



Volume: 2, Issue: 6, 36-40
June 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

Tanushri

Senior Lecturer, Dept. of
OMDR, BBD-CODS,
Lucknow, India

Mishra Neeta

Professor & HOD, Dept. of
OMDR, BBD-CODS,
Lucknow, India

Ahmad Naeem

Senior Lecturer, Dept. of
Prosthodontics, CPGIDS,
Lucknow, India

Bashir Taseer

PG-Student, Dept. of
OMDR, CPGIDS, Lucknow,
India

Chauhan Ashish

Senior Lecturer, Dept. of
Physiotherapy, Paramedical
Sciences, SRMS, Bareilly,
India

Correspondence:

Tanushri

Senior Lecturer, Dept. of
OMDR, BBD-CODS,
Lucknow, India

Lasers power in dentistry- A boon

Tanushri, Mishra Neeta, Ahmad Naeem, Bashir Taseer, Chauhan Ashish

Abstract

Laser is an acronym, which stands for light amplification by stimulated emission of radiation. Several decades ago, the laser was a death ray, the ultimate weapon of destruction, something you would only find in a science fiction story. Then lasers were developed and actually used, among other places, in light shows. The beam sparkled, it showed pure, vibrant and intense colors. Today the laser is used in the scanners at the grocery store, in compact disc players, and as a pointer for lecturer and above all in medical and dental field. The image of the laser has changed significantly over the past several years. The present article presents a review on role of laser in dentistry.

Keywords: laser, light, plumes, ablation

Introduction

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. Dental procedures performed today with the laser are so effective that they should set a new standard of care.^{1,2}

History of Lasers

Approximately, the history of lasers begins similarly to much of modern physics, with Einstein. In 1917, his paper in *Physikalische Zeil*, "Zur Quanten Theorie der Strahlung", was the first discussion of stimulated emission. In 1954 Townes and Gordon built the first microwave laser or better known as 'MASER' which is the acronym for 'Microwave Amplification by stimulated Emission of Radiation'. In 1958, Townes, working with Schawlow at Bell Laboratories, published the first theoretic calculations for a visible light maser – or what was then called a LASER.³

In May 1960, Theodore Maiman at Hughes Aircraft company made the first laser. He used a ruby as the laser medium. One of the first reports of laser light interacting with tissue was from Zaret; he measured the damage caused by lasers incident upon rabbit retina and iris. The first gas laser was developed by Javan et al in 1961. This was the first continuous laser and used helium – neon. The Nobel Prize for the development of the laser was awarded to Townes, Basor and Prokhovov in 1964. The neodymium – doped (Nd): glass laser was developed in 1961 by Snitzer. In 1964 Nd: YAG was developed by Geusic. The CO₂ laser was invented by Patel et al in 1965. In 1968 Polanyi developed articulating arms to deliver CO₂ laser to remote areas. Polanyi in 1970 applied CO₂ laser clinically. In 1990 Ball suggested ophthalmologic application of ruby laser.

Laser Physics

Laser is a device that converts electrical or chemical energy into light energy. In contrast to ordinary light that is emitted spontaneously by excited atoms or molecules, the light emitted by laser occurs when an atom or molecule retains excess energy until it is stimulated to emit it. The radiation emitted by lasers including both visible and invisible light is more generally termed as electromagnetic radiation. The concept of stimulated emission of light was first proposed in 1917 by Albert Einstein.

Properties of Laser: ⁴

1. **Coherent:** Coherence of light means that all waves are in certain phase relationship to each other both in space and time
2. **Mono- chromatic:** Characterized by radiation in which all waves are of same frequency and wavelength.

3. **Collimated:** That means all the emitted waves are parallel and the beam divergence is very low. This property is important for good transmission through delivery systems.
4. **Excellent concentration of energy:** When a calcified tissue for eg. dentin is exposed to the laser of high energy density, the beam is concentrated at a particular point without damaging the adjacent tissues even though a lot of temperature is produced ie 800-900°C.
5. **Zero entropy.**

Laser Design: The laser consist of following components. A laser medium or active medium: This can be a solid, liquid or gas. This lasing medium determines the wavelength of the light emitted from the laser and the laser is named after the medium.

Housing tube or optical cavity: Made up of metal, ceramic or both, This structure encapsulates the laser medium Consists of two mirrors, one fully reflective and the other partially transmittive, which are located at either end of the optical cavity.

