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Review Article

Lasers in Periodontics

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Abstract

Introduction: Lasers in the field of dentistry have seen enormous growth in the past two decades, making them a common phenomenon in routine periodontal procedures. Among the routinely used lasers in dentistry, CO2, Nd: YAG, GaAs (diode) lasers can be safely used in soft tissue procedures like gingivectomy and frenectomy. While the lasers are more versatile pertaining to their ability to act on both soft and hard tissues, Ho: YAG, Er: YAG, Er, Cr: YSGG, and Er: YAG lasers possess superior properties for their use in subgingival calculus removal, soft tissue surgical and non-surgical procedures, root surface alterations, debridement, implant decontamination and in osseous surgeries. Newer devices like Gemini diode laser, Siro laser blue are recent advancements that allow tailoring of laser technology for specific clinical applications in the oral cavity.

Aim: The aim of this review is to provide a concise update on the use of lasers in various periodontal procedures.

Methodology: The article is a comprehensive research of PUBMED papers from 1990 to 2021.

Conclusion: Lasers have been proven advantageous in more than one aspect for their use in routine periodontal procedures. An effective and efficient soft and hard tissue ablation, their ability to provide greater hemostasis, minimal wound contraction, faster healing, minimal collateral damage make them a revolutionary tool.

Keywords: *Lasers; Periodontics; Er: YAG Lasers; Non-Surgical Periodontal Therapy*

Introduction

Advancements in dentistry cover a wide array of instruments and devices that have undergone continuous improvement owing to the research done in the past. The past 20 years have observed a shift in research towards highly technological tools offering an advantage over conventional tools and methods. Light Amplification by stimulated emission of radiation (LASER) came first into existence on its construction in 1960 by Maiman using a ruby crystal medium, based on the earlier work by Charles H Townes. Based on an early theory of stimulated emission of electromagnetic radiation by Einstein, it was now possible to use coherent radiant light when stimulated by energy for its various applications [1].

Initially used by an ophthalmologist, LASER found its use in the field of medicine [2]. In dentistry, the first use of LASER was in 1980 where Myers and Myers modified an Nd: YAG ophthalmic laser for its use in dentistry [3]. Post which, the use of Nd: YAG laser in soft tissue surgery became acceptable [4]. Numerous researches in the field of lasers have deemed Neodymium-doped: Yttrium- Aluminium-Garnet (Nd: YAG), semiconductor diode lasers, and Carbon dioxide laser (CO_2) useful in procedures of the oral cavity. The Erbium-doped: Yttrium-Aluminium-Garnet (Er: YAG) laser was accepted for its use in dental hard tissues later in 1997 [5].

Laser irradiation in the periodontium follows thorough knowledge of its properties and its applications in their use on various biological tissues. Incautious use of lasers may cause damage to soft or hard tissues as the periodontium consists of both. Because of their superior properties, Nd: YAG and CO_2 can be safely used for soft tissue procedures like frenectomy, gingivectomy, and depigmentation. Er: YAG and Er, Cr: YSGG is known to safely ablate all water-containing soft tissues, making their use promising in procedures like scaling and root planing. Other commonly used lasers include Ho: YAG, Nd: YAP, and argon [5].

Lasers work due to their photothermal properties, causing temperature increase in the target tissue. Their clinical use can be determined by specific wavelengths, tissue congestion and conduction, and dissipation of heat. Additionally, optical properties of the target tissue like its water and mineral content, heat capacity and pigmentation also explains why a specific laser is chosen for a certain procedure. Widely they can be divided into soft and hard tissue lasers. Nd: YAG and CO_2 being safe for their use in soft tissue procedures, while lasers from the Erbium family being superior for their use in hard tissue procedures [6].

Properties of lasers

The construction of lasers is based on the concept of stimulated emission. Energy transition in atoms can be induced by light, allowing atoms to change their state to an excited state. Photon emission is organized and has a specific wavelength which depends on the energy difference between the excited state and the ground state. On encountering another atom with an electron in the excited state, the process of ‹stimulated emission› takes off. A pair of mirrors present on either end of the lasing medium ensures the back and forth a reflection of photons of specific wavelength and phase, causing stimulation of other electrons to release more photos of the same wavelength and energy. A cascade effect occurs, allowing the propagation of many photons of the same wavelength and phase [7].

Laser light is non-ionizing, monochromatic (including photons of only one wavelength), coherent (photon beam in one phase), highly directional (low scatter), with a tight, concentrated beam that can be delivered as a continuous wave in a gated pulse mode or a free-running pulse mode. Mode also includes contact and non-contact mode [7,8].

Laser tissue interactions

Possible laser interactions include Photochemical, Photothermal, Photomechanical, and photoelectric interactions [8]. Types include wavelength-dependent and wavelength-independent types. Photo ablation refers to photothermal interaction allowing vaporization and coagulation in tissues. Photo Mechanic interaction causes mechanical disruption of the production of the tissue of cavitations or shock wave formation. Photochemical interactions find their use in the form of biomodulation of tissues affecting its molecular processes like repair and healing [9].

