

Lasers in Conservative Dentistry: An Overview

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ABSTRACT

Lasers are surely one of the most promising technologies in the practice of dentistry. Throughout the last two decades, numerous scientific publications have emerged in literature, concerning laser equipments and their applications in the field

of dental medicine. Presently, laser equipments are available on a large scale. The article reviews the applications of laser in Conservative dentistry and specifies the clinical importance of the lasers in each and every application.

Key Words: Heart rate Variability, Time domain method, Frequency domain method, Mobile phone users and non-users

INTRODUCTION

LASER is an acronym for 'Light Amplification by the Stimulated Emission of Radiation'. Hard Townes and Arthur L.Schawlow [1] in 1953 achieved a "MASER Optic" (Microwave Amplification by Stimulated Emission of Radiation). W.R. Bennet and D.R. Heriott [2] have elaborated the first laser with Helium-Neon in 1961. C.K.N Patel produced the first laser with CO₂ in 1964. In Romania, the first laser with CO₂ and Nd was produced in 1968. Stern and Sognaes in 1964 began looking at the possible uses of the ruby laser in dentistry. A pioneer in the area of clinical periodontal and oral surgery is Pick, who, along with his colleagues in 1985, reported on laser gingivectomy. Maiman generated the first laser beam by using a ruby rod. In 1961, the first gas and continuously operating laser was described by Javan et al. The first laser was introduced into the fields of medicine and dentistry during the 1960s by Goldman et al, but the thermal damage was too great to consider this laser as a clinical instrument [2].

Light is a form of electromagnetic energy that exists as a particle, and travels in waves, at a constant velocity. The basic unit of this radiant energy is called a photon; the wave of photons travels at the speed of light and it can be defined by two basic properties. The first is amplitude, which is defined as the vertical height of the wave oscillation from the zero axis to its peak. This correlates with the amount of energy in the wave: the larger the amplitude, the greater the amount of energy that can do useful work. A joule is a unit of energy; a useful quantity for dentistry is a millijoule, which is one-one thousandth of a joule. The second property of a wave is wavelength, which is the horizontal distance between any two corresponding points on the wave. This measurement is very important, both with respect to how the laser light is delivered to the surgical site and to how it reacts with the tissue. Wavelength is measured in meters; and dental lasers have wavelengths on the order of much smaller units by using the terminology of either nanometers (10⁻⁹ meters) or microns (10⁻⁶ meters.) As the waves travel, they oscillate several times per second, and this is termed as 'frequency'. Frequency is inversely proportional to the wavelength: the shorter the wavelength, the higher the frequency and vice versa [3].

A laser is a device that transforms the light of various frequencies into a chromatic radiation in the visible, infrared, and ultraviolet regions, with all the waves in the phase being capable of mobilizing immense heat and power when they are focused at a close range [4].

It emits light through a process called stimulated emission, which features the collimated (parallel) and coherent (temporally and spatially constant) electromagnetic radiation of a single wavelength. When it reaches the biological tissues, the laser light can be reflected, scattered, absorbed, or transmitted to the surrounding tissues. The emission of wavelength mainly influences these modes of interaction in the target tissue and it must therefore be selected with caution for any diagnostic or therapeutic interventions [5].

Amplification is a part of a process that occurs inside the laser. Identification of the components of a laser instrument is useful in understanding how light is produced. An optical cavity is there at the center of the device. The core of the cavity is comprised of chemical elements, molecules, or compounds and these are called the active medium. Lasers are generically named after the material of the active medium, which can be a container of gas, a crystal, or a solid-state semi-conductor. Surrounding this core is an excitation source, either a flash lamp strobe device, an electrical circuit, or an electrical coil, which pumps the energy into the active medium. There are two mirrors, one at each end of the optical cavity, which are placed parallel to each other; or in the case of a semi-conductor, there are two polished surfaces at each end. These mirrors act as resonators and help in collimating and amplifying the developing beam. A cooling system, focusing lenses, and other controls complete the mechanical components [6].