Some form of an external power source: This external power source excites or “pumps” the atom in the laser medium to their higher energy levels. A population inversion happens when there are more atoms in the excited state rather than a non-excited state. Atoms in the excited state spontaneously emit photons of light which bounce back and forth between the two mirrors in the laser tube, they strike other atoms, stimulating more spontaneous emission. Photons of energy of the same wavelength and frequency escape through the transmittive mirror as the laser beam. An extremely small intense beam of energy that has the ability to vaporize, coagulate and cut can be obtained if a lens is placed in front of the beam. This lens concentrates the emitted energy and allows for focussing to a small spot size.

Laser Light Delivery: Light can be delivered by a number of different mechanisms. Several years ago a hand held laser meant holding a larger, several hundred pound laser usually the size of desk above a patient. Although the idea was comical at the time, it is becoming more feasible as laser technology is producing smaller and lighter weight lasers. In the more future it is probable that hand held lasers will be used routinely in dentistry.

Articulated arms: Laser light can be delivered by articulated arms, which are very simple but elegant. Mirrors are placed at 45° angles to tubes carrying the laser light. The tubes can rotate about the normal axis of the mirrors. This results in a tremendous amount of flexibility in the arm and in delivery of the laser light. This is typically used with CO₂ laser. The arm does have some disadvantages that include the arm counter weight and the limited ability to move in straight line.

Optical Fiber: Laser light can be delivered by an optical fiber, which is frequently used with near infrared and visible lasers. The light is trapped in the glass and propagates down through the fiber in a process called total internal reflection. Optical fibers can be very small. They can be either tenths of micros or greater than hundreds of microns in diameter. Advantages of optical fiber is that they provide easy access and transmit high intensities of light with almost no loss but have two disadvantages, one the beam is no longer collimated and coherent when emitted from the fiber which limits the focal spot size and second disadvantage is that the light is no longer coherent.

Patient to laser: Another method of delivering laser light to the patient is actually to bring the patient up to the laser. Eg: Slit lamp used in the ophthalmologist gist has been doing this

for quite some time. The ophthalmic laser microscope is simply a slit lamp with a laser built into it. The doctor simply images what he wants on the cornea or retina and then pushes the foot pedal to deliver laser beam to the target. Once the laser is produced, its output power may be delivered in the following modes.

1. **Continuous wave:** When laser machine is set in a continuous wave mode the amplitude of the output beam is expressed in terms of watts. In this mode the laser emits radiation continuously at a constant power levels of 10 to 100 w. Eg: CO₂ laser
2. **Gated:** The output of a continuous wave can be interrupted by a shutter that “chops” the beam into trains of short pulses. The speed of the shutter is 100 to 500ms.
3. **Pulsed:** Lasers can be gated or pulsed electronically. This type of gating permits the duration of the pulses to be compressed producing a corresponding increase in peak power, that is much higher than in commonly available continuous wave mode.
4. **Super pulsed:** The duration of pulse is one hundredth of microseconds.
5. **Ultra pulsed:** This mode produces an output pulse of high peak power that is maintained for a longer time and delivers more energy.
6. **Q-scotched:** Even shorter and more intense pulse can be obtained with this mode.

Laser Types: Based on wavelength.

1. **Soft Lasers:** With a wave length around 632mm Soft lasers are lower power lasers. Eg: He Ne, Gallium arsenide laser. These are employed to relieve pain and promote healing eg. In Aphthous ulcers.
2. **Hard lasers:** Lasers with well known laser systems for possible surgical application are called as hard lasers. Eg: CO₂, Nd: YAG, Argon, Er:YAG etc.

CO₂ Lasers: The CO₂ laser first developed by Palet et al in 1964 is a gas laser and has a wavelength of 10,600 nanometers or 10.6 μ deep in the infrared range of the electromagnetic opectrum. CO₂ lasers have an affinity for wet tissues regardless of tissue color. The laser energy weakens rapidly in most tissues because it is absorbed by water. Because of the water absorption, the CO₂ laser generates a lot of heat, which readily carbonizes tissues. Since this carbonized or charred layer acts as a biological dressing, it should not be removed. They are highly absorbed in oral mucosa, which is more than 90% water, although their penetration depth is only about 0.2 to 0.1mm. There is no scattering, reflection, or transmission in oral mucosa. Hence, what you see is what you get. CO₂ lasers reflect off mirrors, allowing access to difficult areas. Unfortunately, they also reflect off dental instruments, making accidental reflection to non-target tissue a concern. CO₂ lasers cannot be delivered fiber optically Advances in articulated arms and hollow wave guide technologies, now provide easy access to all areas of the mouth. Regardless of the delivery method used, all CO₂ lasers work in a non-contact mode. Of all the lasers for oral use, CO₂ is the fastest in removing tissue. As CO₂ lasers are invisible, an aiming helium – neon (He Ne) beam must be used in conjunction with this laser.

