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REVIEW ARTICLE

Lasers in Periodontics: An Overview

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ABSTRACT

Among commonly used lasers in dentistry viz CO_2, Nd:YAG, Ho:YAG, Er: YAG, Er,Cr:YSGG, Nd:YAP, GaAs (diode) and argon, Er:YAG laser, at appropriate settings, possesses the best property for selective subgingival calculus removal without a thermal change of the root surface, soft tissue surgical procedures, root surface alterations, degranulation and implant surface decontamination alongwith proposed application in osseous surgery. Epithelial exclusion using CO_2 laser has been suggested to retard its downward growth. Waterlase® and Periowave™ systems are recent devices that have further revolutionised the laser techonology for its favourable clinical applications; however, the procedural cost with the laser device still constitutes an obstacle for its routine application.

KEYWORDS: *Er:YAG laser, Implantitis, Photodynamic therapy*

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LASER, an acronym for Light Amplification by Stimulated Emission of Raditaion, was first developed by Maiman (1), a scientist with the Hughes Aircraft Corporation, using ruby crystal that emits a coherent radiant light when stimulated by energy based on theory originally postulated by Albert Einstein. Goldman (2), a dermatologist experimenting laser for tattoo removal, showed painless surface crazing of enamel after focusing two pulses of red-light beam from ruby crystal. Following experiments by Stern and Sognnaes (3), pendulum shifted from ruby laser to CO_2 and Nd:YAG lasers for better interactions with dental hard tissues. 1970s and 1980s sought use of lasers for soft-tissue surgical procedures, and Lenz *et al* (4) were among the pioneers to report oral surgical application of CO_2 laser, togetherwith Frame (5), Pecaro (6), and Pick (7) who used the same for oral soft-tissue lesions and periodontal procedures. Myers and Myers (8) described the use of modified ophthalamic Nd:YAG laser for removal of dental caries and received The US FDA's permission for selling of Nd:YAG laser device in 1989 (9). After Myers's suggested use in soft-tissue surgery (10), Nd:YAG laser was eventually used in periodontal procedures (11-13), and since then lasers have been used largely by researchers and clinical periodontal parctioners.

BASIC SCIENCE AND CONCEPT

Laser is a monochromatic light in visible or invisible range with three primary characteristics of collimation, coherency and efficiency. Wave photon produced can be defined by measurement of its velocity, amplitude and wavelength (14).

Amplification occurs in optical cavity present at the center of the laser device, having two parallel mirrors one at each end, and core of this cavity is comprised of chemical elements, compounds or molecules, in gaseous, crystal or solid-state semiconductor form known as active medium, which gave the laser its generic name (14). Excitation source, either a flash lamp strobe device or an electrical coil surrounds the optical cavity which provides the energy into the active medium (Figure 1). Other mechanical components include cooling system, focusing lenses, and other controls.

Based on the quantum theory of physics given by Max Plank (15) and atomic architecture by Niels Bohr (16), spontaneous emission can be defined as the process by which a light source such as an atom, molecule, nanocrystal or nucleus in an excited state undergoes a transition to the ground state and emits a photon. In a laser, atoms are kept in an excited state by "pumping" the laser, and some photons are inserted that causes some atoms to undergo stimulated emission, and the resulting photons cause other atoms to undergo stimulated emission, leading to a chain reaction, that produces an intense, coherent, and easily focused light(14).

Radiation refers to light waves produced by the laser as a specific form of electromagnetic energy. All available dental laser devices have emission wavelengths of approximately 500 nm to 10600 nm and are within visible or invisible infrared nonionizing portion of electromagnetic spectrum that emit thermal radiation. Lasers commonly used in dentistry are CO_2, Nd:YAG, Ho:YAG, Er: YAG, Er,Cr:YSGG, Nd:YAP, GaAs (diode) and argon (17).