Stimulated emission is the process which takes place within the active medium due to the pumping mechanism, and it was postulated by Albert Einstein in 1916.

The light waves which are produced by the laser are a specific form of radiation, or electromagnetic energy. The electromagnetic spectrum is the entire collection of wave energy which ranges from gamma rays, whose wavelengths are about 10⁻¹² meters, to radio waves, whose wavelengths can be thousands of meters [7].

TYPES OF LASERS

The laser systems which have been developed to date have been classified according to the active medium that is stimulated to emit the photon energy. This divides the laser systems into solid-state (Nd:YAG, Er:YAG, Er,Cr:YSGG), gas (CO₂, Argon, Helium-Neon), diode, excimer, and dye lasers. Laser systems also can be classified by their maximum output level, that is, low output (soft) or high output (hard). Lasers may also be classified according to their oscillation mode (continuous or pulsed wave). The pulsed-wave mode can be used by producing independent pulses (a free-running pulse), as in the Nd:YAG, Er:YAG, and the Er,Cr:YSGG lasers, or by interrupting a continuous wave (gated or chopped pulse), as seen in the CO₂ and the diode lasers [5].

CLINICAL APPLICATIONS

Diagnostic/curing lasers: The DIAGNOdent is used for caries and calculus detection by emitting a nonionizing laser beam at a wavelength of 655nm (at a 90° angle) towards a specific darkened groove on the occlusal surface of a patient's tooth where bacterial decay is suspected, or along the long axis of a root surface to detect the presence of a bacteria-laden calculus.

This diagnostic technology, in which the photons of this laser wavelength are absorbed into any existing bacteria in these areas of the patient's tooth, is called laser-induced fluorescence. The instrument's digital display indicates the number of bacteria in this area of the tooth and it may correspond to the extent of decay of the existence of the calculus [8,9].

Cavity preparation: Cavity preparation by using lasers has been an area of major research interest ever since lasers were initially developed in the early 1960s. At present, several laser types with similar wavelengths in the middle infrared region of the electromagnetic spectrum are being used commonly for cavity preparation and caries removal. The Er: YAG laser was tested for preparing dental hard tissues for the first time in 1988. It was successfully used to prepare holes in the enamel and dentine with low 'fluences' (energy (mJ)/unit area (cm²)). Even without water-cooling, the prepared cavities showed no cracks and low or no charring, while the increase in the mean temperature of the pulp cavity was about 4.3degrees C). In 1989, it was demonstrated that the Er: YAG laser produced cavities in the enamel and dentine without any major adverse side effects [10].

Clinical note: Only erbium lasers are used for tooth preparation. There should be at least 1mm of clearance between the end of the laser tip and the tooth structure.

- frequency range: 2 to 20 hz
- pulse energies : 50 to 1000 mj
- power: 1-8 w (depending on the type of tissue.)

Laser assisted cavity preparation	Conventional cavity preparation
Lasers cut at a point of their tip To be used with up and down motion	Burs produce abrasive cutting from their sides and are also cut at the end
Rough edges that need hand instruments such as excavators to carry away the ablation products	Side brushing action is also used along with end cutting
Removes smear layer	Produces smooth edges
Considered safe in cases of unexpected patient movement	Produces a smear layer
	Considered unsafe in cases of unexpected patient movement

Restoration removal: The Er: YAG laser is capable of removing cement, composite resin and the glass ionomer. The efficiency of

the ablation is comparable to that of enamel and dentine. Lasers should not be used to ablate the amalgam restorations, however, because of the potential release of mercury vapour. The Er: YAG laser is incapable of removing gold crowns, cast restorations and ceramic materials because of the low absorption of these materials and the reflection of the laser light. These limitations highlight the need for adequate operator training in the use of lasers [11].

