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Application of Soft Tissue Lasers in Esthetic Periodontal Therapy and Implant Dentistry: A Review

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Abstract:
The popularity of lasers in esthetic periodontal therapy and implant practice has increased tremendously in the last few years due to their innovative technology and versatility. Presently, a range of laser systems is being used in various soft and hard tissue procedures. Among them, diode lasers, carbon dioxide (CO2), neodymium-doped: yttrium-Garnet (Nd:YAG), erbium-doped: yttrium-aluminium Garnet (Er:YAG) are frequently used. It has various applications in esthetic dentistry. This includes surgical and non-surgical procedures; like operculectomy, gingival depigmentation, gingivectomy, growth excision, and many other procedures. Lasers are used in various implantology procedures ranging from implant placement to management of peri-implantitis. Additionally, lasers are documented for laser-assisted new attachment procedures. Lasers have inherent advantages like; providing excellent hemostasis and better visibility of the surgical field, accurate incision without detrimental effect on peripheral tissues, minimal post-operative swelling followed by minimum discomfort and reduced chances of infection due to bactericidal effect over traditional procedures. The clinician must be aware of the proper knowledge, precautions, possible risk during irradiation and limitations of laser.
Key Word: *Dental lasers, Esthetics, LANAP, Implant dentistry, Periodontal therapy, soft tissue lasers*

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I. Introduction

In 1959, Gordon Gould coined the term LASER: LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION. Laser is a technology established on Einstein's theory (1917) of "spontaneous and stimulated emission of radiation". The application of lasers in esthetic dentistry has been increased tremendously in the current scenario. Laser has started a new era in oral-treatment procedures, particularly in the field of periodontal therapy. Lasers was introduced in dentistry in 1960s. The first laser applied in health science was named as Ruby laser by Maimen in 1960.[1] In 1664, Goldman et al.[2] evaluated the impact of laser on dental caries. The use of laser in periodontal surgery was first documented in 1985. Laser beam is characterized as monochromatic, coherent and collimated radiation. Monochromatic emission can be explained as the same energy and frequency of all waves.[3] Collimated radiation means all the rays of emission are parallel and coherent i.e. waves are similar and together in a certain phase. Laser property is primarily determined by its wavelength. Their interactions with targeted tissue produce four phenomena on the target tissue. These can be grouped into photochemical, photothermal, photomechanical and photoelectrical interactions.[4] When the laser meets the tissue there will be its absorption, resorption, reflection, transmission and scattering.[5] The desired effects can be controlled by pulse rate and duration of laser, laser beam, produced heat and tissue vascularity, duration and pulse repetition, energy and power density of laser, mode of delivery, etc. It is the absorbed portion of laser wavelength, which produces heat in the targeted tissue and results in increased temperature of tissue up to the level causing vaporization, coagulation and denaturation of protein.[6] Degree of laser absorbed depends upon the wavelength of the laser and its affinity for water, chromophores and hydroxyl appetite crystal of targeted tissue. There are many ways of categorizing laser. This includes their; 1) light spectrum 2) wavelength 3) state of gain medium 4) oscillation mode 4) energy output. Presently, a range of laser systems has been used in various periodontal and implantology soft tissue procedures. Among them diode lasers, carbon dioxide (CO2), neodymium-doped: yttrium-Garnet (Nd:YAG), erbium-doped: yttrium-aluminiumGarnet (Er:YAG) are frequently used.

