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Laser - An Innovative Tool in Periodontal Therapy - A Review Paper

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ABSTRACT

Dentistry has entered an exciting era of technological advancements. The advent of newer modalities of treatment like the use of laser radiation has heralded a change in the field of Periodontics since its development and subsequent applications for dental hard and soft tissue procedures. Extensive research has been done on the possible benefits of lasers derived from the adjunctive effects of bacterial control and haemostasis associated with its use. This review attempts to explore the current status of laser applications in the treatment of periodontal diseases and the emerging concepts in the utilization of laser energy. The limitations of lasers in periodontal therapy are also briefly discussed.

Keywords: Haemostasis, laser, non-surgical periodontal therapy, periodontics.

INTRODUCTION

The pathogenesis of periodontal diseases has undergone a significant change with respect to the concepts over the last few decades as have its treatment modalities. Since the discovery of LASER (Light Amplification by Stimulated Emission of Radiation) by Maiman in 1960 and its subsequent initial application in dentistry in 1964, extensive research has been carried out in all parameters pertaining to its use in Periodontics (1, 2). Studies conducted in this regard indicate that lasers have definite advantages when used as an adjunct or an alternative to conventional therapeutic modalities (3). Different wavelengths of lasers with peculiar tissue interactions have been invented. This finds applications in all spheres of periodontal therapy (4, 5, 6, 7). Despite the technical advancements, the routine application of lasers in clinical practice is still a controversial issue among clinicians. So the purpose of this review is to analyze the literature to determine the current state of science regarding the safety and utility of lasers in periodontal therapy.

LASER FEATURES

LASER light is a monochromatic, coherent and collimated form of electromagnetic energy which can be delivered to the target tissue in different ways such as a continuous wave, gated pulse mode or free running pulse mode (8, 9). The laser beam can be precisely focused on to the tissues and can be utilized to accomplish the treatment objective.

Action of lasers, depend on their absorption by tissue chromophore within the target tissue. Accordingly, laser beam may be reflected, transmitted, scattered or absorbed by the target tissues (3). Transmission of laser energy through the tissues is dependent on its wavelength. The principal laser tissue interaction is photo-thermal which include incision/excision, ablation/vaporization and haemostasis/coagulation (10). Photochemical effect results in release of singlet O_2 radical for disinfection. Lasers also have biostimulatory effects, which result in faster wound healing, pain relief, increased collagen formation and an anti-inflammatory effect in general.

CLASSIFICATION OF LASERS

Lasers can be classified according to its spectrum of light, state of gain medium, oscillation mode, hardness and output energy which is summarised in Table 1.

Table 1: Classification of Lasers (10)

Based on spectrum of light:	
UV light (100-400nm)	Not used in Dentistry
Visible light (400-750nm)	Most commonly used in Dentistry(Argon & Diagnodent Laser)
Infrared light (750-10,000nm)	Most Dental Lasers are in this spectrum
Based on gain medium	
Solid state	Example: Nd:YAG, Er:YAG, Er:Cr:YSGG
Gas	Example: He, Ne, Ar, CO_2
Excimer	Example: ArF, KrCl
Diode	Example: GaAlAs
Based on oscillation mode	
Continuous wave	Example: CO_2, Diode lasers
Pulsed wave	Example: Nd:YAG, Er:YAG
Based on hardness	
Soft lasers	Example: He:Ne, Ga:As
Hard lasers	Example: Ar, CO_2, Nd:YAG, Er:Cr:YSGG
Based on output energy:	
Low output, soft or therapeutic	Example: Diode lasers
High output, hard or surgical	Example: CO_2,Nd:YAG,Er:YAG

PROPERTIES AND APPLICATIONS OF LASERS

The properties and applications of some lasers are summarised in the Table 2.

Table 2: Properties and actions of some commonly used Lasers (4, 5)

Type	Active Medium	Wave length	Applications	Company
Gas lasers	CO_2	10600 nm	- Soft tissue incision and ablasion - Subgingival curettage - Depigmentation - Analgesia	Deka Lumenis
Diode lasers	In-Ga-As-P, Ga-Al-As, Ga-As	655 nm 810 nm 980 nm	- Detection of caries and calculus - Soft tissue incision and ablation - Subgingival curettage - Bacterial decontamination	Biolase Elexxion KaVo Sirona Picasso
Solid-state lasers	Nd:YAG	1064 nm	- Soft tissue incision and ablation - Subgingival curettage - Bacterial decontamination - Depigmentation	Deka Fotona Periolase
	Erbium group Er:YAG	2940 nm	- Soft tissue incision and ablation - Subgingival curettage - Scaling and root debridement. - Osteoplasty and ostectomy	Deka Elexxion Fotona Hoya KaVo Lumenis Syneron
	Er,Cr: YSGG	2780 nm	- Hard tissue ablation - Bacterial decontamination	Biolase

APPLICATION OF LASERS IN PERIODONTAL TREATMENT

Use of lasers become complex in the treatment of periodontal diseases as it has to encounter both hard and soft tissues. It can be used for initial periodontal therapy (non-surgical), surgical procedures and in the treatment of peri-implantitis.

i) Non-surgical periodontal therapy:

