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Research Article

LASERS: SOFT TISSUE APPLICATIONS IN DENTISTRY

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ABSTRACT

Lasers were introduced into the field of dentistry as they are a precise and effective way to perform many dental procedures. The use of laser has increased rapidly in the last couple of decades. There has been an explosion of research, articles and case reports on laser applications in the last two decades. There are more than 40 uses for Laser. In hard tissue application, the laser is used for caries prevention and excavation, bleaching, restoration removal and curing, cavity preparation, dentinal hypersensitivity, growth modulation and for diagnostic purposes, whereas soft tissue application includes wound healing, removal of hyperplastic tissue to uncover the impacted or partially erupted tooth, photodynamic therapy for malignancies, photostimulation of herpetic lesion. The apex of the research and exploration has affected the laser, which offers lot of capabilities across all regulations in dentistry. The aim of this review is to focus on the soft tissue applications, in dentistry.

INTRODUCTION

The word LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. (Colluzi DJ 2008; Colluzi DJ 2008; Mathew B *et al*, 2011; Raval N *et al*, 2011; Panat SR *et al*, 2014).

Introduction of laser in dentistry, in the 1960s, by Miaman, led to a continuous research in the various applications of lasers in dental practice. There are two scenarios, on the one hand there are hard lasers, such as, Carbon dioxide (CO_2), Neodymium Yttrium Aluminum Garnet (Nd: YAG), and Er:YAG, which offer both hard tissue and soft tissue applications, but have limitations due to high costs and a potential for thermal injury to tooth pulp, whereas, on the other hand is cold or soft lasers, based on the semiconductor diode devices, which are compact, low-cost devices used predominantly for applications, are broadly termed as low-level laser therapy (LLLT) or 'biostimulation'. On account of the ease, efficiency, specificity, comfort, and cost over the conventional modalities, lasers are indicated for a wide variety of procedures in dental practice (Verma SK *et al*, 2012).

History

LASER was initially known as MASER (Microwave amplification by stimulated emission of radiation). Noble prize for the development of LASER was given to Townes, Basov and Prokhorov in 1964. Credit for the development of the theory of spontaneous and stimulated emission of radiation however, is generally given to Einstein for his treatise ' zur quantum theorie der starling ' which was initially published in 1963. (Malik R *et al*, 2011).

The first laser to be developed was the ruby laser, and second was the neodymium laser in 1961. But all the research for the use of lasers in dentistry was carried on the ruby lasers and not on neodymium although ruby was not effective in dental field due to its high thermal effects on dental hard tissue (Malik R *et al*, 2011).

Features

Laser is a type of electromagnetic wave generator. (Patel CKN *et al*, 1964; Misra MB *et al*, 2011)

The emitted laser has three characteristic features.

1. Monochromatic: in which all waves have the same frequency and energy.
2. Coherent: all waves are in a certain phase and are related to each other, both in speed and time.
3. Collimated: all the emitted waves are nearly parallel and the beam divergence is very low.

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The main differentiating characteristic of laser is wavelength, which depends on the laser medium and the excitation mode, for instance continuous wave or pulse mode. Different wave lengths can be classified into three groups:

1. The UV range (ultra-spectrum approximately 400-700 nm).
2. The VIS range (visible spectrum approximately 400-700 nm).
3. The IR range (infra-red spectrum which is approximately 700 nm) to the microwave spectrum.

(Frehtzen M *et al*, 1990; Misra MB *et al*, 2011)

Classifications

The characteristic of a laser depends on its wave-length (WL), and wave-length affects both the clinical applications and design of laser. The WL used in medicine and dentistry generally range from 193 nm to 10600 nm, representing a broad spectrum from ultra-violate to the far infra-red range (Misra MB *et al*, 2011).

Classifications of lasers (Misra MB *et al*, 2011; Singh H *et al*, 2014).

Classification according to material used.		
Gas	**Liquid**	**Solid**
Carbon dioxide Argon	Not so far in clinical use	Diodes Nd:YAG, Er:YAG, Er:Cr:YSGG, Ho :YAG

Classification based on light spectrum		
UV Light	100 nm - 400 nm	Not used in dentistry
Visible light	400 nm to 750 nm	Most commonly used in dentistry (Argon & Diagnodent Lasers)
Infrared light	750 nm to 10000 nm	Most dental lasers are in this spectrum

Laser Tissue Interaction

Light energy interacts with a target medium (e.g. oral tissue) in one of four ways.

Transmission

Laser beam enters the medium and emerges distally without interacting with the medium. The beam exits either unchanged or partially refracted.

Reflection

When either the density of the medium or angle of incidence is less than the refractive angle, total reflection of the beam will occur. The incident and emergence angles of the laser beam will be the same for true reflection or some scatter may occur if the medium interface is non-homogenous or rough.

