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REVIEW ARTICLE

LASERS A TOOL IN DENTISTRY: A REVIEW

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ABSTRACT

Lasers were introduced into the fi old of dentistry as they are a precise and effective way to perform many dental procedures. Treatment with lasers provides a hope of overcoming the disadvantages of conventional dental procedures. As the applications for dental lasers expand, greater numbers of dentists will use the technology to provide patients with precision treatment that may minimize pain and recovery time. Every discipline of dentistry has been positively affected with the use of laser technology including oral medicine, oral surgery, pediatric and operative dentistry, periodontics and implantology, prosthetic dentistry. The ability of the lasers to perform less invasive procedures without any discomfort to the patients had made a tremendous impact on the delivery of dental care. This will continue as this technology will continue to improve and evolve.

INTRODUCTION

In realism, lasers are not latest to dentistry. However it wasn't in the early hours of 1980s that lasers really saw their use in clinical practice. Now a days, lasers have practically found use in almost all aspects of dentistry. The key focus of clinical activity is soft tissue applications for now. Apart from of the wavelength used, they offer a diversity of advantages such as bloodless operational and post-operative field, negligible amount of swelling and high patient support. Lasers offer the ability to negotiate curves without any difficulty and folds in mouth. Pain is reduced or is absent 90% of times, apparently due to sealing of nerve fibers. In some procedures like maxillary midline frenectomy there is assurance of no postoperative pain.

In just single generation since then, lasers have been motivated out of the sphere of fantasy into everyday life. "LASER" is a short form for '*Light Amplification by Stimulated Emission of Radiation*'. A medical laser or apparatus includes a source of electricity, mirrors to undeviate the beam, a crystal or gas that is motivated to release the light and tubing to send the light energy. The character of the substance through which the light passes determines the specific properties of the laser and therefore what it can do in the human body.

The benefits of lasers in dentistry today include, soft tissue procedures, laser fluorescence for caries detection and laser Doppler Flow metry for pulp vitality testing. While potential uses focus on hard tissues such as caries removal, cavity preparation, remineralisation of incipient carious lesions and endodontic procedures, lasers have not yet successfully replaced the whine of the hand piece. This is due to concerns over the deleterious thermal effects of lasers on the underlying pulp. Blum recognized that antibacterial effects of lasers depends on frequency which is only 30 Hz of ND: YAP laser slow down growth of streptococcus mitis. According to in vitro study of Kranendok A ND: YAP laser is helpful in killing six tested periodontal pathogens [1, 2].

HISTORY

Photo chemotherapy was former used in 1400 B.C when Indian used a drug psoralens which is obtained from a plant and used to treat vetiligo. In 1974 in a lot of diseases psoralens shared with ultra violet a radiation (PUVA) were used. LASER (light amplification by stimulation emission of radiation) was initially known as MASER

(Microwave amplification by stimulation emission of radiation).

In 1960 first laser developed was ruby laser of 0.694 um and later in 1961 neodymium laser was developed. In 1963 Einstein published his treatise ‘zur quantum theory. In 1964 Townes, Basov and Prokhorov got the noble prize for the development of LASER. Ruby laser was not effective in dental field because of its high thermal effects on dental hard tissues.

The first report of laser interaction to human vital tooth appeared in 1965 when Leon Goldman applied two pulses of ruby laser to his brother Bernard, who was dentist. According to their report the dental laser patient experienced no pain with only superficial damage to crown. Ironically the first laser dentist was a physician and the first laser dental patient was a dentist. Then from 1960-1980 dental researches continued to search for many other different types of lasers that might be effective for the application to dental hard tissues. Then CO2 laser with 10.6um wavelength was well absorbed by enamel. [3]