Etching: Laser etching has been evaluated as an alternative to the acid etching of enamel and dentine. The Er: YAG laser produces micro-explosions during hard tissue ablation that result in microscopic and macroscopic irregularities. These micro-irregularities make the enamel surface microretentive and they may offer a mechanism of adhesion without acid-etching. However, it has been shown that adhesion to the dental hard tissues after Er: YAG laser etching is inferior to that which is obtained after conventional acid etching [12].

Photopolymerisation [13,14]: The argon laser is one promising source, as the wavelength of the light which is emitted by this laser is optimal for the initiation of polymerization of the composite resins. The argon laser at 488nm (blue) is used. The argon wavelength activates camphorquinone, a photoinitiator that causes polymerisation of the resin composites. The argon laser radiation is also able to alter the surface chemistry of both the enamel and the root surface dentine, which reduces the probability of the recurrent caries.

Clinical Note: It is used at 250+_ 50 mw/ cm² for 10 seconds.

CAD/CAM technology: This technology eliminates the need for conventional intra-oral impression materials. Instead, laser scanners take an optical impression of a prepared tooth and the opposing dentition and they take a bite registration to produce an interactive three-dimensional image. This three-dimensional laser-based imaging technology enables the dentist to take an optical impression and to create a computer file with this data. A virtual model is created, based on the transmitted data and a precise master model is made. The physical model is sent to the laboratory where a final restoration is made [15, 16].

Caries Prevention: Controversial results can be found in the literature regarding the demineralization and the acid-resistance of enamel and dentin after the Er:YAG laser treatment. An increased temperature is necessary to achieve the photothermal effect and the enhancement of the enamel acid resistance. According to Fried et al (1989), the energy density which is necessary to reach the enamel acid resistance by using the Er,Cr:YSGG laser is approximately 8-13 J/cm². This is expected to decrease the enamel solubility by promoting the thermal decomposition of the more soluble carbonate hydroxyapatite into the less soluble hydroxyapatite, with corresponding changes in its crystallinity [17,18].

Laser Desensitization: Dentinal hypersensitivity is one of the most common complaints in the dental clinical practice. Various treatment modalities such as the application of concentrated fluoride to seal the exposed dentinal tubules have been tested to treat the condition. However, the success rate can be greatly improved by the ongoing evaluation of lasers in hard tissue applications. A comparison of the desensitising effects of an Er:YAG laser with those of a conventional desensitising system on cervically exposed hypersensitive dentine showed that the desensitizing of hypersensitive dentine with an Er: YAG laser was effective, and that the maintenance of a positive result was more prolonged than with other agents [19].

Clinical note: Er:YAG 30mJ and 10 Hz with water spray, for 2 minutes. OR Nd:YAG, 30mJ, 10Hz for 2 minutes.

The laser should be placed 10mm from the target site and it should be slowly brought towards the tooth in a circling motion. If the patient feels discomfort, it should be pulled back by 1mm and then it should be slowly circled again. This procedure should be repeated until it is 1mm away from the tooth.

ADVANTAGES AND DISADVANTAGES OF LASERS [5,7,20]

Advantages

- They are often less painful and so this reduces the need for administering anaesthesia.
- Some people are afraid of the conventional drill. They are more at ease with lasers.
- When soft tissue has to be handled, lasers lessen the swelling and the bleeding.
- During cavity treatment, lasers help in retaining more of the tooth that is intact.

Disadvantages

- When a tooth has already got a filling, it is not possible to use a laser there.
- The treatments for which lasers can be used are very limited. They can't be manoeuvred around cavities which are present between two teeth or around bigger cavities that need to be fitted with a crown. Nor can they be used where there are old fillings, or to remove silver fillings, or damaged crowns. Laser technology is also not helpful in preparing the teeth for receiving bridges.
- Even where a laser is utilized, the conventional drill is still required for the bite adjustment, and for shaping and polishing the filling.
- Though laser can reduce the need for the administration of anaesthesia, it cannot eliminate it totally.
- Above all, the treatment does not come cheap.
- Lasers produce an intense, highly directional beam that is absorbed to some degree if it is directed, reflected, or focused on an object. The eye is a critical target for laser injuries.

