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A REVIEW OF APPLICATION OF LASER IN PERIODONTAL THERAPY

Dr.K.Narendhiran; Dr.V.Anitha; Dr.M.Shanmugam; Dr.B.Ashwath; Dr.Agila: Dr.Aishwarya

ABSTRACT

Abstract: Laser have various applications in every section of modern society including consumer electronics, information technology, science, medicine, fiber optic communication, industry, law empowerment, entertainment and military. Several medical specialities use laser in their daily practices and it has become standard of care for surgical therapy in opthalmalogy, otolaryngology and gynecology. In recent years, use of laser in dentistry increased in different area of treatment. Initially, laser introduced as an alternative approach to mechanical cutting device to reduce the patient discomfort. It has now become an instrument of choice in many periodontal procedures both in non-surgical and surgical procedure. It is also used in implant procedure and in the treatment of peri-implantitis. Some of the recent advances in laser provides additional benefit to the periodontal therapy. Use of lasers has become a topic of much interest and is a promising field in periodontal therapy
Key Words: Laser, non-surgical and surgical periodontal therapy, implants

INTODUCTION

Laser stands for **Light Amplification by Stimulated Emission of Radiation**. In laser, the term light includes electromagnetic radiation of any frequency, not only visible light. It differs from other sources of light by the property of coherence, which allows laser light to be focused in a target spot. Laser has various applications in every section of modern society and also used in several medical specialities. The Einstein concept on stimulated emission gave idea for the development of Maser by **Charles H. Townes.** In **May 16, 1960, Theodore H. Maiman (1)** discovered the first laser using ruby crystal as the amplifier and a flash lamp as the energy source. In **1964, Goldman (2)** introduced laser in medical field and also found the impact of laser beam in dental caries treatment and he was the first person to introduce laser in the dentistry There are different components which make up the laser cavity, they are *active medium* composed of chemical elements, molecules or compounds. Lasers are named for the material which is used as active medium, which can be a container of gas (CO_2 laser), a solid crystal (Er:YAG laser), a solid-state semiconductor (diode lasers) and a liquid (Dye laser); *pumping system* are excitation source, such as a flash lamp strobe device, electrical circuit, electrical coil surrounds the active medium, this will pump energy into the active medium. When this *pumping mechanism* provides energy into the active medium, the electrons in the outermost shell of the active medium's atoms absorbs the energy and reach the next shell farther away from the nucleus. This process is called "population inversion". The process of lasing occurs when an excited atom is stimulated to emit a photon before the process occurs spontaneously. This process is called stimulated emission; *optical resonator* present at the end of each optical cavity one mirror is placed parallel to each other, one having more than 99 percent reflectivity and the other having less reflectivity. These mirrors at each end act as *optical resonators*, this will reflect the waves back and forth, and helps in the collimation and amplification of the developing beam. Lasers when used for various soft and hard-tissue procedures, can provide distinct advantages over the conventional instruments such as less postoperative discomfort and provides better visualization of the surgical field (3), laser in periodontal therapy may have the beneficial side-effect of reducing inflammatory mediators, such as interleukin-1β (4), interleukin-6 (5), tumor necrosis factor-α (4) and matrix metalloproteinase-8 (5). The use of lasers also has disadvantages that require precautions to be taken during clinical application are current dental laser instruments are the relatively high cost and the required training (6), the operator should avoid overheating of the tissue and prevents air embolism caused by excessive pressure of air and water spray during laser treatment, no single wavelength will optimally treat all dental disease (7).

LASERS IN NON-SURGICAL PERIODONTAL THERAPY:

Laser produce strong bactericidal and detoxification effects without producing a smear layer and produce excellent ablation of tissue. They are one of the most promising new technical device for nonsurgical periodontal treatment. Another advantage of laser is that they can reach sites which cannot be reached by conventional mechanical instruments (8). The adjunctive or alternative use of lasers with conventional tools enhances the treatment outcome and improves healing.

CO_2 LASER

The CO_2 laser is absorbed by tissue surface with minimal scattering or penetration. Heat generated by CO_2 laser cause ablation of soft tissues, so carbonization easily occurs on the irradiated surface but the heat produced does not scatter. Therefore, the CO_2 laser produces a comparatively thin layer of thermally changed tissue (coagulation) around the irradiated site. Tissue penetration from this laser will be approximately 0.5 mm deep, depends on power density (9). In 1976, CO_2 was approved by US Food and Drug Administration (FDA) for soft tissue surgery, including the surgery of the oral tissues. Recently, new flexible fiber optic delivery and hollow tube wave-guiding systems have been introduced. These advances may provide the use of the CO_2 laser for periodontal pockets effectively.