LASER PHYSICS

Photons are the basic quanta or unit of light. When a photon strikes an atom, electron within the atom jump to a higher energy level (e+).Thus, this atom is now pumped to an excited state. This atom is now unstable and will try to return to its resting state, thus releasing the stored energy in the form of emitted photons. This type of emission is known as spontaneous emission. But in lasers there is something known as stimulated emission and this process of lasing occurs when an excited atom can be stimulated to emit a photon before this process occurs spontaneously. This occurs when the incident photon has the same energy or wavelength as the released photon. So when the incident photon of the same energy or wavelength enters the electromagnetic field, it triggers the decay of excited electron to a low energy state. Thus, the result of stimulated emission is two photons of identical wavelength traveling in same direction. The release of second photon is time locked to release of the first so that the two photons oscillate together in same phase. For lasing to occur there should be population inversion , which means that in a collection of atoms if there are more electrons in a pumped state or an excited state rather than remaining in a resting state.

Laser Components:

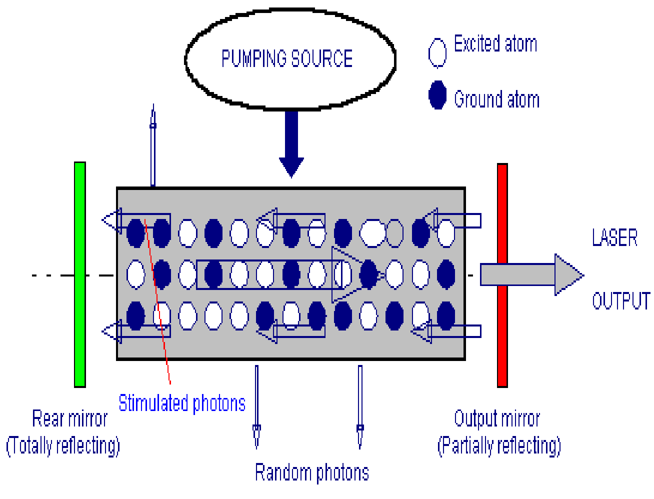
The basic components of a laser includes:

1. **Optical cavity:**

Lasing medium

Parallel mirrors

2. **Pump energy source**
3. **Cooling system**



A LASER SYSTEM

Optical cavity:

To contain and amplify the photon chain reaction that results from stimulated emission in a population of excited atoms it is necessary to place the reaction within the optical cavity. This consists of lasing medium and parallel mirrors.

Lasing medium: contains homogenous population of atoms or molecules that are pumped up to the excited state and are stimulated to lase. The exact species of atom or molecule determines the wavelength of output beam. The active medium is suspended in the optical cavity as a gas, a liquid or distributed in solid state. (e.g. a crystal). The laser is named for the components of the active medium and their state of suspension.

Mirrors: On either side of the lasing medium there are placed 2 parallel mirrors. In this configuration, photons bounce off the mirrors and re-enters the medium to stimulate the release of more photons. The mirrors collimate the light that is photons exactly perpendicular to the mirrors re-enter the active medium, while those off axis leave the lasing process. If one mirror is totally reflective and other mirror partially transmissive, the light that escapes through first mirror becomes the laser beam.

Pump energy source:

Some form of energy is provided to continuously pump atoms up the excited state and maintain the population inversion and high intensity light circulation. This is provided by the pump energy source.

Cooling system:

Because the process is not 100 % efficient and the remaining energy is converted into heat, it is necessary to provide some form of cooling. Thus, stimulated emission within an optical cavity generates a collimated, coherent, and monochromatic beam of light.

Laser delivery systems:

The coherent, collimated beam of laser light must be able to be delivered to the target tissues in a manner that is precise and ergonomic. Two delivery systems are used in dental lasers:

Flexible hollow wave guide: or tube that has an interior mirror finish. The laser energy is reflected along the tube and exits through a handpiece at the surgical end, with the beam striking the tissue in a non-contact fashion (i.e. without directly touching the tissue)**.**

Glass fiber optic cable: this cable is pliant and comes in various diameters, with sizes ranging from 200 to 1000 micrometer. Although the glass fiber is encased in a resilient sheath, it can be somewhat fragile and cannot be bent into a sharp angle. The fiber is snugly fit into the handpiece with the bare end protruding or, in some cases, with an attached glasslike tip. This fiber system is mostly used in contact fashion though it can be used otherwise also.

