in modern dental practice, where they can complement or replace traditional methods, is becoming more recognized. Initially regarded as a sophisticated technology with limited practical applications in dentistry, lasers have gained widespread use. Albert Einstein's 1917 prediction that photoelectric amplification could lead to a single frequency, or stimulated emission, laid the groundwork for the development of lasers and their precursor, the Maser [3].

The first public mention of the LASER, or "light amplification by stimulated emission of radiation," appeared in a 1959 article by Gordon Gould [4]. Theodore Maiman developed the first functional laser at Hughes Research Laboratories in Malibu, California, by combining neon and helium gases [5]. In 1961, the yttrium-aluminum-garnet (YAG) laser was introduced, using 1-3% neodymium (Nd: YAG) as the active medium [4]. The ruby laser was developed in 1963, while the argon laser made its medical debut in 1962, used for retinal lesion coagulation [4]. In 1964, Patel developed the CO2 laser at Bell Laboratories [4]. Today, diode lasers are commonly used in dentistry. Research into the diverse applications of lasers in dental care has continued since Maiman introduced lasers in the 1960s [5].

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Hard lasers, such as neodymium yttrium aluminum garnet (Nd: YAG), carbon dioxide (CO2), and erbium yttrium aluminum garnet (Er: YAG), are used for both soft and hard tissue procedures. However, their high costs and the potential risk of thermal damage to the tooth pulp limit their use. On the other hand, cold and soft lasers, also known as "biostimulation" or "low-level laser therapy" (LLLT), are based on semiconductor diode devices that are compact and affordable [6].

Lasers are increasingly recommended in dental procedures due to their convenience, effectiveness, precision, patient comfort, and cost-effectiveness compared to traditional methods [7]. This review examines the applications of lasers in both soft and hard tissue dental treatments.

Results and Discussion

Types of laser

Lasers in dentistry can be classified in various ways, such as by the type of laser (solid or gas), the type of tissue they are designed for (hard tissue or soft tissue lasers), and their wavelength range. In addition, it is important to assess the potential risks associated with each laser application.

Carbon dioxide laser

The CO2 laser is highly effective in soft tissue removal and hemostasis due to its strong affinity for water, which results in minimal tissue penetration. However, its limitations include its bulky size, high cost, and the potential for damage to hard tissues, despite being the most absorbent laser in terms of wavelength [8].

Neodymium yttrium aluminum garnet laser

The Nd: YAG laser is particularly effective for coagulating and cutting dental soft tissues, thanks to its excellent hemostatic properties and strong absorption by pigmented tissues. Beyond its surgical applications, it has also been explored for non-surgical procedures like sulcular debridement in periodontal disease treatment and the laser-assisted new attachment procedure [9].

Erbium laser

Erbium lasers are classified into 2 types based on their wavelength: those made from yttrium aluminum garnet (Er: YAG) and yttrium scandium gallium garnet (Er: Cr: YSGG). These lasers are highly effective in dental procedures due to their strong absorption of water and hydroxyapatite, making them ideal for dental hard tissue treatments. Since dental soft tissues also contain significant amounts of water, erbium lasers are versatile enough to be used for both hard and soft tissue procedures [10].

Laser action mechanism

Laser light is monochromatic, meaning it has a single wavelength. A laser consists of three main components: an active lasing medium, an energy source, and 2 or more mirrors forming the resonator or optical cavity. The laser system is powered by an electrical current, coil, or other pumping mechanisms, which amplify the energy. The active medium absorbs this energy, leading to the spontaneous emission of photons. Stimulated emission further amplifies the photons as they bounce between the mirrors before exiting the cavity through the output coupler. In dental lasers, light is directed to the target tissue via fiber optic cables, hollow waveguides, or articulated arms. The system also includes cooling mechanisms, focusing lenses, and control settings [11]. The laser's wavelength and other properties are largely determined by the composition of the active medium, whether gas, crystal, or solid-state semiconductor.

The energy from a laser can interact with target tissues in four primary ways: transmission, absorption, scattering, and reflection [11]. Absorption increases the tissue temperature, triggering photochemical reactions. When the temperature reaches 100 °C, the tissue undergoes ablation, causing the water content to vaporize. At temperatures around 60-100 °C, proteins in the tissue begin to denature without vaporizing the tissue. However, at temperatures exceeding 200 °C, the tissue becomes desiccated and carbonized, which can result in unwanted side effects. Chromophores, which are substances with a specific affinity for particular light wavelengths, play a key role in absorption. In dental hard tissues, the main chromophores are water and hydroxyapatite, while hemoglobin, melanin, and water are the key chromophores in soft tissues. Since different laser wavelengths interact differently with these chromophores, selecting the appropriate laser depends on the absorption properties of the tissue components [12].

