Use of Lasers in Clinical Dentistry: A Review

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Improvements in technology have given the dentists many innovative treatment options. Dental Lasers are the most fascinating technologies in dental practice. Lasers offer many advantages over other conventional modalities of treatment; the laser treatment is now the modality of choice, in many dental applications. The emergence of lasers with variable wavelength and the ability to be used for various applications in dentistry have influenced the treatment and treatment planning of dental patients. It has become mandatory for practicing dentists to update themselves on lasers use in dentistry. This paper gives an overview of uses lasers in dentistry.

Keywords: Dental lasers, Diagnodent, Doppler flowmetry

INTRODUCTION

In 1960, Theodore Maiman developed first laser called as a ruby laser.¹ The effect of ruby lasers on enamel and dentin was the first reported in 1965 by Goldman et al. and Stern and Sognnaes.²,³ The use of lasers for dental purpose was popularized by Myers and Myers.⁴ In 1985, they published an article describing the in vivo removal of dental caries using a modified ophthalmic Nd: YAG laser. Today laser dentistry is playing an important role in patient care and well-being.

BASICS OF LASER PRODUCTION

The term LASER is an abbreviation for light amplification by stimulated emission of radiation.⁴ External energy induces transition of electrons in the atoms causing the electrons to move from their lower state to an activated state due to the absorption of energy by the electrons of the atom called “stimulated absorption.” The lowest energy state being stable, the activated electrons returns to their normal state by spontaneously emitting the extra energy called “spontaneous emission.” Instead of spontaneous emission, the electrons of an atom can be stimulated to release energy with a quantum of electromagnetic energy at same transition frequency called as stimulated emission. During this process, it releases an extra photon, which hits against the adjacent activated atom setting off a chain reaction of releasing photons.⁵ These released photons are coherent in nature.

Lasers are named based on the active medium that is stimulated to produce these waves. The active medium can be a gas, liquid, solid or a semiconductor (diode lasers). The active mediums contain atoms whose electrons may be excited to a metastable energy level. The active medium may be excited using light or electricity. The lasers are monochromatic, unidirectional and coherent. These lasers may be delivered as a continuous, gated-pulse or free running pulse.⁶

DENTAL LASERS

Fiber optic delivery systems (FODS) are used to deliver lasers to most parts of the oral cavity and even within the complex root canal system. FODS are used in cavity preparations and soft tissue surgeries but due to the minimal divergence of lasers, it was not of much use in root canal treatment as laser energy need to be transferred laterally in the canals. With recent advances number of fiber optic modifications are proposed for effective delivery of laser energy laterally.⁷ Selecting a delivery system that transmits the laser energy in use with minimal losses is essential for effective treatment.⁸

Depending on the absorption of a given laser by tissue chromophores (water, apatite minerals, and various pigmented substances) within the target tissue (dental tissues, bone, soft tissues and bacteria) results are produced. Better absorption allows for a more effective photothermal sterilization, ablation.

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Lasers primary mechanism of action on a tissue is photothermal\textsuperscript{6,10} other mechanisms may be secondary to this process. Rapid heating of water molecules within enamel causes rapid vaporization of the water and build-up of steam which causes an expansion that exceeds the crystal strength of the dental structures, and the material breaks by exploding this is called ablation. The following are the possible mechanisms of laser action:

1. Photo-thermal ablation: This occurs with high powered lasers, for vaporization of tissues occurs.
2. Photo-mechanical ablation: Disruption of tissue because of shock wave formations, cavitation, etc.
3. Photochemical effects: Laser energy brings chemical changes within the tissue.\textsuperscript{11,12}

Factors that influence the effect of lasers on tissue comprise of exposure time, laser wavelength, pulse energy, spot size, and the tissue variables of physical and chemical composition.\textsuperscript{13}

Lasers are classified into several groups such as Classes I, II, III, IIIb, and IV. Most dental and medical lasers are Class IV, and the compliance with safety standards is necessary to protect the dentist, patient and support staff.\textsuperscript{14,15}

Lasers used in dentistry cover a broad range of procedures, from diagnosis of caries to various soft tissue and hard tissue procedures.

**Lasers in Dentistry Today**

CO\textsubscript{2} (9300, 9600, 10600 nm), Er: YAG (2940 nm), Er, Cr: YSGG (2790 nm), Ho: YAG (2100 nm), Nd: YAG (1064 nm), diode laser (980 nm), diode laser (810, 810 nm), diode laser (635, 670 nm), and He-Ne (632.8 nm) are the lasers extensively studied in dentistry.

