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Review Article

Role of laser in conservative dentistry and endodontics

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ABSTRACT

With dentistry in the high tech era, we are fortunate to have many technological innovations to enhance treatment, including intraoral video cameras, CAD-CAM units, RVGs and Air-abrasive units. However, no instrument is more representative of the term high-tech than the Laser. The rapid development of laser technology, as well as a better understanding of laser interaction with biological tissues, has widened the spectrum of possible applications of lasers in Conservative dentistry and Endodontics. This article reviews the basic mechanism and applications of each laser in conservative dentistry and endodontics.

1. Introduction

LASER is an acronym, which stands for Light Amplification by Stimulated Emission of Radiation.[1] The history of lasers begins similarly to much of modern physics, with Albert Einstein in 1917. Initially his papers were ignored by established physicist of that era but slowly his discoveries altered the course of modern physics. His paper “Zur Quantern Theorie der Strahlung”, was the first discussion of stimulated emission. The basic operating principles of laser were put forth by Charles Townes and Arthur Schalow from the Bell Telephone Laboratories in 1958. The first actual laser which was based on a pink ruby crystal was demonstrated in 1960 by Theodor Maiman. C.K.N Patel developed CO2 laser in 1963. J.E.Geusic and H.M.Marcos developed Nd:YAG laser in 1964.[2]

2. Laser Physics

To understand stimulated emission, first we understand the Bohr atomic model that explains, an electrons orbit the nucleus of an atom. Under the right circumstances an electron can jump from its ground state to a higher state, or it can decay from a higher state to a lower state, but it cannot remain between these states.

For an electron to jump to a higher quantum state, the atom must receive energy from the outside world. This can happen through a variety of mechanisms such as inelastic or semielastic collisions with other atoms and absorption of energy in the form of electromagnetic radiation.[3] Likewise, when an electron drops from a higher state to a lower state, the atom must give off energy either as kinetic activity (nonradiative transitions) or as electromagnetic radiation (radiative transitions).This process is called “Spontaneous emission”[3] Consider the same situation, before an electron has a chance to spontaneously decay, a photon happens to pass by whose energy is approximately E2-E1, there is a probability that the passing photon will cause the electron to decay in such a manner that a photon is emitted at exactly

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the same wavelength, in exactly the same direction, and with exactly the same phase as the passing photon. This process is called "stimulated emission."[3](Figure 1)

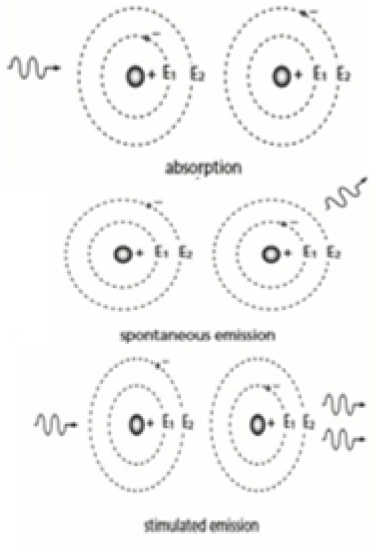

Fig. 1: Laser physics

2.1. *Properties of the lasers*[3]

Lasers are devices that produce intense beams of light which are monochromatic, coherent, and highly collimated:

2.2. *Monochromatic*

When an ordinary white light passes through the prism it differentiate into many colours while being monochromatic laser has Uniform wavelength & single colour when compared to other sources of light.

2.3. *Coherent*

In normal light source, much of the energy is lost as out of phase waves cancel each other while laser beam have a fixed phase relationship (coherence) with respect to one another.

2.4. *Collimated*

The laser light beam is perfectly parallel when leaving the laser aperture & it has very low divergence. It can travel over great distances or can be focused to a very small spot with brightness.

2.5. *Classification of laser*[3]

2.5.1. *Based on the mode of application*

1. Soft Tissue Lasers
2. Hard Tissue Lasers

2.5.2. *Based on absorption wavelength*

1. Ultraviolet rays (140 to 400 nm)
2. Visible light (400 to 700 nm)
3. Infrared (700 to 10600 nm)

2.5.3. *According to type of active media*

1. Gas lasers
2. Solid state lasers
3. Semiconductor lasers

2.5.4. *Based on mode of operation*

1. Pulsed/Nonpulsed
2. Incontact/Out of contact
3. Focused/Defocused

2.5.5. *Laser-tissue interaction*[1]