Dental lasers can be used in contact or non-contact mode.

Clinically, a laser used in contact can provide easy access to otherwise difficult to reach areas of tissue. The fiber tip can be easily inserted into a periodontal pocket, to remove small amounts of granulation tissue, for example. In non- contact mode the laser is directed at the tissue from some distance from it. This modality is useful for following various tissue contours, but the loss of tactile sensation demands that the dentist pays close attention to the interaction of the laser with the tissue. Most of the invisible lasers are equipped with a separate aiming beam. The aiming beam is delivered co-axially along the fiber or wave guide and shows the operator the exact spot where the laser energy is focused.

Focal point:

In either modality, lenses within the laser itself focus the beam. The size and shape of the laser determine the focal length and the spot size of the focal point. With lasers using the hollow wave-guide, the precise spot where the energy is the highest is known as the focal spot. This spot should be used for incisional or excisional surgery. For lasers using the optic fiber, the focal point is at or near the tip of the fiber. When working on tissue the term focused or defocused refers to the position of focal plane in relation to the tissue plane. When the handpiece is moved away from the focal point or the tissue the beam is defocused and becomes more divergent. At a small divergent distance the beam can cover a wider area, which is useful in achieving hemostasis. At a greater distance away, the beam loses its effectiveness because the energy dissipates.

When working on tissue, the laser should always be used with focal point positioned at tissue surface (in focus) or positioned above the tissue surface (defocused). The laser should never be kept with the focal spot deep or within the tissue (prefocused) as this can lead to deeper thermal damage and undesirable tissue effects.

Emission modes:

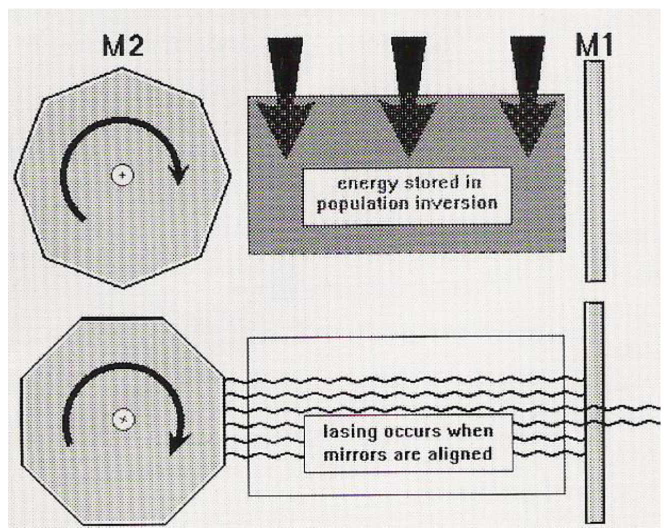
The laser device can emit light in one of three basic modes.

Continuous wave: meaning the beam is emitted at one power level as long as the device is activated by pressing the foot switch.

Gated pulse-mode: meaning there are periodic alternations of the laser energy being on and off, similar to a blinking light. This mode is achieved by the opening and closing of a mechanical shutter in front of the beam path of a continuous wave emission. The duration of on and off times of this type of laser normally is as small as few milliseconds.

Free running pulsed mode: this mode is unique in that large peak energies of laser light are emitted for an extremely short time span, usually in microseconds, followed by a relatively long time in which the laser is off. For example, a free running pulsed laser with a pulse duration of 100 micro seconds with pulses delivered at 10 pulses per second would mean that the energy at the surgical site is only present 1/1000 of a second and absent for the remaining 99.999% of that second. The timing of this emission is computer controlled, not mechanically a in the gate pulsed device.