II. Types Of Lasers

Diode laser: Semiconductor diode lasers were introduced in the mid-1990s. It stands as one of the most versatile laser systems among the currently available systems. It has a range of wavelengths from 635 to 950 nm.[7] It can be used in continuous or gated wave form, in contact or non-contact manner.[8] However, most diode lasers require surface contact for the desired action. They have a high affinity for pigmented tissue compared to non-pigmented tissue. The popularity of diode lasers has been highly increased due to added advantages like small size, portability, price range and wide range of applications. By Diode laser, less than 1 mm thermal necrosis zone can be achieved.[9] It results in high precision and clean incision. Due to high affinity for oxygenated haemoglobin, it promotes hemostasis, coagulation and carbonization of targeted soft tissue. Authors have also reported its effect on clotting factor VII and thus promoting hemostasis.[10] Some authors have also reported the bactericidal effect of diode lasers in the treatment of periodontal pockets. Diode lasers are widely used in various soft tissue procedures like; periodontal pocket therapy, subgingival curettage, soft tissue incisions/excision, frenectomy, crown lengthening, gingival depigmentation and in treatment of periimplantitis, etc.

Neodymium; Yttrium: Aluminium garnet Laser (Nd:YAG): The Nd:YAG laser is the first FDA accepted (May 1990) laser exclusively intended for dental practice. It is commonly used in soft tissue intraoral surgical procedures. Myers TD and Myers WD (1985) first introduced it in dental practice.[11] Nd:YAG laser has a wavelength of 1064 nm and has a wave form of free running pulse mode (150 qs). It is well absorbed by cellular constituents; primarily dark chromophores like melanin and haemoglobin. Most surgical procedures need surface contact with the target tissue. Nd:YAG laser offers excellent haemostasis and reduction in pain as it does not make deep thermal damage.[12] It is also suitable for use in gingival pockets because laser energy is delivered through a flexible fiber-optic tip. Literature shows that Nd:YAG laser facilitates periodontal surgeries with minimum bleeding, less discomfort and high precision. At low power, it is beneficial in the treatment of oral ulcers.

Erbium Lasers: Erbium: Yttrium: Aluminium-Garnet Laser (Er:YAG) and Erbium, chromium: Yttrium-Scandium-Gallium-Garnet (Er,Cr:YSGG)**.** The Erbium lasers have been used in dentistry since 1997.[13] Use of the erbium:yttrium-aluminum-garnet (Er:YAG) and the erbium, chromium: yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser is well documented in the literature. Er:YAG laser emits a wavelength of 2940 nm while Er,Cr:YSGG have a wavelength of 2780 nm; Although, the properties of both the lasers are quite different. Erbium lasers have the shallowest dispersion in soft tissue, at the same time they have the highest absorption in water. They are used in free-running pulsed wave form with contact and non-contact mode. Non-contact mode is less efficient in hemostasis compared to Nd: YAG laser and CO_2 laser. Contact mode employs better hemostasis than non-contact mode. They have high absorption in hard tissue so it is essential to care for neighbouring hard tissue in the surgical area. Erbium lasers produce a char-free layer after application while Nd:YAG laser and CO_2 laser are known for Char layer formation. This avoids fibroblast attachment to the tissue surface. Erbium lasers are well established for their bactericidal effect and scalpel-like incision without delayed healing.[14] Its application is being evaluated in periodontal osseous surgeries also.

Carbon Dioxide Laser (CO_2): Carbon Dioxide laser was introduced by Patel et al. in 1964.[15] It has been used for soft-tissue application since late 1970s and 1980s. Pick RM et al. (1985)[16] has documented the application of CO_2 for the gingivectomy procedure of drug-induced gingival enlargement. CO_2 laser comprises a wavelength of 10,600 nm used as gated or continuous wave form with a wavelength of 10.6 µm. It is delivered by a hollow wave guide and can be used with focused or non-focused handpieces 1 to 2 mm from the target tissue.[17] These properties make CO_2 laser more versatile for periodontal surgical procedures. In contrast to Diode laser and Nd:YAG laser CO_2 laser has a good water absorption coefficient. CO_2 laser is well documented and recognized for various surgical procedures like soft tissue incision, ablation, de-epithelization of gingiva, coagulation of graft donor site.