Treatments of laser in dentistry

Soft tissue laser procedures

Lasers are versatile tools used in a range of soft tissue procedures, such as promoting wound healing, treating aphthous ulcers and post-herpetic neuralgia, providing photodynamic therapy for cancer, reshaping the gingiva for aesthetic purposes, lengthening crowns, exposing partially erupted or immature teeth, removing hypertrophic tissue, and excising various types of tissues [13].

These procedures offer two key benefits over traditional methods like electrosurgery: reduced bleeding during surgery and less pain following the procedure. The effect of a laser on soft tissues depends on the degree of tissue absorption. Hemoglobin and Water in the oral tissues play an essential role in efficiently absorbing many commonly used dental lasers [14]. In cases involving patients with bleeding disorders, lasers with better hemostatic properties are particularly useful for ensuring effective treatment.

Hard tissue laser procedures

Photochemical effects

The argon laser emits high-intensity visible blue light (488 nanometers), which can initiate the photopolymerization process in light-cured dental restorations that contain camphorquinone as the photoinitiator. Moreover, the radiation from the argon laser can alter the surface chemistry of root dentine and enamel, reducing the chances of recurring caries [15].

Cavity preparation, caries, and restorative removal

Since 1988, studies have shown that the Er: YAG laser effectively removes caries from both enamel and dentine through ablation, without elevating the pulp's temperature, even when no water cooling is applied. These lasers function similarly to air-rotor tools, but the floor of the cavity they create tends to be less smooth [16]. The Er: YAG laser is also effective in removing materials such as glass ionomer, cement, and composite resin.

Treatment of dentinal hypersensitivity

Dentinal hypersensitivity is a common issue in dental practice. Research has demonstrated that the Er: YAG laser is highly effective in desensitizing hypersensitive dentine, providing a longer-lasting response compared to traditional desensitizing methods. This is particularly evident in treating cervically exposed, hypersensitive dentine [17].

Etching

When compared to traditional acid etching, laser etching of enamel and dentine produces finer surface irregularities and lacks a smear layer. Specifically, surfaces treated with the (Er, Cr: YSGG) laser exhibit these characteristics [18]. However, following Er: YAG laser etching, dental hard tissues show a reduced bonding strength compared to those etched with acid.

Nerve repair and regeneration

Low-level laser therapy (LLLT) has been shown to accelerate neuronal maturation and promote regeneration after injury. It also reduces the production of inflammatory mediators from the arachidonic acid family in damaged nerves [19]. During LLLT, radiation is typically administered daily over an extended period, such as ten days with 4.5 J each day [19]. When applied to dentistry, LLLT has shown promise in aiding the regeneration of damaged inferior dental nerve tissue following surgical procedures.

The safety of laser

While dental lasers are generally user-friendly, it is essential to adhere to specific safety protocols to ensure their effective and safe operation [20]. Everyone in the vicinity of the active laser must wear appropriate safety eyewear. This includes the patient, the dentist, any assistants, and even any onlookers such as family members or friends. The protective eyewear must be tailored to the specific wavelength of the laser. Additional precautions to avoid unintended exposure to non-target areas include restricting access to the treatment area, eliminating reflective surfaces, placing clear warning signs outside the danger zone, and ensuring the laser is properly maintained with all necessary safety features in place. Any smoke or vapor created during tissue ablation must be evacuated with high-volume suction and standard infection control procedures must be followed to avoid exposure to harmful bacteria. It is also recommended that a dedicated laser safety officer be assigned to oversee proper laser usage, arrange staff training, ensure the correct use of safety goggles, and stay informed about relevant regulations.

Conclusion

After many years of research, laser technology for both soft and hard tissue surgery has reached an advanced stage, with the potential for continued advancements. The application of laser-based photochemical processes holds significant promise, particularly in targeting specific cells, pathogens, or chemicals. It is expected that the use of lasers for both therapeutic and diagnostic purposes will increase in the future. Over the next decade, certain laser technologies are likely to become essential components of contemporary dental practices.

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