Q-Switching:



Shorter duration pulses are obtained with Q-switching. A simple Q -switch uses a mirror as part of the optical cavity. Only when the rotating mirror is precisely aligned with the output mirror is lasing possible, so lasing is restricted to a very short time interval (1-10 seconds). Between alignments, energy is stored in the excited population. Thus several hundred mili joules of energy can be squeezed into nano second pulses.

The important principle of any laser emission mode is that the light energy strikes the tissue for a certain length of time, producing a thermal reaction. If the laser is in pulsed mode, either gated or free running the targeted tissue has some time to cool before the next pulse of laser energy is emitted. Thin or fragile tissue, for example should be treated in pulsed mode so that amount and rate of tissue removal is slower and smaller but the chance of thermal damage to adjacent tissue is minimal In continuous wave mode the operator must cease the laser emission manually so that thermal relaxation of the tissue may occur. Longer intervals between the pulses can also help to avoid the transfer of heat to the surrounding tissue. Also, a gentle air stream or air current from the high volume suction also greatly in keeping the target area cooler. Conversely, thick dense fibrous tissue requires more energy for removal, and continuous wave emission provide a more rapid, yet safe speed of excision. In either case, if too much thermal energy is used, healing can be delayed, and increased post-operative discomfort can occur.

CLASSIFICATION

Lasers are named for the contents of the active medium and the rate of suspension ie CO2 gas laser or argon ion gas laser. Dental lasers fall into two basic categories-

1) Those which work solely on noncontact either focused or defocused for example CO2, erbium laser

2) Those that work either in contact or noncontact mode, the contact mode being focused and the noncontact mode been defocused. This group includes lasers given by fiber optics for example argon, ND: YAG, Ho: YAG

NON CONTACT LASERS

This includes CO2 lasers as they work primarily by non-contact mode which can be either focused or defocused.

The focused mode is when the laser beam hits the tissue at its focal point or its smallest diameter and the diameter in turn is dependent upon the lens used.

Most CO2 lasers have lens that can focus the beam to spot size of 0.1mm to 0.35mm or larger. This focused mode is also called cut mode. The other mode is called as defocused mode in which moving the focal spot away from the tissue planes defocuses the beam and thus, the beam size that hits the tissue plane has a greater diameter thus covering a wide area of the tissue to be vaporized.

FIBER OPTICS LASERS

Lasers with wavelength shorter than 2500 nm can be delivered through fiber optics. It includes ND: YAG and Ho: YAG lasers. The fibers act to direct the photons along the long axis of the fibers and as photon hits the outer surface of the fiber they are reflected into the fibers by a reflecting coating ,thus some photons have a different travel distance as they bounce back along the inside of the fibers. Standard fibers measure about 6-12 feet in length and variety in diameter ranging from 60- 600 um. As the fiber diameter decreases, the potential energy density increases, fiber flexibility increases and lateral fracture of the fiber decreases. Special sapphire coated tips are there that act by absorbing the laser energy within the tip and create hot tip effect that acts as an electro-cautery of the tissues. There are various types of tips used to cut, vaporize or coagulate the tissue. The water spray is intended to cool the target tissue and reduce lateral thermal damage .It also flushes the coagulated tissue debris from the surgical site and prevents the coagulation from building up on fiber tip.

LASER INTERACTION WITH BIOLOGICAL TISSUE

The essential element of laser light that determine its interaction with matter are as follows: -

1) Wavelength of the emitted energy by the laser
2) Power density of the beam
3) Temporal characteristics of the beam energy like continuous / pulsed delivery, pulse rate and pulse duration.

Tissue elements that exhibit a high coefficient of absorption for a particular wavelength are called chromophores like Hb, melanin, hemosiderin.

