ISSN - 2394-7721

American Journal of Oral Medicine and Radiology

Journal homepage: www.mcmed.us/journal/ajomr

DIODE LASER AS AN ESTABLISHED TOOL IN PERIODONTICS – A REVIEW

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Article Info

Received 23/01/2015
Revised 16/02/2015
Accepted 25/03/2015

Key words:- Diode-Laser, Periodontitis, Periodontology.

ABSTRACT

Lasers in dentistry have revolutionized several areas of treatment in the last three and a half decades of the 20th century. Introduced as an alternative to mechanical cutting device, laser has now become an instrument of choice in many dental applications. Evidence suggests its use in initial periodontal therapy, surgery, and more recently, its utility in salvaging implant opens up a wide range of applications. In this paper, a brief history of the development, mechanism and uses of diode laser is presented, with emphasis given to the features that have led to the widespread commercial exploitation of this device mainly in field of periodontics.

INTRODUCTION

Laser is the acronym of the words 'Light Amplification by Stimulated Emission of Radiation'. Lasers [1] have come shown a long way since Albert Einstein described the theory of stimulated emission in 1917. The diode laser is a solid-state semiconductor laser that typically uses a combination of gallium (Ga), arsenide (Ar), and other elements, such as aluminum (Al) and indium (In) to change electrical energy into light energy. Dental laser energy has an affinity for different tissue components.

The 980 nm diode laser has energy and wavelength characteristics that specially target the soft tissues [2]. Since, the diode does not interact with dental hard tissues at reduced power settings, the laser is an excellent soft tissue surgical laser, indicated for cutting and coagulating gingiva and oral mucosa, and for soft tissue curettage or sulcular debridement.

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Diode lasers have high electrical to optical efficiency, are small light weight and compact, hence portable and are quiet devices as compared to other solid state and gas lasers (such as Nd:YAG, KTP.YAG, Ho, YAG, argon, erbium family and CO2) [3]. In, this modern technology world diode laser has become the most effective, affordable and user friendly soft tissue hand piece not only in the field of dentistry but also in other fields like dermatology, plastic surgery procedures, hair removal etc.

History of Lasers

The first laser was invented by Theodore Maiman in May 16, 1960 at Hughes Research Laboratories in Malibu, California., by using a cylinder of synthetic ruby measuring 1 cm in diameter and 2 cm long, with the silver-coated ends to make them reflective and able to serve as a Fabry–Perot resonator (Fig-1).

He used photographic flash lamps as the laser's pumpsource [4]. This initial breakthrough in the modern optics heralded the birth of laser science and the following decade witnessed a spectacular period of growth with the emergence of new and novel laser systems. Just a year after the ruby laser, the first gas laser (helium-neon He-Ne) was introduced by Javan et al [5] in 1961.This was soon followed by other systems using gases like carbon

dioxide (CO_2) [3], Excimers or excited dimmers (XeF, KrF,ArF) [6], Copper vapours [7], Argon ion [8] and Krypton ion. New solid-state laser were also introduced showing new optical crystals as an active medium. The most useful among these was Neodymium-YAG laser [9].
The first successful discovery of diode laser (semiconductor laser) was reported by a group of researchers in 1962 [10-18]. Finally, the organic dye or liquid laser [19] was introduced by Schafer et al. in 1966. This historical discovery in laser technology demonstrated how all the three phases of matter, i.e solid, liquid and gas were used as an active medium or lasing material in Laser machine. However, from a historical perspective only the diode laser has undergone both a dramatic and profile period of growth. Starting from the field of scientific research and information technology, now this laser system is being widely used in the field of spectroscopy, medicine, surgery and dentistry. (Fig-2).

Physics behind Diode Laser

The first observation of light emission by a semiconductor was by H.J Round in 1907 [20]. He applied an electric field to the silicon carbide compound, light was produced by the phenomenon of electroluminescene. The sufficient light was generated from semiconductors used in diode laser by p-n junction diode. This junction acts as a boundary between the regions where the current is carried by impurities or charge carriers. Two type of charge carriers are used in this system one is negatively charged electrons (n-type) and other is positively charged electron (p-type). Light is generated when an electron falls from the conduction band and recombines with a hole (vacant electron site) in the valence band. To convert the p-n junction diode into diode laser two conditions must be satisfied.

First, an inverted population of electron must be created by some excitation or pumping and second an optical feedback or an an optical resonator is required in order to facilitate the stimulated emission and stimulation of the light. This basic technique led to the fabrication of light-emitting diode (LED) [21]. For lasing action optical feedback was facilitated by cleaving the edges of the semiconductor material in which the p-n junction had been already formed.