Nd: YAG Laser: Here a crystal of Yttrium – aluminum – garnet is doped with neodymium. Nd: YAG laser, has wavelength of 1,064 nm (0.106 μ) placing it in the near infrared range of the magnetic spectrum. It is not well

absorbed by water but are attracted to pigmented tissue. Eg: hemoglobin and melanin. Therefore various degrees of optical scattering and penetration to the tissue, minimal absorption and no reflection. Nd: YAG lasers work either by a contact or non-contact mode. When working on tissue, however, the contact mode is highly recommended. The Nd: YAG wavelength is delivered fiber optically and many sizes of contact fibers are available. Carbonized tissue remains often build of on the tip of the contact fiber, creating a ‘hot tip’. This increased temperature enhances the effect of the Nd:YAG laser, and it is not necessary to rinse the build up away. Special tips, the coated sapphire tip, can be used to limit lateral thermal damage. A helium-neon-aiming beam is generally used The Nd:YAG beam is readily absorbed by amalgam, titanium and non-precious metals, requiring careful operation in the presence of these dental materials.

Laser interaction with biologic tissues

Light can interact with tissues in four different mechanisms; Reflection: Reflected light bounces off the tissue surface and is directed outward. Energy dissipates after reflection, so that there is little danger of damage to other parts of mouth and it limits the amount of energy that enters the tissue.

Scattering

occurs when the light energy bounces from molecule to molecule within the tissue. It distributes the energy over a larger volume of tissue, dissipating the thermal effects.

Absorption

occurs after a characteristic amount of scattering and is responsible for the thermal effects within the tissue. It converts light energy to heat energy The absorption properties of tissue and cells depends on the type and amount of absorbing pigments or chromophores. Eg. Hemoglobin, water, Melanin, Cytochromes etc.

Transmission

Light can also travel beyond a given tissue boundary. This is called transmission. Transmission irradiates the surrounding tissue and must be quantified. Its effects should be considered before laser treatment can be justified.

Tissue effects on laser irradiation

When radiant energy is absorbed by tissue 4 basic types of interactions occurs.

Laser effects on Dental Hard Tissues

The absorption and transmission of laser light in human teeth is mainly dependent on the wavelength of the laser light. For eg. – Ultraviolet laser light is well absorbed by teeth. In water and in hydroxyapatite, there is a very low absorption at a wavelength of 2µm in comparison to high absorption of laser energy at 3µm and 10µm.

The laser effects can be grouped as: **Thermal effects:** The best known laser effect in dentistry is the thermal vaporization of tissue by absorbing laser light i.e. the laser energy is converted into thermal energy or heat that destroys the tissues.

- From 45° – 60° → denaturation occurs
- >60° → coagulation and necrosis
- At 100° C → water inside tissue vaporizes
- >300° C → carbonization and later pyrolysis with vaporization of bulky tissues.

1. **Mechanical effects:** High energetic and short pulsed laser light can lead to a fast heating of the dental tissues in a very small area. The energy dissipates explosively in a volume expansion that may be accompanied by fast shock waves. These shock waves lead to mechanical damage of the irradiated tissue.
2. **Chemical effects:** Here molecules can be associated directly with laser light of high photon energies.

Histologic Results

With continuous wave and pulsed CO₂ lasers. When continuous wave and pulsed CO₂ lasers were used, structural changes and damage in dental hard tissue were reported. Microcracks and zones of necrosis and carbonization are unavoidable. Because of drying effects, the microhardnes of dentin increases. The crystalline structure of hydroxyapatite changes and a transformation of apatite to tricalcium phosphate takes place.