When considering the hard tissue like enamel, dentin, and bone it is the hydroxyapatite that acts as the interactive material

TISSUE EFFECT

If radiation energy is absorbed by the tissue there are four different types of responses like.

PHOTOCHEMICAL INTERACTION

It includes the interaction of the beam with the chemical process of the tissue and is further subdivided into three types.

1) Bio stimulation

2) Fluorescence

3) Photodynamic therapy

It is the therapeutic use of lasers for treatment of pathological conditions.

Kingsbury JS (1997) suggest that photodynamic therapy possesses significant reduction /elimination of premalignant tissues. This could be beneficial in treating potential premalignant lesion and adjunct therapy in removal of areas of field concretization adjacent to cancer sites

According to Griffiths CE (2000) PUVA or UVB when used in narrow band of 311nm and combined with retinoid appeared to be effective in psoriasis.

PHOTOTHERMAL INTERACTION

It manifests basically-

Photo ablation: removal of tissue by vaporization and superheating of tissue fluids, coagulation or hemostasis.

Photo pyrolysis: burning away of the tissues

Cho S B (2010) used Q switched ND: YAG laser and stated that they are popular no ablative and selective photothermolysis therapies for pigment disorder.

PHOTOMECHANICAL INTERACTION

It includes:-

1) Photo disruption /photo dissociation
2) Photo acoustic

PHOTOELECTRICAL INTERACTION

It includes Photo plasmolysis

TYPES OF HAZARDS BY LASERS

They are classified into five types:

1) Ocular Hazards: Damage to the eyes (retina or corneal burn) can occur either from the direct emission of laser or by reflection from a mirror like surface for example dental instrument, so the use of carbonized or non-reflective instrument has been recommended along with safety goggles during treatment.

2) Tissue damage: Laser induced damage to skin & other no target tissues can result from a thermal Interaction of the radiant energy with the tissue proteins.

3) Respiratory Hazard: It can occur due to environmental spillage of the laser & potential inhalation of the air borne hazardous material that may be released because of surgical application of laser. This can be taken care of by using surgical laser smoke evacuator. Laser filtration masks which remove particles as small as 0.3um with at least 80% efficacy.

4) Fire and Explosion: In presence of inflammable material laser may pose significant hazards. These inflammable solids, liquids or gas used with the surgical setting can be easily ignited if exposed to surgical beam.

5) Electric Hazards: Because class IV surgical lasers use very high power, they can be associated with electrical hazards like electric shocks hazards, electric fire hazards or explosion hazards. If while lasing the soft tissue the tooth has to be protected, then a blackened or anodized instrument like wax spatula or periosteal elevator can be used. [3]

APPLICATIONS

1) Biopsy: An important point of consideration here is the amount of the tissue damaged laterally to the laser incision in respect to histological examination & wound healing.

2) Tongue lesions: Lesion on the tongue when removed by conventional method bleed like misery & this can be minimized by laser removal of the tongue lesion , which gives a bloodless feeling Average indicated power setting is

3) 3 to12W depending upon the size of the lesion.

4) White lesions vesicalobullous lesions & premalignant lesions: Basically , two type of procedures can be performed:

A] Laser peal procedure also known as surface ablation.

B] Surface vaporization or ablation of the lesions down to the required depth this could be beneficial in treating potentially premalignant lesions, such as oral leukoplakias & useful as an adjunct therapy in removal of area of field concretization adjacent to cancer sites. [4]

5] Apthous ulcers: One of the most remarkable laser benefits is the relief of painful symptoms associated with Apthous ulcers. The laser is brought into highly defocused mode where minimal energy is delivered to the site.

6] Treatment of salivary gland pathologies specially mucocele & ranulla.

7] Herpetic lesions: Lasers especially CO2 are used for symptomatic relief of herpetic lesions.

8] Coagulation: Lasers are used for coagulation of bleeding areas, coagulation of soft tissue donor sites or other small oral bleeding areas.