Types of Diode Laser for periodontal treatment

Two types of diode lasers have been studied for their effects in Laser Assisted Periodontal Therapy: the diode laser (which emits high levels of light energy), and the low level diode laser (which emits low intensity light energy)

Low Level Laser Therapy (LLLT) is treatment where the light energy emitted by the laser elicits beneficial cellular and biological responses. On a cellular level, metabolism is increased, stimulating the production of ATP (adenosine triphosphate), the fuel that powers the cell. This increase in energy is available to normalize cell function and promote tissue healing. With the introduction of the biostimulation delivery tip, the diode laser is able to provide both cutting and therapeutic effects. When the low level tip is used, the laser energy is delivered over a wider area, decreasing the energy level, and producing the low level therapeutic effect.

Mechanism of action

The semiconductor diode laser is emitted in continuous- wave or gated-pulsed modes, and is usually operated in contact mode using a flexible fiber optic delivery system. Laser light at 800 to 980 nm is poorly absorbed in water, but highly absorbed in hemoglobin and other pigments [22]. Since the diode basically does not interact with dental hard tissues, the laser is an excellent soft tissue surgical laser, indicated for cutting and coagulating gingiva and oral mucosa, and for soft tissue curettage or sulcular debridement. The diode laser exhibits thermal effects by using the “hot-tip” caused by heat accumulation at the end of the fiber, and produces a relatively thick coagulation layer on the treated surface.
The mode of action is quite similar to electro-cauterization. Tissue penetration of a diode laser is less than that of the Nd:YAG laser, while the rate of heat generation is higher than that.

Uses In Periodontology

An early version of the diode laser was used effectively in the treatment of periodontal pockets in 1998.The diode laser has become an important tool in the dental armamentarium due to its exceptional ease of use and affordability. It has key advantages with regard to conventional periodontal treatment. The diode laser is well absorbed by melanin, haemoglobin, and other chromophores that are present in periodontal disease [23]. Hence the diode specifically targets unhealthy gingival tissues. The laser energy is transmitted through a thin fibre that can easily penetrate into deep periodontal pockets to deliver its therapeutic effects. More recent studies have shown that instrumentation of the soft periodontal tissues with a diode laser leads to complete epithelial removal while instrumentation with conventional curettes leaves significant epithelial remnants.

1. An Adjunct to Scaling and Root Planing (SRP)

Gingival health parameters are significantly improved with the addition of the diode laser to SRP. Studies have shown decreased gingival bleeding, [24, 25] decreased inflammation and pocket depth [26], as well as decreased tooth mobility and decreased clinical attachment loss.(CAL)This improvement in gingival health remains more stable than with conventional SRP treatment alone and tends to last longer [27]. After SRP, the diode laser is used on the soft tissue side of the periodontal pocket to remove the inflammed soft tissue and reduce the pathogens. Research has demonstrated better removal of the pocket epithelium compared with conventional techniques [28]. Many studies have shown increased reduction of bacteria (especially specific periopathogens) when diode lasers are utilized after SRP [29, 30].

2. Effects of diode Laser on Periodontal Therapy
Pain relief

- Laser therapy blocks the pain signals transmitted from injured parts of the body to the brain. This decreases nerve sensitivity and significantly reduces the perception of pain.
- Increases the production and release of endorphins and enkephalins which are natural pain-relieving chemicals within our bodies.

Inflammation reduction

- Laser therapy causes the smaller arteries and lymph vessels of the body to increase in size – a mechanism called vasodilatation.
- This increased vasodilatation more effectively allows the following:
- Inflammation, swelling, and edema to be cleared away from injury sites.
- Promotes lymphatic drainage which also aids in this vital healing process.

Accelerated tissue repair and cell growth

- Photons of light emitted by therapeutic lasers penetrate deeply into the tissues of the body to stimulate the production centers of individual cells.

This stimulation increases the energy available to these cells, causing them to absorb nutrients and expel waste products more rapidly

3. As A Substitute To Antibiotics Used In Periodontitits

Periodontal disease is a chronic inflammatory disease caused by a bacterial infection. Hence the bactericidal and detoxifying effect of laser treatment is advantageous in periodontal therapy [31]. The diode laser's bactericidal effectiveness has been well-documented [32-34]. Moreover, there is a significant suppression of A. Actinomy cetemcomitans, an invasive bacterium that is associated with aggressive forms of periodontal disease that are not readily treated with conventional scaling and root planning (SRP) . A. Actinomycetemcomitans is not only present on the diseased root surface, but it also invades the adjacent soft tissues, making it difficult to remove by mechanical periodontal instrumentation alone [35, 36]. This necessitates the use of adjunctive antibiotic therapy [37]. The diode laser provides a non-antibiotic solution which ultimately decreases the antibiotic resistance.