There are four type of laser- tissue interaction observed. They are

1. Absorption
2. Transmission
3. Reflection
4. Scattering

2.5.5.1. Absorption. Maximum therapeutic effect of laser is due to absorption of radiant energy in the tissue they are.

2.5.5.2. Photochemical interaction. In photochemical interaction specific wave length of laser light are absorbed by naturally occurring chromophores that are able to induce certain biochemical reactions at cellular level. These interactions are used in two ways;

1. Photodynamic therapy
2. Biostimulation

2.5.5.3. Photothermal interaction. In this radiant light energy absorbed by the tissue substances & molecules become transferred into heat energy, which produces tissue effect like; photo ablation (removal of tissue by vaporization) photocoagulation and photo pyrosis (burning away of tissue).

2.5.5.4. Photomechanical interaction. Photomechanical effects include photo disruption which is the breaking apart of structures by laser light and also photo acoustic effect which involve removal of tissue by shock wave generation

2.5.5.5. Photoelectrical Interaction. Photoelectrical include photo plasmolysis, which describes how tissue is removed though formation of electrically charged ions.

The amount of energy that is absorbed by tissue also depends on the tissue characteristics such as pigmentation & water content. Figure 2 showed that shorter wavelengths (from 500 nm to 1000 nm) are absorbed readily by pigmented tissues such as melanin & hemoglobin. Argon is highly absorbed by hemoglobin. Diode and Nd:YAG have a high affinity for melanin and less interaction with hemoglobin. The longer wavelength is more interactive with hydroxyapatite & Water. The largest absorbtion peak for water is just below at 3000nm which is at the Er:YAG. CO2 is well absorbed by hydroxyapatite. This knowledge helps us to select the laser for a particular clinical applications.[1]

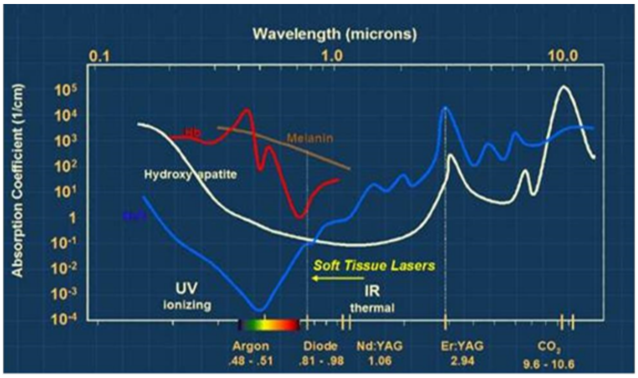

Fig. 2: Approximate net absorption curves of various tissue components

2.5.6. Transmission

Transmission is the second characteristic of laser in which laser energy transmitted through the tissue without any effect on target tissue. This effect is highly dependent on the wavelength of laser light. Figure 3 shows the relative depth of penetration in water of various wavelengths. Erbium family acts on surface with absorption depth of 0.01mm,whereas diodes are transmitted through the tissues to depth up to 100mm. Water is transparent to shorter wavelengths like Argon, Diode, Nd:YAG whereas tissue fluids readily absorb the Erbium & CO2 at the outer surface.[1]

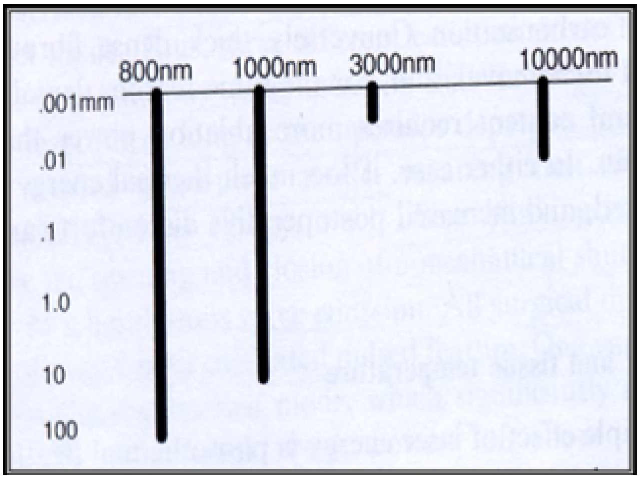

Fig. 3: Depth of penetration of various laser wavelengths in water

2.5.7. Reflection

The third effect is reflection, which is theredirecting laser beam from surface, having no effect on target tissue.Caries detecting Laser device uses the reflected light for its diagnostic ability.[1]