Beam of laser can be delivered by a flexible hollw waveguide or tube that has an interior mirror finish or glass fiber optic cable, in three different emission modes; continuous wave, gated pulse mode and free-running pulsed mode or true pulsed. The principle effect of laser energy is photothermal; this effect on tissue depends on the degree of temperature rise and corresponding reaction of the interstitial and intracellular water (14). Optical properties of periodontium for example pigmentation, water content, mineral content, heat capacity and latent heats of transformation can also dictate the clinical application beside specific wavelength, heat conduction and dissipation, degree of tissue inflammation and vascularity and the availability of progenitor cells for healing (17).

CLINICAL APPLICATIONS

Initial periodontal therapy

Initial periodontal therapy includes nonsurgical debridement of tooth structure, local drug delivery, host modulation and reduction of sulcular bacteria with laser coagulation of the treatment site (18, 19). Soft tissue lasers are used as an adjunct or an alternate in periodontal therapy to reduce the soft tissue inflammation (20). It reduces the bacterial populations photothermally and in addition elimnates the antimicrobial's problems like resistance, allergy and side effects, thus can be used even in children and pregnant women (14,21).

For bacterial reduction and coagulation, soft tissue lasers as argon (22) (488 nm, 514 nm), diode laser (23) (800-830 nm, 980 nm) and Nd:YAG (24-26) (1064 nm) are a good choice for periodontally diseased dark inflammed tissues and pigmented bacteria. Laser energy is delivered with a thin, flexible fiber optic system and are well absorbed by melanin and hemoglobin and other chormophores but transmitted through water and poorly absorbed in hydroxyapatite (14). Although well absorbed by hydroxyapatite and water, Er,Cr:YSGG (2790 nm), may also be applicable for soft tisue therapy when used carefully by keeping the fiber in contact with target tissue and in vitro study had shown significant bactericidal effect on P. gingivalis and A. actinomycetemcomitans (27). Laser pocket thermolysis uses the argon laser in conjunction with scaling and root planing for reducing the pathogens within the pocket.

Unlike CO_2 and Nd:YAG laser, Er:YAG (28,29) and Er,Cr:YSGG (30) lasers are capable of providing selective subgingival calculus removal to a level equivalent to that provided by scaling and root planing (31). Er:YAG had been shown to remove subgingival calculus without a thermal change of the root surface (21,32,33) similar to ultrasonic scaler with cementum ablation of 15-30 μm (21). Rechmann (34) suggested selective removal of supragingival and subgingival calculus and dental plaque without ablating underlying cementum or enamel with frequency doubled Alexandrite laser (337 nm).

Soft tissue surgical applications

With the beneficial properties over conventional scalpel that includes relative ease of ablation of soft tissue, hemostasis (31), instant sterlization, reduced bacterimia, little wound contraction, reduced edema, minimal scarring, reduced mechanical trauma, less operative and post-operative pain (17,35,36), faster healing, increased patient acceptance (17), no or few sutures, and requiring no or topical anaesthesia (37), soft tissue lasers viz CO_2, Nd:YAG, diode, Er:YAG and Er,Cr:YSGG are being widely used as a tool for ginigival soft tissue procedures such as gingivectomy, frenectomy, gingivoplasty, epulis or benign tumors removal (31), gingival depigmentation, second stage exposure of dental implants, irradiation of apthous ulcers, coagulaton of free gingival graft donor sites (17), and soft tissue crown lengthening (31). Performance of lasers differs depending on their penetration depth and hence may possibly damage the underlying tissues by thermal effects. In CO_2, Er:YAG, and Er,Cr:YSGG lasers, laser light is absorbed in superficial layers and hence is advantageous, with rapid and simple vaporisation of soft tissues. However, deeply penetrating Nd:YAG and diode lasers having greater thermal effects, leave a thicker coagulation area on treated suface (21,31,37) and hence used similar to electrosurgical procedures (31). Finkbeiner (38) has suggested the usefulness of argon laser in soft tissue welding and soldering compared to conventional tissue closure method. Epithelial exclusion using CO_2 laser had been suggested to retard its downward growth, and studies have shown effective removal of epithelium from gingiva tissues without damaging the underlying connective tissues (39-43).