4. In Wound Healing

Improved blood flow

- Laser therapy significantly increases the formation of new capillaries (tiny blood vessels) within damaged tissues.

Reduced formation of scar tissue

- Laser therapy reduces the formation of scar tissue (fibrous tissue) following tissue damage related to cuts, burns, and surgery.
- Laser therapy is able to reduce this formation by speeding up the healing process, improving the blood flow to the injured area, and more effectively carrying away waste products. Faster healing always leads to less scar tissue formation
- Diode lasers are very effective for soft tissue applications including incision, hemostasis and coagulation [38]. Many advantages of the laser vs. the scalpel blade have been discussed in the literature. These include a bloodless operating field, minimal swelling and scarring, and much less or no postsurgical pain [39-40].

4. Laser & Implants

Gingival enlargement is relatively common around implants when they are loaded with removable prosthesis. Lasers can be used for the hyperplasia removal as well as in the treatment for peri-implantitis .Significant improvement in the treatment of peri-implantitis also occurs with the addition of diode laser therapy [41]. Due to its bactericidal and decontamination effect, has high bactericidal effect without heat generation around implants and can be used in the maintenance of implants.

5. Laser-assisted new attachment procedure (LANAP)

Some reports suggest that LANAP can be associated with cementum-mediated new connective tissue attachment and apparent periodontal regeneration of diseased root surface in humans.

6. In Soft lesion Excisions

It is widely used in the excision of soft tissue lesions like oral fibroms, pyogenic granuloma, papillomas, operculotomy, gigivectomy, epulis excision and crown lengthening procedures etc. (Fig-3,4,5)

7. In Dipigmentation

It is also used in removing melanin patches mainly in upper and lower anterior esthetic region because it is more effective and precise as compare to conventional ways.

Laser Safety

General safety include laser warning sign outside the clinic, use of barriers within the operatory, and the use of eyewear to protect against reflected laser light or accidental direct exposure. (Fig-6,7) High volume suction must be used to evacuate the plume from tissue ablation. Several authors have studied the thermal effect of lasers on the periodontal ligament and surrounding bone [42]. Hence, periodontal tissues are not damaged if the temperature increase is kept below 5°C. A threshold temperature increase of 7°C is commonly considered as the highest thermal change, which is biologically acceptable to avoid periodontal damage [43, 44].

Controversies with Diode Laser

Somewhat in contrast to the beneficial applications noted above, the use of a diode laser in photodynamic therapy (PDT) for treatment of periodontal disease has yielded inconclusive results. Currently, there are 15 published human clinical studies [45-59]. The aggregate of studies show little differences between scaling and root planing (SRP) alone versus SRP + PDT with respect to reductions in probing depth, bleeding on probing (BOP), and subgingival bacterial loads, and gains in clinical attachment level (CAL).

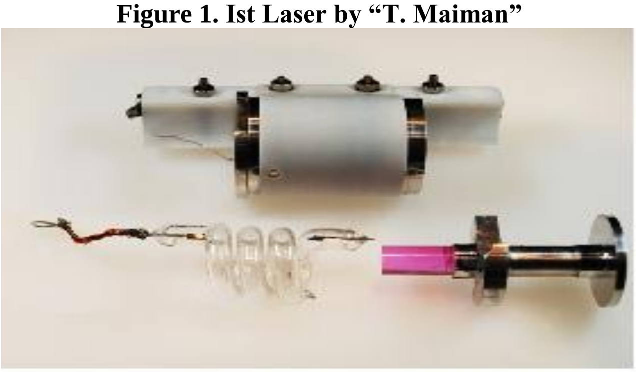

Figure 1. Ist Laser by "T. Maiman"