Nd:YAG laser**:** Nd:YAG laser radiation absorbed well into sub gingival calculus. Use of higher energy levels of this laser may ablate calculus more efficiently but may be unsuitable for clinical usage due to increased thermal side-effects. In 1990, the FDA approved soft tissue removal by means of a pulsed Nd:YAG laser (10). **Morlock et al in 1992** (11) found that the Nd:YAG laser at 1.25–1.50 W (62.5–75 mJ/pulse, 20 Hz) produce surface pitting and crater formation with charring, carbonization, melting, and crater production.

Er:YAG laser**:** During Er:YAG laser irradiation, water molecules and hydrous organic components of biological tissues absorbs laser energy, thermal effect produced by this laser results in evaporation of water molecule and organic components. This process is known as 'photothermal evaporation'. In hard tissue procedures, the water vapour production induces an increase of internal pressure within the tissue and results in explosive expansion called 'microexplosion' (12). Since the Er:YAG laser ablates both dental hard tissues such as enamel ,dentin and capable of removing dental calculus at much lower energy levels. To limit undesired removal of root tissue, a combination of pulsed emission at frequency > 10 Hz and low energy (40 – 100 mJ/ pulse) is recommended. The Er:YAG laser does not produce carbonization of the irradiated root surface, but it has been showed that the ablated surface becomes chalky after drying because of micro-irregularities on the lased surface.

Diode laser**:** The major application for the 810 dental diode laser in the periodontal therapy is the removal of diseased pocket epithelial lining and disinfection of periodontal pockets. Power setting of 0.8-1 W can ablate the lining of epithelium. Ablation starts nearer to the base of the pocket and slowly upwards. The treatment time per pocket should be around 20-30 seconds, possibly 1-2 minutes per tooth site. Re treatments should follow at weekly intervals for maximum of 4 weeks period. Many studies have shown increased reduction of periopathogens when diode lasers are irradiated after scaling and root planing (13). However, the adjunctive use of the diode laser with SRP indicates that the adjunctive use of laser with SRP provides an effect comparable to that of SRP alone.

Lasers in surgical periodontal therapy:

Gingival soft tissue procedures: Laser are generally accepted and most commonly used tool for soft tissue management. The major beneficial properties of laser are comparatively ease of ablation of tissues with effective hemostasis and bactericidal property. Gingivectomy, gingivoplasty and frenectomy are the most common procedures carried out using laser. Minimal wound contraction and minimal scarring are other benefit of laser surgery that are not observed in conventional scalpel surgery (14). Depending on the penetration depth, the performance is different for each type of laser on soft tissue surgery. CO_2

laser provides rapid vaporization of soft tissues with strong hemostasis, which maintains a clear operating field and requires no suturing. Gingival hyperplasia is a typical indication for CO_2 laser surgery. The CO_2 laser is also effective in removing small tissue irregularities (gingivoplasty) seen after periodontal and peri-implant surgery. CO_2 laser surgery of oral soft tissue is generally performed with a power setting of 5 to 15 watts, in either pulsed or continuous mode. The deeply penetrating laser like Nd: YAG and diode lasers, can also be used to cut and reshape soft tissues. The Er:YAG laser is also effective in soft tissue surgical procedure. Usually this laser absorbs more water molecule than other dental lasers. Er:YAG laser is safest and used for esthetic periodontal soft tissue management because this laser is capable of precisely ablating soft tissues. During surgical procedures, the power output is 1.0W-8.4W, yielding an energy density of 100-700 mJ**.**

Laser associated crown lengthening procedures: Soft tissue crown lengthening can be done easily with a laser in two conditions. First when there is sufficient bone and bone contouring is not required; second, there must be adequate attached after the soft tissue has been ablated. The patient should be anesthetized with 2% lidocaine containing 1:100,000 epinephrine. During soft tissue crown lengthening procedure, periosteal elevator placed between the gingival tissues and the teeth so that the hard tissue would not be damaged by the CO_2 wavelength with a power setting of 5 to 15 watts.