Scatter

There is interaction between the laser beam and the medium. This interaction is not intensive enough to cause complete attenuation of the beam. Result of light scattering is a decrease of laser energy with distance, together with a distortion in the beam (rays travel in an uncontrolled direction through the medium).

Absorption

The incident energy of the laser beam is attenuated by the medium and converted into another form. With the use of dental diode lasers, the most common form of conversion of laser energy is into heat or, in the case of very low energy values, biomodulation of receptor tissue sites seems to occur (Kujawa J, *et al* 2003, 2004). Heat transfer mediated physical change in target tissue is termed photothermolysis. (Pirnat S *et al*, 2007).

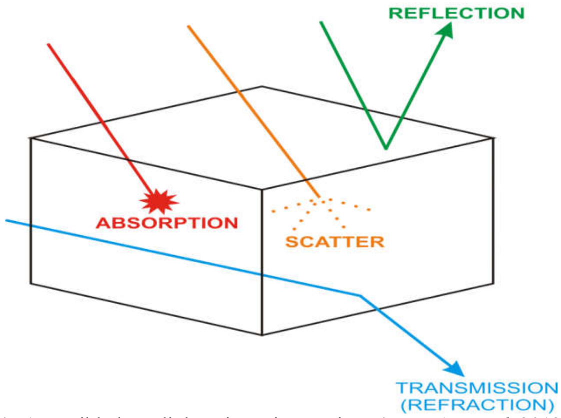

Fig 1 Possible laser light - tissue interactions (Dang AB *et al*, 2013)

Summary of thermal effects on soft tissues (Colluzi DJ, 2008)

Thermal effects of lasers on soft issues	
Tissue temperature(C)	Observed Effect
>37	Hyperthermia
>50	Non- sporualting bacteria inactivated
>60	Coagulation, Protein denaturation
70-80	Tissue welding
100	Vaporization
>200	Carbonization

Absorption requires an absorber of light, termed *chromophores*, which have a certain affinity for specific wavelengths of light. The primary chromophores in the intraoral soft tissue are Melanin, Hemoglobin, and Water, and in dental hard tissues, Water and Hydroxyapatite. Different laser wavelengths have different absorption coefficients with respect to these primary tissue components, making the laser selection procedure-dependent (Verma SK *et al*, 2012).

Soft Tissue Applications

Wound healing

At low doses (e.g., 2 J/cm), laser application stimulates proliferation, while at high doses (e.g. 16 J/cm) it is suppressive. It affects fibroblast maturation and locomotion, and this in turn may contribute to the higher tensile strengths reported for healed wounds. There are some positive data, which indicate that LLLT promotes healing of mucositis and oropharyngeal ulcerations in patients undergoing radiotherapy for head and neck cancer (Verma SK *et al*, 2012).

Apthous Ulcer

The mechanism by which laser therapy can reduce pain is not fully understood. Some of the explanations for the analgesic effect of laser therapy are blockage of action potential generation and conduction of nociceptive signals in primary afferent neuron, increase in amount of natural analgesics such as opoid peptides, decrease in release of chemical substances such as histamine and blockage of acetyl choline, reduction in synthesis of bradykinin and prostaglandin E_2, improvement in local microcirculation and supply of oxygen to hypoxic cells and mediation of synaptic gate transfer substance (Misra N *et al*, 2013). The laser is brought into highly defocussed mode where minimal energy is delivered to the site (Malik R *et al*, 2011).

Post herpetic neuralgia

Photostimulation of recurrent herpetic lesions, with low levels of laser energy (HeNe) can provide pain relief and accelerate healing. In the case of recurrent herpes simplex labialis lesions, photostimulation during the prodromal (tingling) stage seems to arrest the lesions before painful vesicles form, accelerate the overall healing time, and decrease the frequency of recurrence (Verma SK *et al*, 2012). The technique is exactly the same as used for apthous ulcers (Malik R *et al*, 2011).

Coagulation

Lasers are used for coagulation of bleeding areas. For active bleeding areas the laser of choice in the order are: Argon > Nd: YAG > Ho:YAG (Malik R *et al*, 2011).

Vesiculobullous lesions and premalignant lesions

Lasers can be used in the treatment of oral leukoplakias, OLP, beningn MMP, sublingual keratosis and various hyperkeratotic growths. Basically 2 types of procedures are performed:

1. Laser peel procedure also known as surgical ablation.
2. Surface vaporization or ablation of the lesion down to the required depth.

Malignant lesions

A focused mode is usually used at a power setting ranging from 4 to 10 W. A potential advantage hypothesized is that the chance of seeding the lesion and subsequent metastasis may be minimized or eliminated because lasers have the ability to seal the blood vessels and lymphatics. (Malik R *et al*, 2011).