Argon Laser (Ar): Argon laser was developed in 1962,[18] although the first documented use of laser in the medical field was a ruby laser, which was used to coagulate retinal lesions in 1963. Afterward, Kiefhaber in 1977 introduced Ar laser to the surgical field. Ar laser has a wavelength of 488-514 nm delivered through a flexible fiber-optic system. It can be used as a gated or continuous wave form. It is the only soft tissue laser that has a visible light spectrum (blue-green). Ar laser has a good affinity for pigmented tissue and is instantly absorbed by soft tissue. Thermal effect on soft tissue depends on the energy of argon laser transfer in heat which, primary coagulation and then vaporization. Currently, Ar laser has a valuable role in soft tissue welding and soldering. It provides faster and less traumatic wound closure compared to conventional wound closure

techniques.[19] Ar laser is useful in soft tissue incision, ablation and guided tissue regeneration by de-epithelialization of the wound.

Holmium lasers (Ho:YAG): Ho:YAG laser is a solid state laser that was introduced in 1960s. It emits a wavelength of 2.1 µm and it is applied through flexible quartz optical fiber. Precise surgical control is obtained with surface contact mode. However, it can be used in both contact and non-contact mode. Ho:YAG laser is known for effective cut, ablation and vaporization of tissue. The photothermal effect of Ho:YAG laser does not depend on haemoglobin and other dark pigments.[20] It is mainly used in the ablation of soft tissue and incision.

III. Application Of Lasers In Periodontal Procedures

Management of localized overgrowth: Laser is a very promising tool for the management of localized benign gingival reactive lesions. The accurate incision, hemostasis and minimum post-operative edema and discomfort facilitate more effective and easier excision by laser than conventional surgical excision (Figure 1). Researchers have shown less alteration in the excised biopsy tissue, facilitating a more accurate diagnosis.[21] Diode soft tissue laser is highly efficient in management of focal reactive gingival overgrowth due to its added advantages like a bloodless field, reduced bacteremia, minimal intra and post-operative discomfort over conventional modalities.[22] There is sufficient documentation available to establish the efficacy of laser in excision of gingival fibroma, pyogenic granuloma, peripheral ossifying fibroma and giant cell granuloma.

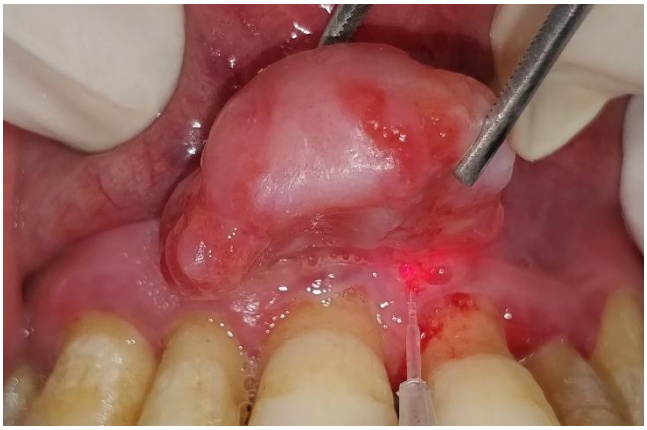

Figure 1 *Excision of gingival overgrowth by diode laser*

Gingivectomy procedure: Laser application for Gingivectomy procedure has been found to be associated with less recurrence of overgrowth, compared with conventional techniques. Effective hemostasis, minimum required anaesthesia, minimum post-operative discomfort and faster post-operative healing are the inherent advantages offered by lasers.[23] Other advantages include better control of the operator resulting in the less required time for the procedure.

Periodontal plastic procedures: Lasers are frequently employed in a variety of periodontal plastic surgeries. This includes various frenectomy (Figure 2a and 2b), frenotomy, vestibular-deepening, etc. Laser surgery has added advantages; efficient soft tissue cutting, no need for suturing, required no or minimal analgesic after surgery.[24] This offers frenectomies with superior patient satisfaction over conventional surgery. Kalakonda B et al. (2016)[25] recommended laser vestibuloplasty as a more secure and efficient method over scalpel.

