REVIEW ARTICLE

Clinical Application of Soft Tissue Lasers in Periodontics

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ABSTRACT

Laser is an acronym for light amplification by stimulated emission of radiation. The use of laser in dentistry dates way back to 1960s. Since then, its use has increased manyfold. The dental lasers cut tissue by a principle known as photothermal interaction or photothermal ablation. Lasers are effectively used in operculectomies, gingival depigmentation, gingivectomies, and many more procedures. Laser cannot only be used for surgical procedures but can also be used as an adjunct to scaling and root planing. The diode laser is used on the soft tissue side of the periodontal pocket to remove the inflamed soft tissue and reduce the pathogens. Lasers have been suggested as an adjunct and/or alternative to conventional techniques for various periodontal procedures and considered superior with respect to easy ablation, decontamination, and hemostasis along with less operative and postoperative pain.

Keywords: Implant, Laser, Nonsurgical periodontal therapy, Root modification.

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INTRODUCTION

Lasers have been a part of dentistry for over 25 years, but because of their bulky body and cost, they have been largely ignored. The history of lasers dates back to 1960s, when Maiman introduced us to the concept of "light amplification by stimulated emission of radiation" (laser).[1] The first application of a laser to dental tissue was reported by Goldman et al and Stern and Sognnaes, each article describing the effects of the ruby laser on enamel and dentin.[2] There are various lasers available that can be used in periodontics. Optical properties of periodontium, such as pigmentation, water content, mineral content, heat capacity, and latent heats of transformation can also determine the clinical application alongside specific wavelength, heat conduction and dissipation, and the amount of tissue congestion.[1]

Lasers for hard tissues encourage efficient diagnosis of caries and improve the resistance of dental enamel to caries, laser etching of enamel, cavity preparations, photopolymerization of composite resin, and sterilization of the root canal system.[3] Various advantageous characteristics, such as hemostatic effects, selective calculus ablation, or bactericidal effects against periodontopathic pathogens, might lead to improved treatment outcomes. Because of an excellent soft tissue ablation capacity, CO_2 lasers have been used successfully as an adjunctive tool to de-epithelialize the mucoperiosteal flap during traditional flap surgery. Diode and Nd:yttrium aluminum garnet (YAG) lasers were mainly used for laser-assisted subgingival curettage and disinfection of the periodontal pocket with various degrees of success.[4]

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MECHANISM OF LASERS

Laser is a monochromatic light in visible or invisible range with three indistinctive features of collimation, coherency, and efficiency. Based on the quantum theory of physics given by Max Plank and atomic architecture by Niels Bohr, the concept of spontaneous emission was proposed. It 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 cause 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.[5] This phenomenon does not occur anywhere in nature.

CLASSIFICATION OF LASERS

Lasers can be classified according its spectrum of light (Table 1), material used (Table 2), hardness, etc. They are also classified[6] on the basis of hardness:

Table 1: Classification based on light spectrum

Ultraviolet light	100–400 nm	Not used in dentistry
Infrared light	400–750 nm	Most commonly used in dentistry (argon and diagnodent laser)
Visible light	750–10000 nm	Most dental lasers are in this spectrum

Table 2: Classification according to material used

Gas	*Liquid*	*Solid*
Carbon dioxide	Not so far in clinical use	Diodes, Nd:YAG, Er:YAG, Er:Cr:YSGG, Ho:YAG

YAG: yttrium aluminum garnet; YSGG: yttrium-selenium-gallium-garnet

- Soft lasers
- Hard lasers

LASER APPLICATIONS IN PERIODONTAL THERAPY

The use of laser in periodontal treatment is more complex as periodontium consists of both hard and soft tissues, so the erbium group of lasers seems more beneficial for periodontal applications as it can be used for both hard and soft tissues.[1]

Nonsurgical Periodontal Treatment

Lasers have solved the limitation of mechanical instrumentation as the beam can reach the deepest pockets and grooves. Periodontopathogens are deactivated in 50°C, according to many researches[7,8] and coagulation, inflamed tissue removal is achieved by laser at 60°C.[7,8] Also, lasers offer clear field views, which are advantageous over the conventional treatments. For bacterial reduction and coagulation, soft tissue lasers, such as argon, diode laser,[9] and Nd:YAG[10-12] are a good choice for inflamed tissues and pigmented bacteria. Er:YAG lasers had been shown to remove subgingival calculus without a thermal change of the root surface, which is equivalent to that provided by scaling and root planing.[5,13,14]