Application of Lasers in Dentistry: ^{5,6}

Application	Possible Laser Types
Basic research Laser tissue interaction Technical development of applications of lasers in dentistry	All types All types
Measurement and diagnosis Holography Laser Doppler fowmetry Spectroscopy (caries diagnosis)	He Ne, diodes He Ne, diodes Various types
Oral and Maxillofacial Surgery Cutting and Coagulation Photodynamic therapy	CO ₂ , Nd: YAG, Ar, dye Dye, Au-Cu vapour
Conservative dentistry Preventive dentistry (fissure sealing) Caries treatment Composite resin light Curing Tooth surface conditioning	CO ₂ , Nd:YAG, ruby CO ₂ , Nd:YAG, Er: YAG, Excimer Ar, dye, HeCd Excimer, CO ₂ , Nd:YAG, Er:YAG
Endodontics Root canal treatment Apicoectomy	Nd: YAG, CO ₂ , Excimer CO ₂ , Nd:YAG
Periodontics Laser sealing of affected root surfaces Excision of gingival soft tissues	CO ₂ , excimer CO ₂
Analgesic effect and bio-stimulation Stimulation of wound healing Low power laser radiation with analgesic Effects	He Ne, diodes Nd: YAG

Advantages of laser welding: ⁷

1. High bond strength and corrosion resistance since laser welding is a form of sweating that does not use solders of different materials.
2. Reduced oxidation when argon gas is used for welding.
3. Decreased thermal influence and greater precision in processing than with soldering or other techniques.

Laser in Restorative Dentistry and Endodontics

Lasers find numerous applications in restorative dentistry and endodontics ranging from prevention of caries to antibacterial action in root canals.

Prevention of caries

Yamamoto and Oaya used as YAG laser at energy densities of 10 to 20 J/cm³ and demonstrated that the lased enamel surface was more resistant to in vitro demineralization than non lased enamel. Stern and Sognnaes demonstrated in vivo that enamel subjected to 10 to 15 J/cm² showed a greater resistance to dental caries than the controls. Stern concluded that energy levels below 250 J/cm² did not permanently alter the pulp but necrosis could occur when energy level, reached 1800 J/cm² or higher. Lobene and Collogues in their experiment with CO₂ laser, observed that CO₂ irradiation to tooth enamel caused small amounts of hydroxyapatite to be converted to more insoluble calcium orthophosphate apatite. This paved the way for widespread use laser in prevention of caries. Lasers can be used for removal of incipient caries, sealing pits and fissures. The CO₂ and Nd:YAG lasers can remove the organic and inorganic debris found in pits and fissures. Following the removal a synthetic hydroxyapatite compound is attached to enamel using the laser. Power densities used are low and it did not alter the health of pulp tissue. In 1985 Terry Myers used Nd:YAG laser for debrident of incipient caries. When a topical fluoride treatment was performed after argon laser conditioning of enamel, an even more dramatic reduction in enamel acid demineralization was observed.

Diagnosis

Lasers can be used to detect incipient carious lesion which cannot be diagnosed clinically and radiographically. Transillumination using lasers is used for this purpose. The lesion appears as a distinct dark red area easily differentiated from the rest of the sound tooth structure. Decalcified area appears as a dull, opaque, orange color. Also enamel fractures and recurrent decay around metallic and resin restoration can be diagnosed.

Laser Doppler Flowmetry

Pulpal blood flow can be assessed using laser doppler flowmetry. He Ne and diodes can be used.

Cavity preparation

The use of lasers for cavity preparation has been under scrutiny for 20yrs as many investigators found that pulpal necrosis would occur with use of lasers. The search for laser that can be used to cut hard tissues begun in 1964 by Dr. Leo Goldman who used laser on his brother Bernard's teeth. The subsequent search included many laser wavelengths such as CO₂ but its disadvantages include cracking with flaking of enamel surface.

Etching the Enamel

The laser absorbed by enamel causes the enamel surface to be heated to a high temperature, generating micro cracks in the

surface and this aids in enhancing adhesion of composite to the tooth structure. The surfaces appear similar to acid etched surfaces. The Nd:YAG laser is not readily absorbed but absorption can be increased by using a dye on enamel surface.

Desensitization

Lasers are effective tool in the treatment of hypersensitivity. Mode of action is by blocking the dentinal tubules resulting in change in hydraulic conductance.

Lasers in Surgical Systems

Lasers are an alternative to conventional surgical systems. Stated best by Apfelberg in 1987, lasers are a "new and different scalpel" (optical knife, light scalpel).

Certain proven uses for dental soft tissue procedures using lasers are

1. Frenectomy Maxillary midline Lingual (Tongue tie)
2. Incisional and exasional biopsies.
3. Removal of benign lesions
4. Removal of lesion in patients with hemorrhagic disorders.
5. Implants – Stage II – at the time of recovery.