Classification of lasers:

- Hard tissue lasers
- Soft tissue lasers.

Types	Waveform	Wavelength	Delivery System	Applications in Periodontics
DIODE LASER In-GaAsP, GaAlAs, GaAs (Indium-gallium-arsenide-phosphide;Gallium-aluminium- arsenide; Gallium- arsenide)	Gated or continuous	635 to 950	Flexible fiberoptic system	• Soft tissue incision and ablation • Subgingival curettage • Bacterial elimination.
Argon Laser	Gated or continuous	488 and 514	Flexible fiberoptic system	• Soft tissue incision and ablation • Sulcular debridement for periodontium • Debridement in peri-implant tissues
Carbon dioxide (CO_2) laser	Gated or continuous	10600	Hollow waveguide or articulated arm	• Subgingival curettage • Biopsy • Implant decontamination
Nd:YAG (Neodymium- Yttrium-ALuminum-Garnet) Laser	Pulsed	1064	Flexible fiberoptic system	• Soft tissue incision and ablation • Subgingival curettage • Bacterial elimination.
Er.YAG (Erbium-Yttrium-ALuminum-Garnet) Laser	Free running pulsed	2940	Flexible fiberoptic system or Hollow waveguide	• Soft tissue incision and ablation • Subgingival curettage • Scaling • Root conditioning • Osteoplasty and ostectomy • Degranulation and decontamination of implants
ER,CR:YSGG (Erbium, Chromium-Yttrium-Selenium-Aluminum-Garnet) Laser	Free running pulsed	2780	Air-cooled fiber optic	• Soft tissue incision and ablation • Subgingival curettage • Scaling of root surfaces • Osteoplasty and ostectomy

Table 1: *Summary of lasers and their applications in periodontics [9].*

Laser applications in periodontal therapy

The application of laser therapy on the periodontium is made complicated by it being a tissue containing both soft and hard tissue. Most periodontal diseases have plaque as a precursor, the removal of which is carried out using mechanical methods to remove plaque and its retentive factors. Complicated root anatomy may make areas inaccessible with mechanical debridement alone. Lasers, however, provide an advantage by reaching deep gloves and pockets. The thermal effect of lasers causes most periodontal pathogens to deactivate at 50°C and coagulate inflamed tissue at 60°C [10]. Temperatures higher enable effects of tissue welding (70 - 80°C), evaporation (100°C) and carbonization (200°C) [11].

The use of lasers alone or as an auxiliary tool along with mechanical debridement has proven to be safe and effective in periodontal therapy. It allows higher patient acceptance due to reduced noise and vibration compared to traditional methods using scalers. Other advantages include a dry surgical field, better visualization, sterilization of the tissue surface, improved hemostasis, decreased inflammation and scarring, thereby allowing faster healing and reduced post-operative pain [10,11].

Soft tissue applications

Gingival tissue procedures

Soft tissue lasers like CO_2, Er: YAG, Nd: YAG, Er, Cr: YSGG(Yttrium-selenium-gallium-garnet) find their applications in intraoral soft tissues due to their ablative, coagulative, and incisive properties. In addition, laser irradiation allows homeostasis and bactericidal effects on tissues making them effective in procedures like gingivectomy, frenectomy, gingivoplasty, gingival sculpting, removal of mucocutaneous lesions (malignant or benign) [10,11].

Aesthetic gingival procedures

Aesthetic procedures include reshaping and recontouring of gingiva in crown lengthening. Use of Er: YAG lasers, due to their precise ablative properties, are safe for use. Depigmentation of excessive melanin in gingiva is treatable with CO_2, Diode, and Nd: YAG lasers. The use of Er: YAG lasers in very thin gingiva should be done with caution as it poses a risk for ulceration due to the deeply penetrative effects of the laser beam [11,12].

Non surgical pocket therapy

Conventional root debridement

In periodontally involved teeth, root surfaces are contaminated with bacterial endotoxins from the plaque and calculus harbored by the root. The first step to resolving symptoms of the disease is debridement of the root surface. Conventional mechanical debridement using curettes and scalers may be less effective in inaccessible areas, also increasing discomfort due to the sharp noise from scalers. In contrast, lasers allow complete debridement of the root surface [13].

Removal of subgingival calculus

Calculus removal is imperative to the success of any periodontal treatment. This can be effectively achieved by Er: YAG and Er, Cr: YSGG as research states removal of up to 15 - 30 μm of superficial cementum layer with these. Unlike CO_2 or Nd: YAG lasers which prove to be ineffective in calculus removal, the erbium family lasers can allow selective removal of calculus up to an extent favoring fibroblast attachment. The use of water coolant further reduces the thermal ill effects of the laser [14].

Root surface alterations

In its earlier use, CO_2 lasers were found to spontaneously carbonize root cementum, reducing to a charred layer which made reattachment of the periodontal tissue hard. Research in the past decade regarding various parameters and power settings in the use of CO_2 lasers had found it useful in de-epithelization without causing damage to the root [16]. A defocused and pulsed beam was found to safely smoothen the root surface compared to the previously used continuous focused beam [15].

