Laser in Periodontics - A Review of Literature

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ABSTRACT

Dental lasers have been commercially available for several decades. Laser are an exciting technology, widely used in medicine, kind to tissue and excellent for healing. Lasers have provided us with a potential alternative to simultaneously remove the diseased soft tissues, target the micro‑organisms as well as stimulate wound healing. A laser generates a precise beam light concentrated with energy. Every laser technology is engineered to perform specific special functions without changing or damaging the surrounding tissues. In 1960, Maiman introduced "light amplification by stimulated emission of radiation" (LASER) using Einstein's theories about the stimulated emission. Since then, different lasers, such as diode, CO2, Nd: YAG, Er: YAG, and Er, Cr:YSGG have been developed and within a few years have been used in dentistry.

KEYWORDS: Laser, Laser Bacterial Reduction (LBR), Low Level Laser Therapy , LNAP (laser new attachment procedure)

INTRODUCTION

In the past several years development in the field of mechanical cutting devices are using in dentistry. Producing noise and vibration by the mechanical action of the air turbine and ultrasonic scalers patients were afraiding. Since 20th century, upsurge in the field of dental devices which depend upon photo-mechanical interactions.[1]

May be no one ever imagined that the magic beam shown in the Star Wars movies could some day treat their gums. LASER "light amplification by stimulated emission of radiation" was introduced in 1960 by Maiman using Einstein's theories. Diode, CO2, Nd: YAG, Er: YAG, and Er, Cr:YSGG are some lasers used in a days.[2]

From several decades Dental lasers commercially used. Laser are an exciting technology, widely used in medicine, kind to tissue and excellent for healing.[3] Lasers target is to remove the diseased soft tissues, micro‑organisms, stimulate wound healing.[4] A laser generates a precise beam light concentrated with energy. Every laser technology is engineered to perform specific special functions without changing or damaging the surrounding tissues.[5]

HISTORY

Today the dental lasers has benefited laser theories and researchs. The properties of light and its applications are seen since ancient time starting from 1021 Ibn-al-haythams book of optics to wave theory of light by Robert Hooke in 1665.[6,7] In 1900 Max Plane gave the quantum theory of light. Based on the quantum theory two fundamental radiation process were explained: (1) Stimulated absorption (2) Spontaneous absorption. Theory lead to the newer concept stimulated emission, the reverse of stimulated absorption which was followed before any significant progress was made in the laser development.[8]

MASERS AND LASERS

Nearly 40 years later, American physicist CharlesH. Townes introduced frequencies, and Microwave Amplification by stimulated Emission Of Radiation (MASER) used for the first time in 1951. In 1957 an American physicist Gordon Gould gave the term LASER(Light Amplification by Stimulated Emission of Radiation) was invented.[9] In 1960, H. Theodore Maiman was operated the first laser- a solid-state ruby laser.

- In 1960, Sorokin and Steven- solid state uranium laser.
- In 1960, Ali Javan, and William R. Bennett, and Donald Herriott/ constructed the first gas laser, using helium and neon.
- In 1961, Neodymium laser by jhonson and Nassau was demonstrated.
- In 1962, Robert N.Hall demonstrated the first laser diode devices, made of gallium arsenide.
- In 1964, Geusic, Marcos, and Van demonstrated neodymium doped yttrium-aluminium-garnet laser.
- In 1964, Patel demonstrated CO_2 -Corbon dioxide laser.
- In 1964, Hughes laboratories developed argon laser.[9]

WHAT IS LASER?

A laser is a device produces coherent electromagnetic radiation. Laser radiation is characterized by a low divergence of the radiation beam and, with few exceptions, a well-defined wavelength. (Fig. 1)[10]

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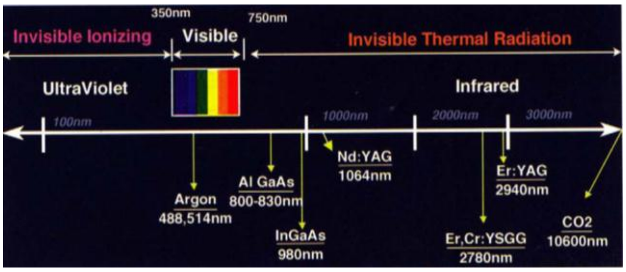

Fig. 1: A portion of the electromagnetic spectrum showing dental laser wavelengths being used for treatment

LASER BEAM DELIVERY SYSTEM

- Fiber-optic – Quart silica fibers with a handpiece – Diode laser, Neodymium-doped: Yttrium-Garnet (Nd: YAG)
- Hollow tube wavelength – It is hollow tube lined with series of well-aligned mirrors which reflect the laser beam from the unit to the handpiece. Co_2, Er-doped: Yttrium-Aluminium–Garnet (Er: YAG).

MODE OF USE

- Contact mode – In this type of option the distal end of the fiber-optic is placed in direct contact with the target tissue. Here, tactile feedback is perceived or felt.
- Noncontact mode – The handpiece is held away from the tissue and guide is provided to focus the beam at the desired target tissue. The operator has to adjust the focus of the beam by varying the distance between the handpiece and target to have the desired effect.