Photoactivated dye disinfection using lasers

Low power laser energy is useful for photochemical activation of oxygen-releasing dyes, causing membrane and DNA damage to the microorganisms. The photoactivated dye (PAD) technique can be undertaken with a system using low power (100 milliwatts) visible red semiconductor diode lasers and tolonium chloride (toluidine blue) dye. The major clinical applications of PAD include disinfection of root canals, periodontal pockets, deep carious lesions, and sites of periimplantitis. Tolonium chloride is used in high concentrations for screening patients, for malignancies of the oral mucosa and oropharynx.

Photodynamic therapy for malignancies

Photodynamic therapy (PDT), which has been employed in the treatment of malignancies of the oral mucosa, particularly multifocal squamous cell carcinoma, acts on the same principle of PAD, and generates reactive oxygen species, which in turn, directly damages the cells and the associated blood vascular network, triggering both necrosis and apoptosis; this activates the host immune response, and promotes anti-tumor immunity through the activation of macrophages and T lymphocytes (Verma SK *et al*, 2012).

Aesthetic gingival re-contouring (gingivectomy) and crown lengthening and exposure of unerupted or partially erupted teeth

For crown lengthening power setting of 3 to 6 W with beam moving from focused to defocused mode as per the necessity. For gigivectomy beam power can be adjusted according to the tissue thikness with range of 4 to 10 W in defocused and focused mode (Malik R *et al*, 2011).

Exposure of implants (stage II)

Uncovering of implants is done at a power setting of 3 to 6 W in circular motion in a defocused mode and this is termed as cookie cutter approach (Malik R *et al*, 2011).

Frenectomies

Laser assisted frenectomy is a simple procedure that is best performed after the diastema is closed as much as possible. Ankylosglossia can lead to problems with deglutition, speech, malocclusion, and potential periodontal problems. Frenectomies performed with a laser permit excision of the frena painlessly, without bleeding, sutures, or surgical packing, and with no need for special postoperative care (Verma SK *et al*, 2012). 4 to 5 W of beam power in highly defocused mode for 35 seconds to 2 to 3 minutes is used for this procedure (Malik R *et al*, 2011).

Preprosthetic surgery

Lasers are used for removing inflammatory papillary hyperplasia, vestibuloplasty, epuli and other preprosthetic surgeries (Malik R *et al*, 2011).

Laser Curettage

Both the Nd:YAG and diode lasers are indicated for curettage. Laser assisted curettage significantly improves outcomes in mild to moderate periodontitis. The treatment is not invasive and comfortable to the patients. The beneficial effects of these lasers are due to the bacterial properties particularly against periodontal pathogens such as *A. actinomycetemcomitans* and *P. gingivalis*. However, recent studies have shown that there are no added advantages of these lasers as compared with the conventional debridement (David CM *et al*, 2015).

Laser Assisted Incisional and Excisional Biopsy

These procedures are accomplished at 100°C. The lasers are placed in cutting or focused mode, held perpendicular to the tissue and follow the surgical outline. When laser light interact with the soft tissue, there is vaporization of intra and extracellular water content resulting in ablation or removal of biological tissue. However, when the temperature exceeds 200°C, there is heat generation within the tissues which results in carbonization and irreversible tissue necrosis.

In addition, there are specific soft tissue indications for the clinical use of lasers, including gingival depigmentation, operculectomy, sulcus debridement, pre-impression sulcular retraction, laser assisted new attachment procedures, removal of granulation tissue (David CM *et al*, 2015).

Advantages

There are many advantages to the use of lasers which include: hemostasis and excellent field visibility, precision, enhanced infection control and elimination of bacteremia, lack of mechanical tissue trauma, reduced postoperative pain and edema, reduced scarring and tissue shrinkage, microsurgical capabilities, less instruments at the site of operation, asepsis due to non-contact tissue ablation and prevention of tumor seeding (Strauss RA *et al* 2000, Muller JG *et al* 2006). There is no need for suturing and also minimal patient discomfort (Malik R *et al*, 2011). Lasers can successfully and safely be used on wide range of the population such as children and pregnant women and old age persons (Mathew B *et al*, 2011).

Limitation

The initial investment for some devices is high. Training and continuing education is essential.

Lasers are hazardous to human eye sight (Colluzi DJ 2008).

CONCLUSION

Lasers can be used in oral soft tissue pathologies, surgeries and small prominent lesions because of its easy application, better coagulation, no need for suturing, less swelling and pain, as well as for its capability for treatment of premalignant lesions, physiologic gingival pigmentation from an esthetic point of view and pain relief in recurrent apthous ulcers and herpetic neuralgias. Laser technology has made rapid progress over few past decades, and lasers have found a niche in many specialities. Because of their many advantages, lasers have become indispensable in oral pathologies and surgeries as an additional modality for soft tissue surgery. There are many uses for lasers, and the advent of new wavelengths will undoubtedly lead to new procedures that can be performed with laser technology.

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