Root surface modifications

Root surface modification using CO_2, Nd:YAG, Er:YAG and diode laser had been studied with conflicting results and shown to be related to the energy density and selection wavelength of laser. It is seen that carbonated hydroxyapatite of root surface has intense absorption bands in mid-infrared region, hence Er:YAG laser is amongst the lasers of choice (17). In vitro studies have shown better fibroblasts adherence after suitable Er:YAG laser irradiation of diseased surfaces than mechanical scaling alone (44,45). In contrast to focused mode, root conditioning effects with defocused mode CO_2 laser prepare the root surface for favourable fibroblast attachment (46). Nd:YAG laser irradition results in reversible (47) root surface changes that includes surface pitting, crater formation, melting, charring and carbonization (48), alongwith unfavouable fibroblast attachment (49).

Osseous surgery

Since laser-biologic tissue interactions are photothermal (17), hence, inspite of having added advantages of surgical precision, reduced collateral damage of soft tissue, reduced noise and eliminating vibrations with conventional instruments (31), effect of most dental lasers on bone is determinental for osseous surgery with the exeption of Er:YAG and Er,Cr:YAG (17). Fourier Transformation Infrared Spectra of bone surfaces has shown formation of toxic by-products that delays healing (50) after 'Er:YAG laser without water coolant (51), and CO_2 laser irradiation (31,52). Recent clinical applicatons for Er:YAG laser in bone surgery have been reported (53,54), however, lower cutting efficiency as compared to conventional instruments and lack of depth control are its limitations (31).

Implant therapy

Er:YAG laser have been suggested to prepare fixture holes in bone due to its ability to produce effective bone tissue ablation during first stage implant therapy (31). Prior to placement of the healing abutment, various lasers have been used in second stage implant therapy for uncovering the submerged implant, with advantages of improved hemostasis, fine cutting surface, less postoperative discomfort, and favourable healing (31,55).

Because of difficult and time consuming mechanical debridement, emergence of bacterial resistance to antibiotics, lasers are now being proposed for treating peri-implantitis. Nd:YAG laser is contraindicated because of morphological changes it produces on implant surface (56,57) and previous studies with CO_2 lasers have shown the associated risk with high temperature (58). Amongst dental lasers, Er:YAG laser at appropriate settings possess the best property for degranulation and implant surface decontamination, without causing titanium surface changes (59) and like CO_2 laser it does not influence the attachment rate of osteoblasts (60).

RECENT ADVANCES

Waterlase ® system is a revolutionary dental device that uses laser energised water to cut or ablate soft and hard tissue and provide periodontists with the opportunity to perform more procedures in fewer appointments with less need for anesthesia, scalpels and drill (61).

Periowave™, a photodynamic disinfection system utilises non-toxic dye (photosensitizer) in combination with a low-intensity lasers enabling singlet oxygen molecules to destroy bacteria (62). After applying light-sensitive drug (photosensitizer), low-intensity laser is directed on the area treated with the drug resulting in phototoxic reactions. Although the use of photosensitizers for complete suppression of the anaerobic perio-pathogens have been suggested, however, the same is not true for facultative anaerobes(63).

HEALING AFTER LASER TREATMENT

In spite of ostensible advantages of lasers based on clinical observation and patient acceptance, claims of faster healing response or decreased scarring, which itself appear to be wavelength specific and highly sensitive to energy density, do not find much data to support it (17). Limited experimental animal studies (64-68) involving CO_2, Nd:YAG, diode lasers, or Er:YAG have evaluated the histological and immunhistochemical patterns of periodontal tissue healing following surgical and non-surgical periodontal therpy. Sculean *et al* (69) and Yukna *et al* (70) reported healing response of intrabony defects after open flap surgery or treatment using a laser assisted new attachment procedure in humans using Er:YAG and Nd:YAG lasers respectively.