2.5.8. Scattering

The fourth effect is a scattering of the laser light, weakening of the intended energy & possibly producing no useful biologic effects.Scattering of the laser beam could cause heat transfer to adjacent tissue & cause unwanted damage. However a beam deflected in different directions is useful in facilitating curing of composites resin.[1]

2.6. Lasers used in dentistry[1] (Table 1)

3. Applications of Laser in Restorative Dentistry

3.1. Prevention of caries

Using CO2 laser, energy is absorbed in few micrometers of the external enamel surface and converted into heat. Loss of carbonate from mineral and fusion of hydroxyapatite crystals occur which reducing the interprismatic spaces and increases its acid resistance which gives caries-preventive effect.[4]

3.2. Diagnosis

Lasers can be used to detect incipient carious lesion which cannot be diagnosed clinically and radiographically. Transilliumination is used for this purpose. Quantitative measurement of the fluorescence emission pattern induced by laser, the technique of laser-induced fluorescence, has been used in the assessment of caries.[5,6]

3.3. Etching and bonding

Er:YAG laser etching can apparently replace acid etching with similar effect on enamel and without the negative influence of phosphoric acid.[7] Diode laser irradiation increases microtensile bond strength of adhesive systems to Dentin.[8]

3.4. Curing of composites

Curing of composite can also be done by laser which increases the depth of curing as compared to halogen light. The argon laser have been shown to be effective in the initiation of polymerization of dental resins.[8]

3.5. Bleaching

Lasers also find use in bleaching of vital and non-vital teeth. The laser is used to enhance the bleaching material.[9]

Table 1: Lasers used in dentistry

	Argon Laser	Diode Laser	Nd:YAG Laser	Erbium family lasers	CO_2 Laser
Active Medium	Argon gas	Semiconductor crystals (al, in,ga,ar)	Garnet crystal (yt, al, neo)	ER,CR:YSGG ER:YAG	Co2 molecule
Transmission	Fiberoptic cable	Fiberoptic cable	Fiberoptic cable	Fiberoptic cable	Hollow tube-like wave guide
Mode	Continuous or gate pulsed mode	Continuous or gate pulsed mode	Free running pulse mode	Free running pulsed	Continuous or gate pulsed mode
Wavelength	488nm (blue), 514nm (green)	800nm, 980nm	1064nm	2780nm 2940nm	10,600nm

4. Applications of Laser in Endodontics

4.1. Pulp diagnosis

Laser doppler flowmetry (LDF) was developed to assess blood flow in microvascular systems also can be used for diagnosis of blood flow in the dental pulp. This original technique utilized a light beam from a He-Ne laser and diode laser at a low power of 1 or 2 Mw.[10]

4.2. Dentinal hypersensitivity

To treat dentinal hypersenstivity a low out put laser can be used for irradiation on the electric activity of nerve fibers within the dental pulp whereas high power laser can be used for melting and fusing of the dentinal tubules.[11]

4.3. Pulp capping and pulpotomy

Lasers facilitate pulpal healing after irradiation at 2 W for 2 second. CO2 laser was found to be a valuable aid in direct pulp capping in human patients (Moritz 1998).[10]

4.4. Cleaning and shaping the root canal system

Nd:YAG laser improved in cleanliness of the canal wall when compared with conventional techniques. In photo induced photoacoustic streaming (PIPS) Er:YAG laser is used to clean the canal.[10]

4.5. Photo activated disinfection

PAD^{TM} high level disinfection. It has two components: an aqueous solution of dilute tolonium chloride (a vital stain) and a red light system of (wavelength 635 nm) to activate the PAD^{TM} solution. When this solution is activated by the PAD^{TM} light, it releases singlet oxygen which ruptures the cell membranes of bacteria.[12]

4.6. Root canal obturation

Argon, CO_2 and Nd:YAG lasers have been used to soften gutta-percha and results indicate that the Argon laser can be used for this purpose to produce a good apical seal.[12]

4.7. Endodontic periapical surgery

The use of laser in endodontic periapical surgery have various advantage which include the following: improved hemostasis and concurrent visualization of the operative field, potential sterilization of the contaminated root apex, potential reduction of the permeability of the root surface dentin, a reduction in postoperative pain.[10]

5. Conclusion

It is well said by Albert Einstein “Any advancement in the technology should be for the benefit of humankind and I fear the day that technology surpass humanity”. We as a dental practitioner should have in-depth knowledge about the principal of laser application in our field to deliver maximum therapeutic effect to the patients.

6. Conflict of Interest

The authors declare that there is no conflict of interest.

7. Source of Funding

None.

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