Figure 2 a. application of laser for frenectomy, and b. immediate post-op

Gingival Depigmentation: Lasers are a commonly used and safe therapeutic approach for gingival depigmentation (Figure 3). Due to its many potential advantages, a laser is preferred over conventional procedures. Bakhshi M et al. (2015)[26] advocated that laser gingival depigmentation is the most impressive, reliable, and satisfactory method. Also, Giannelli M et al. (2014)[27] concluded in their split-mouth randomized study that diode laser provides less pain and post-operative discomfort compared to Er: YAG laser. Additionally, margins of soft tissue remain more stable after gingival depigmentation.[28]

Figure 2 Raw surface after depigmentation by diode laser

Crown lengthening: Crown lengthening procedure is frequently performed to achieve an adequate crown structure exposure for aesthetic, restorative, prosthetic as well as orthodontic purposes (Figure 4). At present, flapless techniques are commonly used for crown lengthening and laser is very useful apparatus for that. Farista S et al. (2016)[29] conducted a clinical study to compare laser and scalpel for soft tissue crown lengthening; and observed that laser is a harmless and efficient option over conventional methods.

Figure 3 Crown lengthening by diode laser

Operculectomy: Excellent hemostatic properties and accurate ablation of soft tissue makes laser very operator friendly to be used in difficult to reach regions of the oral cavity. Laser is considered a valuable tool for the removal of the operculum. Laser-assisted operculectomy is a very promising alternative treatment modality for the management of inflamed operculum.[30]

Free gingival graft: Presently lasers are also employed in the preparation of recipient site and donor site wound healing. Türer CC et al. (2015)[31] evaluated the effectiveness of Er:YAG laser with scalpel and observed similar efficiency of laser with scalpel in recipient site preparation. It is believed that laser increases the speed of palatal wound healing by better wound organization and aid in angiogenesis. Also, in vivo study researchers found that with laser, wound closing, re-epithelialization, and collagen deposition were accelerated.[32]

Low level laser therapy (LLLT): Low level laser therapy is a laser treatment modality to produce desired non-thermal and biostimulatory effect. It uses low energy output with a single wavelength. The application of LLLT is well documented in various periodontal surgical procedures and can be effectively used in pain management during surgery. It creates analgesia by stabilizing depolarizing potential of nerve fibers.[33] It accelerates wound

closure and advances revascularization. LLLT is a valuable adjunctive which promotes healing after gingivectomy and healing of donor site in free gingival graft.[34]

Laser-assisted new attachment procedure (LANAP):

LANAP: LASER-ASSISTED NEW ATTACHMENT PROCEDURE was developed by Gregg and McCarthy in 1990. They developed a new bladeless and less invasive technique for the treatment of periodontal diseases by use of pulsed neodymium yttrium aluminium garnet (Nd: YAG) 1064 nm wavelength laser.[35] Later on, a group of researchers applied this idea in the field of regeneration. Yukna RA et al. (2007)[36] reported cementum mediated new connective tissue attachment and apparent periodontal regeneration of diseased root surfaces in humans after LANAP application for the management of periodontal pockets, histologically. There were no adverse changes around the LANAP sample on histological examination. Furthermore, in 2004 LANAP got FDA (Food and Drug Administration) clearance. Periodontal pocket depth ≥4 mm is indicated for LANAP. LANAP offers selective absorption in diseased periodontal tissue. McAllister J (2009)[37] conducted a study using LANAP (Nd:YAG PerioLase MVP-7) in periodontitis cases and concluded that LANAP is less invasive treatment with superior regeneration. Harris DM et al. (2014)[38] suggested in their multicenter study that LANAP has a systemic effect on subgingival wound healing. LANAP offers added advantages like superior patient compliance, decreased post-operative discomfort, better tissue stability, regeneration and accelerated wound healing (Figure 5).