Figure 2. Diode Laser

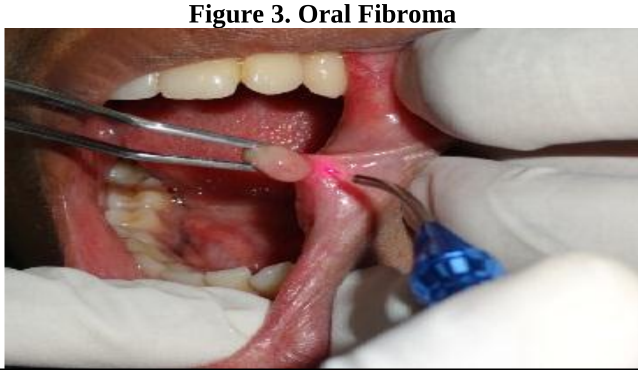

Figure 3. Oral Fibroma

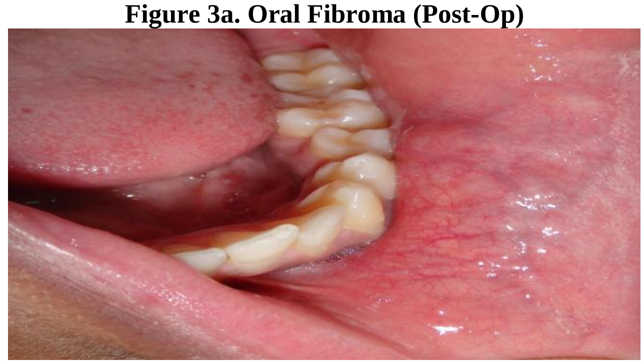

Figure 3a. Oral Fibroma (Post-Op)

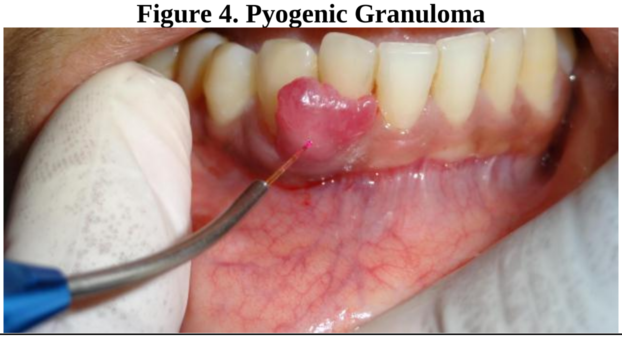

Figure 4. Pyogenic Granuloma

Figure 4a. Granuloma Excised

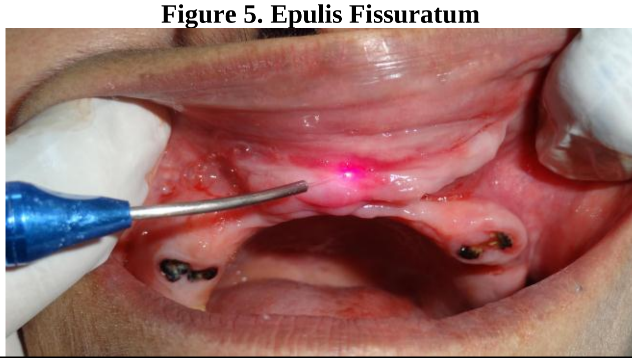

Figure 5. Epulis Fissuratum

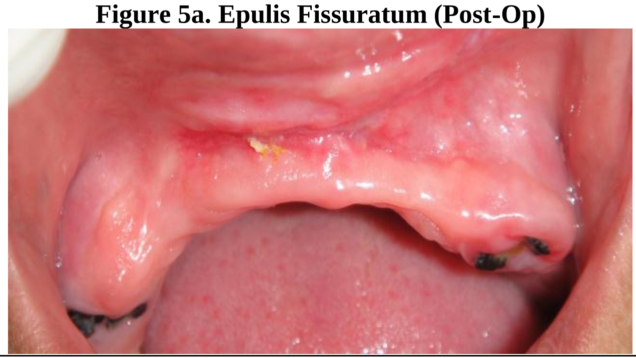

Figure 5a. Epulis Fissuratum (Post-Op)

Figure 6. Danger Sign

Figure 7. Eye protection

CONCLUSION

Lasers have been a part of the dental scene for over 25 years. Unfortunately, they have tended to be big, clunky, hard to -use, expensive machines that were largely ignored. Affordable, effective, user-friendly diode lasers have only recently arrived on the scene. In fact, the diode laser, in a very short time, has proven itself to be the ideal "soft-tissue hand piece" Laser Assisted Periodontal Therapy is non - invasive. With the diode laser there is a reduced need for systemic or locally applied antimicrobials. This leads to fewer allergic reactions and antibiotic resistance. Due its ease of use and affordability have made it the predominant laser in the field periodontology.

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