Lasers in Periodontics: An Overview
Vivek K Bains¹, Sanjay Gupta², Rhythm Bains³

ABSTRACT
Among commonly used lasers in dentistry viz CO₂, 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 CO₂ laser has been suggested to retard its downward growth. Waterlase® and Periowave™ systems are recent devices that have further revolutionised the laser technolony 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

¹BDS, MDS
Reader
Department of Periodontics,
Saraswati Dental College & Hospital,
Lucknow (UP)-227105. India
E mail: doc_vivek76@yahoo.co.in

Correspondence Address
House No. 1317, Sector 16,
Indiranagar,
Lucknow-226016 (UP)
Phone : +91-9935023439

²BDS, MDS
Reader
Department of Periodontics
Career Post Graduate Institute of Dental Sciences & Hospital,
Lucknow (UP)-226020. India.

³BDS, MDS
Senior Lecturer
Department of Conservative Dentistry and Endodontics,
Saraswati Dental College & Hospital,
Lucknow-227105 (UP) India

L ASER, an acronym for Light Amplification by Stimulated Emission of Radiation, 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 CO₂ 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 CO₂ 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 ophthalmalic 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 CO₂, 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 hollow 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 eliminates 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 chromophores 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 tissue 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 CO₂ 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 sterilization, reduced bacteremia, 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 CO₂, Nd:YAG, diode, Er:YAG and Er,Cr:YSGG are being widely used as a tool for gingival 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 CO₂, 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 surface (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 excision using CO₂ 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 CO₂, 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 CO₂ laser prepare the root surface for favourable fibroblast attachment (46). Nd:YAG laser irradiation results in reversible (47) root surface changes that includes surface pitting, crater formation, melting, charring and carbonization (48), alongwith unfavourable 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 determinant for osseous surgery with the exception 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 CO₂ laser irradiation (31,52).

Recent clinical applications 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 CO₂ 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 CO₂ 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 CO₂, Nd:YAG, diode lasers, or Er:YAG have evaluated the histological and immunohistochemical patterns of periodontal tissue healing following surgical and nonsurgical periodontal therapy. 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 CO₂ 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...
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 compared to conventional scalpel surgeries (17). Recent studies of low-level laser therapy using GaAlAs radiation within milliwatt range have been shown to positively influence proliferation of gingival or periodontal ligament fibroblasts, thus support periodontal and peri-implant wound healing (72).

**SAFETY 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 clinician 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 along with 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, patient risk and procedural cost must always be considered and fully understood before its application.

**REFERENCES**

4. Coated from Jesse J, Desai S, Oshita P. The evolution of lasers in dentistry: Ruby to YSGG. 4-Continuing Dental Education Units.

**Table 1: Summary of lasers used in periodontics**

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