De-epithelialization**:** In regeneration many techniques have been suggested to prevent the downward growth of epithelium. Until the emergence of resorbable barrier membranes that would maintain their integrity for longer period of time for attachment to occur, method of epithelial exclusion using a CO_2 laser was suggested. Animal and human studies have shown that the CO_2 laser can effectively remove epithelium from gingival tissues without damaging the underlying connective tissue. These studies show that when CO_2 energy is applied to a full-thickness mucoperiosteal flap, the underlying connective tissue is not damaged despite the complete removal of the epithelium. The use of Er:YAG laser in combination with CO_2 laser increases the periodontal regeneration. The Er.YAG laser may be used to remove diseased tissue from the root surface. This process makes the root surface smooth, with no char layer and the collagen matrix left exposed. The next step in the periodontal surgical procedure is de-epithelialization of the flap. This procedure makes the connective tissue to form new attachment onto the smooth root surface. This double–laser surgical procedure has increased potential in periodontal regenerative surgery.

Frenectomy**:** Lasers such as Nd:YAG, CO_2, and Er:YAG had been used for frenectomy procedures. Among these laser, CO_2 laser is most commonly used (15). During this procedure the area was anesthetized with 2% lidocaine with 1:100,000 epinephrine. The frenum was removed with a CO_2 laser at 5 W in continuous mode.

Lasers in periodontitis treatment: All dental lasers have high thermal effect. In general, most nonsporulating bacteria, including anaerobic periopathogen, are readily deactivated at temperatures of 50ºC. Laser irradiation produce coagulation of the inflamed soft-tissue wall of a periodontal pocket and hemostasis, both are achieved at a temperature of 60ºC. These high thermal effect produced by laser can able to deactivate the periopathogen. Dental laser with various wavelengths have been used by clinicians in the treatment of periodontitis, most commonly the diode laser, Nd:YAG, Er:YAG and Er,Cr:YSGG and the CO_2 laser. **Joanna et al in 2007** (16) studied the effect of diode Laser (980 nm) treatment on aggressive periodontitis and evaluated the microbial and clinical parameters. Diode laser adjunct with SRP showed a superior effect over SRP alone or diode laser treatment alone for certain microbial and clinical parameters in patients with aggressive periodontitis over the 6-month period.

Laser assisted new attachment procedure**: Dr. Robert Gregg and Delwin McCarthy** explored the use of a specific free-running (FR) pulsed Nd:YAG laser for the treatment of periodontal disease. They developed a specific protocol for LANAP (**Laser Assisted New Attachment Procedure)**, with research-proven operating parameters. LANAP received FDA clearance in 2004.

LASER IN IMPLANT:

Both lasers and implants are considered to be the popular treatment modalities of modern dentistry, and combining them provides best practice from number of perspectives. The role of lasers in dental implantology was explored by **Romanos et al** (17) and they found that soft-tissue lasers could provide hemostasis, as an adjunct to soft-tissue peri-implant recontouring, and for improving wound healing. Hard-tissue lasers (Er,Cr:YSGG and Er:YAG wavelengths) were helpful for laser-assisted osteotomies, and improves the early osseointegration and their fixture placement (18). Alterations of titanium implant surfaces occurs when they were irradiated at average power settings over 2W for 30 s. Laser also helpful in the treatment of peri-implantitis.

One of the most important application of lasers in implantology is the removal of granulation tissue and disinfection of the extracted socket. Erbium lasers can be used for this purpose, especially in case of chronic infection before extraction, regardless of whether implants or bone grafts are being placed. After superficial disinfection and removal of granulation tissue, a diode or Nd:YAG laser can be used for deep disinfection. Er:YAG laser is most efficiently used in the treatment of peri-implantitis. Er:YAG, laser able remove the granulation tissue both on the bone surface and implant surface. Once the underlying reason for peri-implantitis has been diagnosed and recurrence can be prevented and further treatment for peri-implantitis done effectively with the Er:YAG laser (19).

Recent advancement of laser in periodontal therapy:

Periowave: Periowave is a photodynamic disinfection system which uses the photosensitizer (nontoxic dye) in combination with low-intensity laser, results in the production of singlet oxygen molecules that will destroy bacteria. This method is used as an alternative to conventional mechanical approaches (20). A small quantity of blue-coloured photosensitizer solution is applied topically at the treatment site, these photosensitizer attaches to microbes and toxins associated with gingivitis or periodontal disease followed by a low-intensity laser irradiation directed on the area treated with the photosensitizer resulting in phototoxic reactions destroying bacteria beneath the gingiva. Each treatment site requires only 60 seconds of laser irradiation and it is a quick and painless procedure.