Different mode of laser Beam:

- Pulsed mode- It emits the energy from the laser beam in series of pulses a burst of peak energy at each pulse with a resting time in between. This allows the tissue to cool in between each delivery and minimize heat conduction with optimum benefits.
- Continuous mode- The laser wave emits energy in continuous mode at average power till they are cut off using an external source like foot switch or pre-setting in the laser unit. This type of energy is useful in ablative procedures or coagulating.[5]

CLASSIFICATION OF LASER

- **Based on state of the medium:**

1. Solid
2. Gas
3. Excimer
4. Diode

- **Based on output energy:**

1. Low output, soft or therapeutic-He-Ne, Ga-Al-As
2. High output, hard or surgical – Athermic laser emitted at wavelength in visible, infrared and U.V range utilized to cut, coagulate, vaporize/ and carbonize. For example CO_2 – Ar, Nd: YAG

- **Based on Oscillation mode:**
  - Continuous wave
  - Pulsed wave[15]

Types of Laser: [14] (Table 1)

Types	Delivery System[14]	Wavelength	Colour
Excimer laser :			
Argon Fluoride (ArF)		193 nm	Ultraviolet
Xenon Chloride (XeCl)		308 nm	Ultraviolet
Gas Laser:			
Argon	Optical fibre	488 nm	Blue
		514 nm	Blue-green
Carbon Dioxide (CO_2)	Waveguide, articulated arm	10,600 nm	Infrared
Helium Neon (HeNe)	Optical fibre,	637 nm	Red
Diode laser :	Optical fibre	800-980 nm	Infrared
Solid State Laser:			
Neodymium:YAG (Nd:YAG) Optical fibre	Optical fibre	1064 nm	Infrared
Erbium:YAG (Er:YAG)	Optical fibre, waveguide articulated arm[14]	2,940 nm	Infrared [11]

Table 1 : Types of Laser

MECHANISM OF ACTION

In the earlier period of 19th century, the physical principle of the laser developed by Einstein's theories developed. In 1960, Maiman was the first to introduced laser device. Since then, in the field of medicine and surgery lasers are routinely used. The laser light is a single photon wavelength. The process laser wave formation occurs of lasing occurs when an excited atom is stimulated to emit a photon. Spontaneous emission of a photon by one atom stimulates the release of a subsequent photon. This stimulated emission generates a very coherent (synchronous waves), monochromatic (a single wavelength), and collimated form (parallel rays) of light.[12]

The laser is a type of electromagnetic wave generator. By the lasers electromagnetic energy is converted into thermal energy. It has three characteristic features. (1) Monochromatic: which consist of waves of same frequency and energy. (2) Coherent: consist of waves which are related in speed and time. (3) Collimated: consist of waves which are parallel, and with low divergent beam.[12]

The laser concentrates energy of light and have strong effect, tissues are targeted, and which is lower than that of natural light. The photon is released which depends on the state of the electron energy with specific wavelength. In identical states two atoms with electron, photons released. Term waveform describes the manner in which laser power is delivered over time, either as a continuous or as a pulsed beam emission. Continuous waves deliver

large amounts of energy by laser resulting in increased heat productions. The small amount of energy is deliver by pulsed wave laser and there is interrupted bursts, thereby countering the build-up of heat in the surrounding tissue. The wavelength ,wavelength effects both applications, and design of laser are lasers characteristic.[12]

Wavelengths can be classified into:

- The Ultraviolet range 100-400 nm.
- The VIS range 400-700 nm.
- The IR range approximately 700 nm.

ADVANTAGES OF LASER

- Greater hemostasis
- Bactericidal effect
- Minimal wound contraction
- Laser helps in cut, ablation and reshaping the oral soft tissue more easily as compare to scalpel.[12]

DISADVANTAGES OF LASER

- Their will be destruction in the bottom of pocket
- In periodontal pockets excessive ablation of root surface and gingival tissue occurs
- Injury by thermal to root surface, gingival tissue, pulp and bone tissue

Caution before and during irradiation:

- Use of glasses for the protection (patient, operator and assistants)
- Inadvertent irradiation (action in noncontact mode)
- Protection of patient's eyes, throat and oral tissue
- Outside the target site
- Reflection from shiny metal surfaces
- Adequate high-speed evacuation to capture the laser plume[11]

Thermal Effect of laser on soft tissue: [13]

Tissue Temperature (^{0}C)	Observed effect
>37	Hyperthermia
>50	Non-sporulating bacteria inactivated
>60	Coagulation, Protien denaturation
70-80	Tissue welding
100	Vaporization
>200	Carbonization[13]

Table 1 : Thermal Effect of laser on soft tissue

LASER-TISSUE INTERACTION

- Absorption: Laser light is converted into effective thermal energy.
- Scatter: Light energy is re-emitted in a random direction and ultimately absorbed over a greater surface area which produces less intense and less precisely distributed thermal effect.
- Transmission: Light energy passes freely through the tissue. Without interaction of any kind and has little or no effect.
- Reflection: Light energy reflects off tissue surface with little or no absorption and consequently has no effect on tissue.[5]

APPLICATION OF LASER IN PERIODONTAL TREATMENT

Laser in Diagnosis

- Detection of Caries: Caries detection with laser works on the priniciple of differential fluoresce between healthy and diseased tooth.
- Detection of Calculus: Wavelength of 655nm can also be used for calculus detection. Calculus Fluoresce (glow) differently than healthy tissue.