Photodynamic therapy is another important application of a low-power laser that decontaminates the periodontal pocket through activation of a photosensitizer agent, which potentiates the bactericidal effect of laser.[5]

Periodontal Surgery

Soft tissue lasers, viz., CO_2, Nd:YAG, diode, Er:YAG, and Er,Cr: yttrium-selenium-gallium-garnet (YSGG), are being widely used as a tool for gingival soft tissue procedures such as gingivectomy, gingivoplasty, epulis or benign tumor removal, frenectomy,[2] gingival depigmentation, crown lengthening surgeries, irradiation of aphthous ulcers, second-stage exposure of dental implants, coagulation of free gingival graft donor sites. A summary of different laser wavelengths and their periodontal application can be seen in Table 3.[15]

The purported advantages of lasers *vs* scalpel surgery include increased coagulation that yields a dry surgical field and better visualization; the ability to negotiate curvatures and folds within tissue contours; tissue surface sterilization and, therefore, reduction in bacteremia; decreased swelling, edema, and scarring; decreased pain; faster healing response; and increased patient acceptance.[2] Most laser excisional or incisional procedures are performed at 100°C, where intra- and

Table 3: Laser application in periodontics

Laser type	*Wavelength (nm)*	*Contact*	*Clinical applications in periodontics*
Carbon dioxide laser	10,600	Beam focused at 1–2 mm from target surface	Soft tissue incision and ablation; subgingival curettage; biopsy; depigmentation, decontamination of implant
Neodymium:yttrium-aluminum-garnet (Nd:YAG) laser	1,064	Surface contact required	Soft tissue incision and ablation; subgingival curettage; bacterial elimination
Erbium:yttrium-aluminum-garnet (Er:YAG) laser	2,940	Surface contact required	Soft tissue incision and ablation; subgingival curettage; scaling; root conditioning; osteoplasty and ostectomy; degranulation and decontamination of implants, melanin and metal pigment removal
Erbium,chromium:yttrium-selenium-gallium-garnet (Er,Cr:YSGG) laser	2,780	Surface contact required	Soft tissue incision and ablation; subgingival curettage; scaling of root surfaces; osteoplasty and ostectomy
Indium-gallium-arsenide-phosphide (InGaAsP); Gallium-aluminum-arsenide (GaAlAs); Gallium-arsenide (GaAs) (diode) laser	635 to 950	Surface contact required	Soft tissue incision and ablation; subgingival curettage; disinfection, sulcular debridement, melanin pigment removal
Argon laser	488 and 514	Noncontact or no contact mode	Soft tissue incision and ablation, subgingival curettage; bacterial elimination, putpotomy, root canal disinfection sulcular debridement caries removal, aphtus ulcer treatment, analgesia, melanin pigment removal, treatment of dentine hypersentitivity

extracellular water vaporizes and leads to ablation or removal of tissue. Clinicians should have knowledge that if the tissue temperature exceeds 200°C during the procedure, then carbonization and irreversible tissue necrosis will take place.[16]

A key factor in determining how the laser will interact with the underlying tissues depends 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. However, deeply penetrating Nd:YAG and diode lasers having greater thermal effects, leaving a thicker coagulation area on the treated surface similar to electrosurgical procedures.[1,2,5]

Effect of most dental lasers on bone is detrimental for osseous surgery. Exposure of bone to heating at levels ±47°C is reported to induce cellular damage leading to osseous resorption, and temperature levels of ±60°C result in tissue necrosis.[2] But, surprisingly, there are exceptions like Er:YAG and Er,Cr:YSGG laser, which can be used for ostectomy and osteoplasty.[5] However, lower cutting efficiency as compared with conventional instruments and lack of depth control are limitations of these lasers.[17]

Root Surface Modifications

Root surface modification using CO_2, Nd:YAG, Er:YAG, and diode laser has been studied by many authors with conflicting results and is related to the energy density and laser wavelength selection. *In vitro* studies have shown better fibroblast adherence with Er:YAG laser irradiation than mechanical scaling alone,[18,19] whereas conflicting results were seen with Nd:YAG laser.[20,21]