9] Frenectomy: There is no better use of lasers other than for maxillary midline or lingual frenectomy. In this 4 to5w of power in a highly defocused mode from 35sec to 2 to 3min is used. There is pain free healing & the problem of removal of the suture from the no keratinized mucosa is also not there.

10] Crown lengthening: Lasers can be used for crown lengthening. Power setting of 3 to 6W with the beam moving from focused to defocused mode as necessary.

11] Gingivectomy: Beam power of 4 to 10W depending on the thickness of the tissue & is used in defocused & focused mode with a spatula being used to protect the tissue. To treat overgrowth pockets or hyperplasias of various causes. [5]

12] Gingivoplasty: Laser used in about 2 to 5W depending upon the size of the lesion can be used to remove small tissue abrasions.

13] Preproshetic surgery: For removal of epuli, inflammatory papillary hyperplasias, vestibuloplasty or other preprosthetic surgical need.

14] Malignant lesion: A focused mode is usually used at a power setting ranging from 4to 10W. A potential advantages hypothesized is that the chance be minimized or eliminated because lasers have the ability to seal the blood vessels & the lymphatic.

15] Hemorrhagic disorders:

Lasers have been of very much importance to treat patients who have various intraoral lesions compounded by hemorrhagic disorders like: infantile hemangiomas especially in head & neck regions. [6]

16] Hypersensitivity: Lasers have proven to be effective in reducing or completely eliminating temperature sensitivity especially due to could. It is used in highly defocused mode at a low indicator power setting (1-2W) [7, 8].

17] Exposure of implants: Lasers works especially well for uncovering implants whether they are single or multiple fixtures. This is done in a defocused mode at a power a setting of 3 to 6W in a circular motion. This is also called as a cookie-cutter approach

18] Hard tissue like tooth cutting: According to the study done by Whittlers CJ & Strang R say that a novel pulsed CO2 lasers in an effective method for cutting cavities in the teeth. They say that using this there was no charring or surface cracks on the lased enamel surface using microscopic technique [9].

19] Bony surgeries: There have been many attempts to try using lasers for the bony surgeries. According to Friesen LR the most common lasers used for dental procedures are the ND: YAG & the CO2 lasers to the area where soft tissue closely approximates the bone may transfer sufficient energy to the bone to cause damage & or necrosis [10].

20] Vitality checking: Evans D stated that the laser Doppler flowery in a successful noninvasive method to check the pulpal blood flow & found it to be a consistent method of assessing the pulpal status of traumatized anterior teeth [11].

21] Lasers –assisted tooth whitening: Reyto Y (1998) states that cosmetic surgery & adhesive dentistry has not only enhanced patient self-esteem & confidence but also increased an alertness of the value of well teeth & gums [12].

22] Root canal treatment: Roper MJ stated that the erbium laser are the same to rotary files in the coronal & middle thirds but not in the apical thirds of the root canal system. [13].

ADVANTAGE:

1) Seals the blood vessel and protect dry operating field and admirable visibility

2) Seals lymphatics vessels which reduces post operating swelling.

3) Reduces pain

4) Capability to negotiate curves and fold less chances of mechanical trauma, minimal scaring and sutures required.

6) Amplify patient acceptances, Decline in bacterial count and in some cases it sterilize the field [3].

CONCLUSION

In the near future the role of lasers in the dental treatment will rise tremendously and to meet this foreseen requirement it is really necessary for upcoming dentist to have detail knowledge of the physics and interactions involved in laser. Cobb CM mentioned the usage of lasers have become a highly dependable and desirable tool replacing the traditional scalpel based surgeries for periodontal needs. This is an excellent mode that can be used for various application ranging from soft tissue to hard tissue [14]. Weesner BW says that there has been explosion in research, articles and case reports about laser therapy in recent years. The future is promising and the literature is exciting but sometimes conflict in findings .Laser may seem to be have a much greater role in the future than is now realized [15].

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