Periodontal waterlase: Waterlase is commercially available Erbium-Chromium doped: Yittrium-Selenium-Gallium-Garnet (Er,Cr:YSGG) laser. It uses combination of laser energy and water, this process called hydrophotonics. This performs wide range of dental procedures. Hydrokinetic energy produced by waterlase removes gently and precisely wide range of human tissue including enamel and soft tissue without heat and pain. Scanning electron microscopy has shown that it makes clean cut through enamel and dentin without creating smear layer (21) Food & Drug Administration (FDA) approved waterlase to cut tooth structure in 1998.

Laser assisted peri implantitis procedure: The Nd:YAG laser (PerioLase MVP-7) is used in the Laser-Assisted Peri-Implantitis Procedure (LAPIP) that is based on the LANAP (Laser-Assisted New Attachment Protocol) therapy. It is an emerging experimental technique in the treatment of peri-implantitis (22). The LAPIP technique is an implant-specific modification to the LANAP procedure. Both the techniques utilize an ablation step to remove inflamed sulcular tissue and decontaminate the root/ implant surface, which is followed by a scaling is done. Laser induced hemostasis which further decontaminates the tissue and cause the blood to clot. This seals the treated area and prevents the down growth of the gingival epithelium and allowing the area to heal from the base of the defect coronally.

LASER SAFETY:

When the laser used for any purpose, the entry to the operatory should be restricted, a caution sign should be posted and all personnel who involved in the treatment including the patient must have eye protection. For CO_2 laser application, regular safety glasses with clear lenses are necessary. The Nd:YAG laser operation requires special dark green lenses for the safety glasses that protect from the blue-green spectrum. Caution should also be taken for the reflective surfaces, since the laser beam may be reflected off by dental mirrors or instruments and hit other intraoral sites (23). Laser vaporous by-products (laser plume) are generated as smoke once the vaporization of the tissue surface occurs. This plume has been shown to contain particles with mean diameters of 0.1-0.3 pm, and within this plume of carbonized tissue, viable tumour cells and viral particles have been cultured (24). Wearing surgical mask and using high-speed evacuation helps in infection control, but the standard dental surgical mask does not filter out particles less than 0.5 pm. A new generation laser surgical masks are now available that will filter to 0.1-pm particles.

Laser classified into four classes based on the potential for causing biological damage by **ANSI** (American National Standard Institute) and **OSHA** (Occupational Safety and Health Administration). (25)

Class I: Low powered lasers that are safe to use.
Class II a: Low powered visible lasers is hazardous when viewed directly for more than 1000 seconds
Class II b: Low powered visible lasers is hazardous when viewed for more than 0.25 seconds.
Class III a: Medium powered lasers that are hazardous if viewed for less than 0.25 seconds without magnifying optics.
Class III b: Medium powered lasers, hazardous when viewed directly.
Class IV: High powered lasers that are hazardous to eyes and skin.

CONCLUSION

The application of lasers has been considered as an adjunctive or alternative approach in periodontal and peri-implant therapy. The major indication of laser is soft tissue procedures. CO_2, Nd:YAG, diode, Er:YAG and Er,Cr:YAG lasers are widely accepted laser for soft tissue procedures. Laser treatments have been shown to be more advantageous than conventional mechanical approaches with regards to easy ablation, decontamination and hemostasis, as well as less surgical and postoperative pain in soft tissue management. Laser or laser-assisted pocket therapy is expected to become a new therapeutic modality in periodontal treatment. The Er:YAG laser shows better root surface debridement ability, such as calculus removal and decontamination. Concerning the use of laser for bone surgery, CO_2 and Nd:YAG lasers are considered unsuitable because it results in carbonization and degeneration of hard tissue. Currently, the Er:YAG laser is safest and efficient method for periodontal bone surgery when used with water irrigation. Application of laser has also been considered in implant therapy, especially the Er:YAG laser is an alternative approach in the treatment of peri-implantitis. Application of photodynamic therapy in the treatment of periodontitis and peri-implantitis is a newer technique. Among the currently available laser, the Er:YAG laser seems to possess the most suitable criteria for various types of periodontal treatment.

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