Bio-stimulation and Photodynamic Therapy

Photodynamic therapy is an experimental cancer treatment that is based on a cytotoxic photochemical reaction. This reaction requires molecular oxygen, the photoactive drug dihematoporphyrin ether, a hematoporphyrin derivative and intense light, which is typically delivered by a laser. Dihematoporphyrin which is relatively retained in malignant tissue after several days, is given intravenously to a patient. Laser light at a wavelength corresponding to the absorption peak of the drug is used to activate the drug to an excited state. The drug then reacts with molecular oxygen to produce singlet oxygen, a highly reactive free radical which ultimately leads to tissue necrosis.

Laser Hazards and Laser Safety

The subject of dental laser safety is broad in scope, including not only an awareness of the potential risks and hazards related to how lasers are used, but also a recognition of existing standards of care and a thorough understanding of safety control measures.

Laser Hazard Class for according to ANSI and OSHA Standards: ⁸

Class I - Low powered lasers that are safe to view

Class IIa - Low powered visible lasers that are hazards only when viewed directly for longer than 1000 sec.

Class II - Low powered visible lasers that are hazardous when viewed for longer than 0.25 sec.

Class IIIa - Medium powered lasers or systems that are normally not hazardous if viewed for less than 0.25 sec without magnifying optics.

Class IIIb - Medium powered lasers (0.5w max) that can be hazardous if viewed directly.

Class IV - High powered lasers (>0.5W) that produce ocular, skin and fire hazards.

The types of hazards can be grouped as follows

1. **Ocular Injury:** Potential injury to the eye can occur either by direct emission from the laser or by reflection from a specular (mirror like) surface or high polished, convex curved instruments. Damage can manifest as injury to sclera, cornea, retina and aqueous humor and

also as cataract formation. The use of carbonized and non-reflective instruments has been recommended.

2. **Tissue Hazards:** Laser induced damage to skin and others non target tissues can result from the thermal interaction of radiant energy with tissue proteins. Temperature elevation of 21°C above normal body temp (37°C) can produce cell destruction by denaturation of cellular enzymes and structural proteins. Tissue damage can also occur due to cumulative effects of radiant exposure. Although there have been no reports of laser induced carcinogenesis to date, the potential for mutagenic changes, possibly by the direct alteration of cellular DNA through breaking of molecular bonds, has been questioned. The terms photodisruption and photoplasmolysis have been applied to describe these type of tissue damage.

Respiratory

Another class of hazards involves the potential inhalation of airborne biohazardous materials that may be released as a result of the surgical application of lasers. Toxic gases and chemical used in lasers are also responsible to some extent. During ablation or incision of oral soft tissue, cellular products are vaporized due to the rapid heating of the liquid component in the tissue. In the process, extremely small fragments of carbonized, partially carbonized, and relatively intact tissue elements are violently projected into the area, creating airborne contaminants that are observed clinically as smoke or what is commonly called the 'laser plume'. Standard surgical masks are able to filter out particles down to 5µm in size. Particle from laser plume however may be as small as 0.3µm in diameters. Therefore, evacuation of laser plume is always indicated.

Fire and Explosion

Flammable solids, liquids and gases used within the clinical setting can be easily ignited if exposed to the laser beam. The use of flame-resistant materials and other precautions therefore is recommended.

Conclusion

Laser has become a ray of hope in dentistry. When used efficaciously and ethically, lasers are an exceptional modality of treatment for many clinical conditions that dentists treat on daily basis. But laser has never been the "magic wand" that many people have hoped for. It has got its own limitations. However, the futures of dental laser are bright with some of the newest ongoing researches.

References

1. Myers TD, Myers WD, Stone RM. First soft tissue study utilizing a pulsed Nd:YAG dental laser. *North west Dent.* 1989; 68:14-7
2. Frame JW. Carbon dioxide laser surgery for benign oral lesions. *Br Dent J* 1985; 158:125-8
3. Pick RM, Pecaro BC, Silberman CJ. The laser gingivectomy. The use of the CO2 laser for the removal of phenytoin hyperplasia. *J Periodontol.* 1985; 56: 492-4
4. Einstein A. Zur Quantum Theorie Der Strahlung. *Verk Deutsch Phys Ges.* 1916; 18: 318
5. Myers TD. Lasers in dentistry: their application in clinical practice. *J Am Dent Assoc.* 1991; 122: 46- 50
6. Miserendio LJ, Pick RM, eds. Lasers in Dentistry. *Chicago: Quintessence;* 1995: Chapter 2, pages 27-38

7. Manni JG. Dental Applications of Advanced Lasers. *Burlington, MA: JGM Associates;* 2004: Pages 1-15
8. Wigdor H, et al. Lasers in dentistry. *Lasers Surg Med* 1995; 16: 103-33