OTHER USES OF LASERS IN DENTISTRY

In endodontics, lasers have been used as an adjuvant treatment in both low-intensity laser therapy and in high intensity laser treatment to optimize the outcome of the clinical procedures. The clinical application of a low-intensity laser in endodontic therapy has been considered to be useful in: post-pulpotomy (with the laser beam being applied directly to the remaining pulp and on the mucosa towards the root canal pulp); post-pulpectomy (with the irradiation of the apical region); and periapical surgery (irradiating the mucosa of the area which corresponds to the apical lesion and the sutures). High-intensity lasers such as Nd:YAG (neodymium: yttrium, aluminum, garnet), Ho: YAG (holmium: yttrium, aluminum, garnet), Er:YAG (erbium: yttrium, aluminum, garnet), Excimer, CO₂ (carbon dioxide) and diode have been recommended successfully as adjuvant methods in the endodontic treatment of contaminated canals, to remove bacteria from the root dentinal surfaces as well as from the deep dentinal layers. Also, the use of lasers in replacing aerosol-producing handpieces in periapical surgery can reduce the risk of contamination of the surgical environment by blood borne pathogens. The unique properties of the laser light as they pertain to endodontic surgery, have been listed as follows: precision; coagulation; decreased postoperative pain, oedema and reduced scarring; sterilization; and selective absorption [21-24].

In gingivectomy and gingivoplasty, various lasers can be used. The laser which is routinely used for removing gingival hyperplasia is the CO₂ laser. Also, the Nd: YAG laser can be used in the treatment of hyperplastic gingiva by gingivectomy, phrenectomies, bridectomies, gingivectomies in hypertrophies and tumoural lesions; gingivoplasties with physiognomic or hygienic purposes; scaling and planning of root surfaces (in combination with the use of curettes); minor adjustments of the healing area, in the first stage of implant introduction; revealing of the implant, in the second stage; and gingival retraction, with the purpose of prosthetic impression. The Nd: YAG and the diode lasers are the prime candidates for use as adjuvant lasers in closed curettage. The recommended setting of 1.25 W to 3 W is used, in order to avoid the risk of irreversible damage which results from the blind guidance of the beam in the gingival pockets [23].

The main applications of lasers in orthodontics are laser scanning, holography, and applications on soft and hard tissues. Plaque gingivitis, as a direct consequence of the retention of the bacterial plaque in orthodontic patients, can benefit from laser therapy. The lasers which have been reported as having been tested in this regards are the CO₂ and the Nd: YAG lasers, which have proved their ability in destroying bacterial plaque [20-24].

Dental Laser Welding

Laser welding is an advantageous method of connecting or repairing metal prosthetic frameworks, because there are fewer effects of heating on the area which surrounds the spot which has to be welded, and no further procedures, such as those which are used for conventional soldering, are necessary. Laser welding has been increasingly applied for fabricating the metal frameworks of prostheses and for other procedures, such as recovering the metal ridge and the cusp, blocking holes on the occlusal surfaces after excess occlusal adjustment, thickening the metal framework, or adding contact points after excess grinding and adjusting of the crown margins.

Low Level Laser Therapy (LLLT) is a method that is almost pain-free and sterile, and it can be used by all the practitioners. The purpose of using LLLT is to supply direct biostimulative light energy to the body's cells.

CONCLUSION

As the dental technology continues to evolve, new methods of performing certain dental procedures will continue to replace those which were once thought to be the pinnacle. A few of the practitioners are aware of this new technology, but others continue to plead for conventional instruments. In the past, dental treatment offered a lot of reasons for a patient to avoid the specialty services: not understanding the necessity of a treatment, psychological discomfort and economic and social factors; however, the fact that the greatest issue was the "fear of pain" was scarcely discussed. When the knowledge of the parameters which are necessary for an ideal treatment is a reality, lasers can be developed, which can provide the dentists with the ability to care for their patients with improved techniques and equipment.

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