Figure 4 Laser assisted new attachment procedure (LANAP) by diode laser

IV. Application In Implant Dentistry

At present different lasers systems are frequently employed in implant dentistry. The lasers commonly used in implantology practice are diode lasers; Nd: YAG, Er:YAG, Er:Cr:YSGG, and CO2 lasers. Among them diode lasers, CO_2 lasers and Nd: YAG are frequently practiced for soft tissue procedures, while application of Er:YAG and Er:Cr:YSGG lasers are generally practiced for hard tissue procedures because they have more absorption from hydroxyapatite.[39,40] Lasers are used in various implantology procedures ranging from implant placement to implant explantation. Popularity of laser in implant practice has increased tremendously in last few years due to its inherent advantages like; providing excellent hemostasis and better visibility of the surgical field, accurate incision without detrimental effect on a peripheral tissue, minimal post-operative swelling, followed by minimum discomfort and reduced chance of infection due to bactericidal effect. Every laser has a specific wavelength which is useful in a particular procedure. Additionally, every laser possesses specific tissue interaction based on its properties. Systemic knowledge about the properties of the laser and their effect on tissue is required. Soft tissue lasers are popular for implant placement by a less invasive method by tissue punch. Hard tissue lasers can also be used for initial osteotomy preparation and cortical bone removal.[41] However, whole osteotomy preparation is not possible by laser. A very promising use of lasers in implant surgery is the uncovering of implants during stage II and excising excess peri-implant soft tissue. CO2 lasers and Er: YAG lasers are commonly used for this. Nd: YAG laser is not so popular for it because it increases the temperature which can lead to thermal damage to the implant.[42] During laser irradiation care should be taken to avoid overheating. Peri-implantitis is the most common complication in implant dentistry. It is almost impossible to reduce whole plaque and bacterial endotoxins through conventional instrumentation. The Co_2 laser, Diode laser and Er: YAG is documented for efficiently removing plaque and deposits. Schwarz et al. (2003)[43] evaluated that Er: YAG laser is able to reduce bleeding on probing and pocket depth and gain in clinical attachment level in peri-implantitis. At low power, Co_2 laser is advantageous in peri-implantitis. CO_2 demonstrated a significant

reduction in periodontopathogenic microbes, it is also established that CO_2 is able to reduce the count of P. gingivalis.[44] The Nd: YAG and Ho: YAG lasers are not advocated for maintenance and removal of deposits.[45] Lasers are also advocated in gingival retraction and gingival contouring for adequate flow of impression material and prosthesis preparation/ impression subsequently. Lasers are also implicated for laser irradiation to accelerate osseointegration[46] and laser welding of titanium components.[47] Sometimes osteotomy or block resection is required to remove ailed implants. The Er: Cr: YSGG laser offers a less invasive method for implant explantation.[48]

Laser-assisted peri-implantitis procedure (LAPIP): Gregg and McCarthy initiated and took forward the concept of LAPIP. It is an adapted treatment procedure from LANAP for the treatment of periimplantitis and peri-mucositis diseases. The LAPIP is FDA approved treatment method which follows specific, strict and scientifically proven protocols for the treatment of gum diseases. This protocol advocate use of PerioLase MVP-7 Free-Running (FR) pulsed Nd:YAG laser.[49] Dental lasers also exhibit a positive effect on peri-implant pathogens.[50] Dental lasers are proficient in implant surface decontamination without altering microstructure and promote osseointegration.[51]

V. Conclusion

Laser is one of the most innovative and versatile device used in Esthetic Periodontal therapy and implant dentistry. The popularity of lasers in periodontology and implant practice has increased enormously in last few years due to their inherent advantages like; providing excellent hemostasis, better visibility of the surgical field, accurate incision without detrimental effect on peripheral tissues, minimal post-operative swelling followed by minimum discomfort and reduced chances of infection due to bactericidal effect. There are certain limitations coupled with the use of lasers such as it requires specific training and it is a costly device. There are different lasers for different procedures and clinicians must be aware of the precautions, possible risks during irradiation and limitations of the use of lasers. With the precautions and safety measures, the lasers are definitely a potential treatment modality in the field of periodontal therapy.

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