**USES OF LASERS IN DENTISTRY**

**Laser Doppler Flowmetry (LDF)**

Noninvasive, painless, semi-quantitative method, reliable in measuring the blood flow to pulp. As it does not cause any noxious stimuli, patients accept it more readily. Laser light is transmitted to the pulp using a fiber optic probe.\textsuperscript{16} LDF uses diode lasers at a power of 1-2 mW. The scattered light from the moving red blood cells in the circulation will be frequency-shifted while those from the static tissues remain unshifted. The reflected light mixed with shifted and unshifted light is returned by the afferent fibers of the Doppler flowmeter and a signal is produced. The tooth to be checked should be isolated and the probe is positioned close to the gingival one-thirds because there the volume of pulp tissue is more.\textsuperscript{17} At that position, the potential gingival contamination is high.\textsuperscript{18} Therefore, the ideal position is to place the probe 2-3 mm from the gingival margin. Different ranges of bandwidth can be set to filter the reflected signal, with a wider frequency being more sensitive to the moving red blood cells.\textsuperscript{19} A wider bandwidth such as 15 kHz is preferred, but in a clinical case of pulp vitality testing, a much narrower 3 kHz bandwidth is sufficient.\textsuperscript{20} The end of the LDF probe which contacts the tooth contains both sending and receiving optic fibers.\textsuperscript{21} Due to the pulsatile nature of the blood flow in a vital tooth readings have rhythmic fluctuations.\textsuperscript{21-23}

**Laser Fluorescence Caries Detection**

Manual probing can actually stimulate caries as a result of iatrogenic damage caused by probe-force. The non-invasive DIAGNOdent\textsuperscript{24} uses laser fluorescence within tooth structure to detect caries. The wavelength with which the DIAGNOdent operates, clean, healthy tooth structure exhibits no fluorescence, but carious tooth structure will exhibit high fluorescence, proportionate to the degree of caries, resulting in elevated scale readings on the display of the DIAGNOdent. An audio signal allows the operator to hear changes in the scale values, enabling focus on the patient.

**Lasers in Endodontics**

Lasers are an effective tool for the removal of debris, smear layer, obturation materials, and an effective disinfection tool. The primary use of lasers in endodontics is for eradicating micro-organisms in the root canals. The lasers with a wavelength that has high transmission through hydroxyapatite and water are most suitable for this purpose. Nd: YAG lasers show the best results in transmission and micro-organism reduction in the root canals.\textsuperscript{25} The 810 nm and 980 nm diode lasers are the second best in eradicating microorganisms in the root canals. All other wavelengths are less effective in dental tubules disinfection.\textsuperscript{25} Their absorption in hydroxyapatite and water is so high that micro-organism reduction would predominantly only take place in the main canal, although reduction through thermal effects can still be detected in the lateral dentinal tubules up to depths of 300-400 μm. Er: YAG and Er, Cr: YSGG lasers can, however, be successfully used to remove organic tissue and smear layers. The root canals of the molars should be prepared to a size of at least ISO 30, and the root canals of all the remaining tooth groups as far as medically necessary (fine dentine chips) and anatomically possible. A standardized physiological salt solution is used as a rinsing medium. The canals are dried with sterile paper tips. The length of the root canal obtained through the X-ray measuring picture, is transferred exactly to the fiber-optical waveguide to ensure that the flexible 200 km optical fiber reaches the physiological apex. The fiber is first introduced into the root canal up to the apex without activating the laser. Only then the laser is activated, and the fiber guided in an apical to coronal direction with rotary movements and in contact with the root canal wall.\textsuperscript{26} Then, the root canals are filled.
Lasers in Soft Tissue and Hard Tissue Procedures

Intraoral soft tissue surgical procedures with lasers than with conventional scalpel are better as it provides better bleeding control. Diode lasers are indicated in soft tissue procedures and erbium lasers for both hard and soft tissue procedures. Diode lasers are highly absorbed by soft tissues and poorly absorbed by tooth and bone. Erbium lasers (2780-2940 nm) can be absorbed by both hard and soft tissues. With both the lasers, the settings for clinical use for different procedures should be strictly followed according to manufacturer’s instructions.

Laser safety

Safety requirements include a laser warning sign outside the clinic, use of barriers within the operatory, and the use of eyewear to protect against reflected laser light as instructed by the manufacturer. The selection of the correct eyewear depends on the laser system being used. High volume suction must be used to evacuate the plume from tissue ablation. The laser equipment should be in good working condition and should be used and stored as per manufacturer’s instruction. It is important to make sure that the equipment is serviced and checked regularly.

Adequate precautions to prevent injury or damage to adjacent soft and hard tissue or to the pulp and periodontal apparatus. According to Zach and Cohen, an intra-pulpal temperature increase of approximately 5.5°C can promote necrosis and a temperature increase of 7°C is considered as the highest thermal change biologically acceptable to avoid periodontal damage.

CONCLUSION

During the last decade that lasers have shown rapid strides in technology advances. The emergence of lasers with variable wavelengths and the ability to be used for various applications in dentistry have influenced the treatment of dental patients. It has become mandatory for practicing dentists to update themselves on lasers use in dentistry.

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