Bactericidal and detoxification effects

Reduction of viable bacterial count in the gingival sulcus is another application that lasers are accepted for. The Nd: YAG laser was initially accepted and was proven to reduce the load of the periodontal pathogen count. Later, the use of a 980 nm diode laser in adjunction to the use of ultrasonic was found to be superior, providing a reduction in bacteremia in patients with immunocompromised systems, even without systemic antibiotic therapies [17]. The use of a thin fiber diode laser for bacterial laser reduction (LBR) is hence commonly accepted. For maintenance appointments in patients with aggressive periodontitis, PDT (Photodynamic therapy) has been found to provide better clinical results when compared to the Nd: YAG or diode lasers [18].

Periodontal pocket treatment

Periodontal pocket therapy by removal of sulcular epithelium of the periodontal pocket is carried out fairly well by lasers. The use of Nd: YAG laser in the same has proven advantageous in controlling bacteremia and bleeding in the gingiva [19]. A pulsed Nd: YAG laser has demonstrated reduced bleeding index scores and pocket depth in contrast to conventional curettage without causing carbonization or necrosis of the underlying area. In deep periodontal pockets, lasers can be used to remove the pocket epithelium on the inner and outer side of the pocket, allowing reattachment of connective tissue epithelium without a recession of the gingiva. This stable attachment follows the principle of guided tissue regeneration (GTR), in this case, termed «laser-assisted guided tissue regeneration," allowing reattachment to the previously denuded root surfaces [20].

Surgical pocket therapy

For success in surgical periodontal therapy, the debridement and decontamination of the intrabony defects and the root surface is imperative. Lasers provide access to deep intrabony defects and furcation areas allowing removal of most etiological factors. Laser irradiation with Er: YAG, Er, Cr: YAG limiting to the superficial layers alone provides effective clinical improvement post-surgery [21].

Hard tissue applications

Osseous surgery

Laser application for osseous surgeries is in the form of cutting, shaving, reshaping, and recontouring the bone of interest to its physiological contours to allow reattachment of the gingival epithelium. Erbium lasers hold an advantage over traditional methods, including sharp bone chisels, files, and rotary instruments, by providing more precision and lesser risk of damage to the surrounding tissues. YSGG lasers continue to prove safe for their use in osteoplasty, osteotomy, and osseous recontouring procedures [1,22].

Applications in implant dentistry

In implant therapy, lasers are usually used in the second stage to remove soft tissue for submerged implant exposure. Lasers provide the advantage of fine cutting, clear field view, improved hemostasis, less post-operative pain, and superior healing. Debridement and sterilization of the implant surface by Er: YAG irradiation has also been validated for the treatment of peri-implantitis without hampering the osteoblast attachment rate. Er: YAG has also been applied in the first stage of implant therapy, demonstrating lower mechanical stress and faster osseointegration [23].

Photodynamic therapy

Photodynamic therapy allows a strong photochemical reaction for the treatment of malignancies. Laser activation of dyes produces reactive oxygen species capable of destruction of cells, causing necrosis or apoptosis. This characteristic of PTD (photodynamic therapy) finds its use in reducing tumor sizes and promoting immunity through the activation of macrophages and lymphocytes [24].

Recent advances

Advancement in the laser technology has been an ongoing area of research that has led to the construction of newer services. Approval of another such device called Waterlase took place in 1998. This revolutionary device allows the use of Er, Cr: YSGG laser energized water to carve, shape, and ablate soft and hard tissues. It offers the advantage of faster procedures and reduced pain during periodontal procedures [24].

Periowave is another device, the use of which is done to destroy bacteria. It utilizes a photosensitizer with low-intensity lasers to produce reactive oxygen species to destroy bacteria. Reduction in anaerobic periodontal pathogens like *A. actinomycetemcomitans, P. gingivalis*, and *P. intermedia*, B has been observed with the use of periowave, while it doesn't have the same effect on facultative anaerobes [24].

Gemini 810 +980 diode laser is a double frequency delicate tissue diode laser for use in delicate tissues in about 20 dental procedures. Another laser presented in 2018, SiroLaser Blue, has an edge with three available frequency options- 970, 660, and 445 nm with higher cutting abilities [25].

Conclusion

Plaque and calculus removal, infected tissue debridement, faster and precise ablation, clear field view, hemostasis, sterilization of action site, and reduced post-operative discomfort make lasers a useful tool in a wide range of periodontal procedures. Amongst the various lasers available today, the Erbium group lasers offer the advantage of application on both hard and soft tissues. The few disadvantages regarding the use of lasers are also shrinking owing to continuing research in the field of laser application in dentistry. With thorough knowledge of wavelengths and properties, skill in the use of different laser types, lasers increasingly find their use in everyday practice. While procedural costs and patient risk are something to keep in mind, lasers continue to be a blessing for today's modern clinicians.

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