Implant Therapy

Most commonly, lasers have been used in the implant dentistry for soft tissue removal during second-stage implant exposure.[1] Various lasers have been used in second-stage implant therapy for uncovering the submerged implant, prior to placement of the healing abutment. They offer advantages of improved homeostasis, fine cutting surface, less postoperative discomfort, and favorable healing. Although Er:YAG lasers have been used to prepare fixture holes in bone during first-stage implant therapy, because of difficult and time-consuming mechanical debridement, emergence of bacterial resistance to antibiotics, lasers are now being proposed for treating peri-implantitis.[5] Among the dental lasers, Er:YAG lasers at appropriate settings possess the best property for degranulation and implant surface decontamination, without causing surface changes in implant.[5,22]

ADVANTAGES AND DRAWBACKS

Advantages of laser treatment are greater hemostasis, bactericidal effect, and minimal wound contraction.[22-24] Compared with the use of a conventional scalpel, there is reduced need for anesthesia; lasers can cut, ablate, and reshape the oral soft tissue more easily, with no or minimal bleeding and little pain as well as no or only a few sutures.[6] Thus it reduces stress and fatigue for the operator and patients with greater comfort during and after surgery with high acceptance of treatment. It also produces less collateral thermal damage than will an electrocautery. Lasers are also beneficial in managing peri-implantitis cases. Bactericidal properties and delicate debridement of microscopic fins and recesses are advantageous over conventional hand instruments.

Unlike antibiotics, lasers render their bactericidal properties without common side effects such as bacterial resistance, drug interactions, and gastrointestinal complications, and can thus be used in childhood and pregnancy without limitations. It has been reported that soft tissue surgery with CO_2 laser reduces the surgery time to one-fourth. But there is loss of tactile sense when using soft tissue lasers, such as CO_2, diode, and Er:YAG.[4]

On the other side, the use of lasers also has disadvantages in that all lasers require specialized training and attention to safety precautions. Laser irradiation can interact with tissues even in the noncontact mode, which means that laser beams may reach the patients' eyes and other tissues surrounding the target in the oral cavity. Clinicians should be careful to prevent inadvertent irradiation to these tissues, especially to the eyes.[6] Thus safety issues, technical complexities, cost, and lack of evidence-based studies about therapeutic effects and efficiencies are drawbacks of laser treatment.[1] Also, no single laser can perform all desired dental applications.

PRECAUTIONS AND RISKS ASSOCIATED WITH CLINICAL USE OF LASERS: PRECAUTIONS BEFORE AND DURING IRRADIATION[25]

- Use glasses for eye protection (patient, operator, and assistants).
- Prevent inadvertent irradiation (action in noncontact mode).
- Protect the patient's eyes, throat, and oral tissues outside the target site.
- Use wet gauze packs to avoid reflection from shiny metal surfaces.
- Ensure adequate high-speed evacuation to capture the laser plume.

Potential Risks

- Excessive tissue destruction by direct ablation and thermal side effects.
- Destruction of the attachment apparatus at the bottom of pockets.
- Excessive ablation of root surface and gingival tissue within periodontal pockets.
- Thermal injury to the root surface, gingival tissue, pulp, and bone tissue.

RECENT ADVANCES

Waterlase system is a revolutionary dental device that uses laser-energized 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.[5]

Periowave is a photodynamic disinfection system that utilizes nontoxic dye (photosensitizer) which, in combination with low-intensity lasers, enable singlet oxygen molecules to destroy bacteria. 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 has been suggested, however, the same is not true for facultative anaerobes.[5]

CONCLUSION

As technology advances in the field of dentistry, whether laser or any other exciting technology, the options available to clinicians will continue to increase. Although the use of lasers in dentistry is relatively new, the future looks very bright. In summary, laser treatment is expected to serve as an alternative or adjunctive to conventional mechanical periodontal treatment.[6] Based on this review of the literature, there is a great need to develop an evidence-based approach to the use of lasers for the treatment of chronic periodontitis. Simply put, there is insufficient evidence to suggest that any specific wavelength of laser is superior to the traditional modalities of therapy. Safety regarding the use of lasers is not optional. It should be the highest priority of all clinicians involved in the surgical procedure. There should be a concerted effort to better educate physicians, provide more educational support for perioperative staff members, and conduct additional research to improve equipment and ancillary supplies.[26] Prevention of accidents requires thorough knowledge of their causes and the application of measures to avoid them.[15] Introduction of lasers in implant therapy and newer laser technical modalities has revolutionized the periodontal treatment outcome with patient acceptance. However, patient risk and procedural cost must always be considered and fully understood before its application.[5]

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