Laser in prevention

- Laser toothbrush: Laser toothbrush is designed to provide an antibacterial effect in oral cavity using an irradiating laser beam of 630 nm low output semiconductor laser.

Laser in nonsurgical pocket therapy

- Laser Bacterial Reduction (LBR): It is a simple non-surgical procedure to eliminate or, at least, reduce the number of viable bacteria in the gingival sulcus. In this procedure a diode laser is used with a thin fiber optic fiber.[15]
- Calculus removal: If the calcified accretions on the root surface are not removed, the therapy is doomed to fail. Laser now are being used for this procedure. Not only does the laser remove the calculus on the root surface, but it also alters the cementum surface in such a way that it makes it favorable for fibroblast attachment.
- Photodynamic therapy: Photodynamic therapy or photochemotherapy uses a photoactive dye that is activated by exposed to the light in the presence of oxygen with specific wavelength, forming free radical species that kill target microbes.
- Laser in the treatment of hypersensitivity: Low-level laser therapy (LLLT) has shown in the hyperemia and inflammation of the dental pulp by resulting anti-inflammatory, analgesic and cellular effects. For the treatment of hypersensitivity, a 780nm diode laser can be used at a power of 30m W, or Nd: YAG laser at low power can be used.

Laser in surgical procedures

- LNAP (laser new attachment procedure): the laser is used to remove the epithelial lining of the sulcus as well as junctional epithelium.
- Biopsy and excision of soft tissue pathologies.[15]

Soft tissue application

- Gingival soft tissue procedures: Laser is generally accepted and widely used as a tool for soft tissue management. The major advantageous properties of a laser are relative ease of ablation of tissues together with effective hemostasis and bacterial killing. The most popular procedures such as Crown lenghthening, Gingivectomy, Gingivoplasty, and frenectomy which carried out using a laser. Compared with the use of a conventional scalpel, lasers can cut, ablate, easily reshaping of the oral soft tissue, less bleeding and a little pain with a few sutures. Laser surgery occasionally requires no local anesthetic or only topical anesthetics.

- Esthetic gingival procedures: Laser can apply in esthetic procedures such as recontouring or reshaping of gingival crown lengthening. For the esthetic periodontal soft tissue management Er: YAG laser is very safe and useful. The precisely ablating soft tissues using the laser is capable to fine contact and wound healing is fast.
- The major indication of laser is soft tissue surgery. The CO_2, Nd: YAG, diode, Er: YAG lasers are generally accepted as useful tools for this type of surgery.[1]
- Osseous surgery: The use of erbium lasers is becoming increasingly popular for bone surgery. Erbium lasers, in general, offer more precision and better access than mechanical instruments. They reduce the risk of collateral damage, particularly when compared with rotary instruments that may become entangled with soft tissue. Lasers also improve the comfort of both patients and surgeons by markedly reducing the noise and eliminating the grinding of the bone tissue.
- Lasers in implant therapy: Use of laser in implant may have several advantages, including improved hemostasis, production of a fine cutting surface with less patient discomfort during the postoperative period, and favorable and rapid healing following abutment placement, thus permitting a faster rehabilitative phase because of the ability of the laser to produce effective bone tissue ablation.
- Periodontal pocket treatment: One of the possible advantages of laser treatment of periodontal pockets is the debridement of the soft tissue wall. Gold and Vilaridi reported that Nd: YAG laser is safe for removal of the sulcular epithelium in periodontal pockets. It has an added advantage of protecting the underlying connective tissue by causing necrosis or carbonization.[1]

LASER HAZARDS

- Ocular injury: Injury to eye occur either direct emission from the laser or reflection from a mirror.
- Tissue damage: Laser includes damage to skin and other nontarget tissue which results in thermal interaction. Above the normal temperature can produce cell destruction by denaturation of cellular enzymes and structural proteins.
- Environment: Inhalation of airborne biohazardous material which results in the application of laser chemical like methane, benzene, formaldehyde present in the laser which can injuries if inhaled.
- Combustion hazards: Flammable gas, solid, liquids used within the clinical setting can be easily ignited if expose to a laser beam.
- Electrical Hazards: This is due to very high currents and high voltage required to use the present dental lasers. These can be electrical shock hazards or electrical fire or explosion hazards.[15]

CONCLUSION

Laser treatment is expected to serve as an adjunct to conventional mechanical periodontal treatment.The use of laser should be based on the proven benefits of hemostasis, a dry field, reduced surgical time and less post operative swelling. So, laser is safe and efficient for periodontal bone surgery when used concomitantly with water irrigation. This is an exciting field with many promising possibilities to be investigated and represents an area that may ultimately prove to be rich with utility in the context of Periodontics.

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