Lippert *et al* (71) claimed that CO_2 laser-induced-wounds in oral and oropharyngeal mucosa healed significantly faster (in 32.8± 9.2 days) than those created by Nd:YAG laser (in 40.4 ± 9.2). However, in contrast to conventional scalpel surgery, the histological findings showed that the beginning of wound healing was delayed after laser surgery and it depends on the size of the initial defect. Due to the more pronounced zone of necrosis at the base of the wound ground this effect is more evident using the Nd:YAG laser (71). Although, as compared to conventional

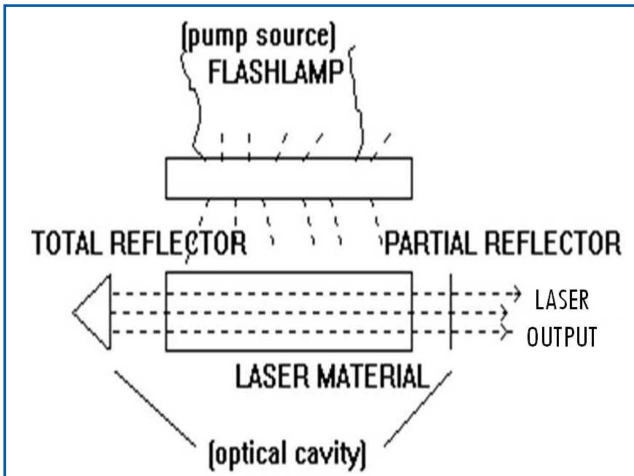

Fig. 1: Diagram showing basic components of laser

treatment, overall (71) as well as initial periodontal wound healing laser application (72) has been shown to be delayed, few studies have reported that laser-induced wounds show a decreased tendency toward scar contraction comapared to conventional scalpel surgeries (17). Recent studies of low-level laser therapy using GaAIAs radiation within milliwatt range have been shown to positively influence prolferation of gingival or periodontal ligamnet fibroblasts, thus support periodontal and peri-implant wound healing (72).

SAFTEY AND COST

An integral part of providing dental treatment with laser instrument is safety and Laser safety officer (LSO) is a designated, trained person who directs laser safety practices and ensures a safe environment for using it (73). Every clincian should be careful to prevent inadvertent irradiation and protective eyewear specific for the wavelength of laser in use must be worn by the patient, operator and assistant and in addition, should attend certificate courses by dental laser organisations and follow lasers safety guidelines; but the cost and size of laser device still constitute an obstacle for its routine application (74).

CONCLUSION

Lasers have been suggested as an adjunctive or alternative to conventional techniques for various periodontal procedures and considered superior in respect to easy ablation, decontamination, and hemostasis alongwith less operative and post-operative pain. Introduction of lasers in implant therapy and newer laser technical modalities has revolutionised the periodontal treatment outcome with patient acceptance. However, pateint risk and procedural cost must always be considered and fully understood before its application.

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Table 1: Summary of lasers used in periodontics

Laser type	Wave-length (in nm)	Wave form	Delivery system	Contact	Clinical appliations in periodontics
Cabondioxide (CO_2) laser	10600	Gated or continuous	Hollow waveguide/ articulated arm	Beam focused at 1 to 2 mm from target surface	Soft tissue incision and ablation; subgingival curettage; biopsy; decontamination of implant
Neodymium:Yttrium-aluminium-garnet (Nd:YAG) laser	1064	Pulsed	Flexible fiberoptic system	Surface contact required	Soft tissue incision and ablation; subgingival curettage; bacterial elimination.
Erbium:yttrium-aluminium-garnet (Er:YAG) laser	2940	Free running pulsed	Flexible fiberoptic system or Hollow waveguide	Surface contact required	Soft tissue incision and ablation; subgingival curettage; scaling; root conditioning; osteoplasty and ostectomy; degranulation and decontamination of implants
Erbium,Chromium: yttrium-selenium-gallium-garnet (Er,Cr;YSGG) laser	2780	Free running pulsed	Air-cooled fiberoptic/ handpiece	Surface contact required	Soft tissue incision and ablation; subgingival curettage; scaling of root surfaces; osteoplasty and ostectomy
Argon (Ar) laser	488 and 514	Gated or continuous	Flexible fiberoptic system	Noncontactor contact mode	Soft tissue incision and ablation
Indium-gallium-arsenide-phosphide; Gallium-aluminium-arsenide; Gallium-arsenide InGaAsP, GaAlAs, GaAs(diode) laser	635 to 950	Gated or continuous	Flexible fiberoptic system	Surface contact required	Soft tissue incision and ablation; subgingival curettage; bacterial elimination.

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