Laser assisted pocket therapy is emerging as a promising new approach in Periodontics. The application of Nd:YAG and diode lasers has been recommended for bacterial elimination as well as for soft tissue debridement within periodontal pockets as an adjunct in nonsurgical pocket therapy, in combination with mechanical instruments. The CO_2 laser is not suitable since it has the potential to cause thermal damage as indicated by previous studies (11). The Er:YAG laser may hold the most promise for root surface debridement such as selective calculus removal and decontamination with bactericidal effects against *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* although there is no consensus till date regarding the level of detection and calculus removal (12,13). Current laser-assisted methods address the biofilm of the tissue wall, supplementing conventional methods that address the tooth structure (14).

ii) Surgical therapy:

Laser is effectively used to perform soft tissue procedures such as gingivectomy, gingivoplasty, frenectomy, free gingival graft procedure, crown lengthening and operculectomy (15). Azzeh et al. reported in a case series that gingival depigmentation can be done safely and reliably by Er:YAG laser and that no repigmentation was found during the follow-up period of 6-18 months (16). During flap surgeries, laser application for removal of granulation tissue seems to be safe and effective with results equal to or even superior to those of conventional mechanical methods (10). Nelson et al. after testing several energy levels, reported that Er:YAG laser produced ablation of bone with minimal thermal damage to adjacent tissue (17). Moreover, laser treated bone is found to heal more quickly than bone treated using conventional procedures. Er:YAG laser is reported to be quite safe for periodontal bone surgical procedures which include osseous removal or recontouring, when used simultaneously with saline irrigation in areas where resistance of the junction of newly formed bone over lased bone is not critical (10).

iii) Implant therapy:

In the field of implant dentistry, the use of lasers for uncovering the submerged implant (second-stage) is reported to enhance the rehabilitative phase (18, 19). Faster osseointegration is found in the implants for which Er:YAG laser is used to prepare osteotomy sites. This may be attributed to less tissue damage produced in comparison to conventional bur drilling (20, 21). Kesler *et al*. also found similar results of early bone-to-implant contact following Er:YAG laser in comparison to conventional methods (22). The titanium surface of the implants is unaffected by the use of CO_2 laser and diode laser as evidenced by some studies (23). Takasaki et al. have found out another potential use of Er:YAG laser in degranulation and implant surface decontamination without thermal adverse effects (24). Also the Er;YAG laser is promising in flap surgeries as proved by Schwarz et al., who reported that laser irradiation during flap surgery improved all the parameters investigated in an animal study for the treatment of peri-implantitis in a circumferential crater like bone defect (25). It is interesting to note that lasers tend to show better results in animal studies than in clinical studies. Current evidence points out that application of lasers hold great promise as an alternative or adjunctive tool in the treatment of peri-implant diseases.

Photodynamic therapy

Photodynamic therapy (PDT) has been introduced as a novel disinfection therapy in dentistry. It is based on the principle that a nontoxic photo sensitizer binds to the target cells which can be activated by a light of suitable wave length. This results in release of reactive species like singlet oxygen and other agents which cause toxic effects on microorganisms by means of destruction of membrane lipids, protein and ion channels, critical metabolic enzymes and virulence factors like lipopolysaccharides (LPS) (26). The photosensitizer of PDT is highly selective to prokaryotic cells while avoiding damage to human tissues (27). There is accumulating evidence to show that the adjunctive use of PDT to scaling and root planning(SRP) on a short term basis(up to 3-6 months) may result in higher reductions in bleeding on probing(BOP) with probing pocket depth(PPD) reductions and clinical attachment level(CAL) gains comparable to results after SRP alone . Chondros et al. (2009) found significant reduction in *F.nucleatum* and *E.nodatum* in the group receiving combined treatment (PDT+SRP) at 3 month evaluation (28). Recent studies indicate that multiple courses of PDT (repeating 5 times in 2 weeks) may improve healing outcomes and may give long term effects (29). de Oliveira et.al in 2009 reported reduced TNF-alpha and RANKL levels following treatment by PDT or SRP in aggressive periodontitis patients (30). Braham et al. in 2009 also found an inactivation of host destructive cytokines after the application of a single *in vitro* PDT treatment (31). Although current reports have not shown significant superior effects of

PDT compared to conventional methods, it still holds promise as a novel non invasive treatment either as a monotherapy or in conjunction with conventional methods.

Low level laser therapy (LLLT)

The bio stimulant effects of lasers might be beneficial in faster wound healing by higher cell proliferation and reduction of discomfort or pain which is not the case in conventional mechanical therapy. LLLT uses a light source that generates extremely pure light with a single wave length which causes photochemical reactions within cells. Kreisler *et al*. in 2003, showed that LLLT enhances the activation of human gingival fibroblasts, proliferation of PDL cells and release of growth factors *in vitro* (32). Safavi *et al.* in 2007 reported that LLLT decreases the amount of inflammation and accelerates wound healing by changing the expression of genes responsible for the production of inflammatory cytokines *in vivo* (33).

Regarding osteogenesis, *in vitro* studies by Ozawa *et al*. and Stein *et al*. have suggested that LLLT can promote new bone formation by proliferation and differentiation of osteoblasts. It has also been reported to increase the alkaline phosphatase activity and mRNA expression of osteopontin, osteocalcin and bone sialoprotein in osteoblasts thereby promoting bone nodule formation (34, 35). Consequently LLLT has been recently applied in implant dentistry as it has been proven to achieve faster osseointegration of implants following irradiation. In addition, LLLT appears to stimulate the proliferation and attachment of fibroblasts and osteoblasts cultured on titanium disks (36, 37). Further clinical studies are needed to explain the real beneficial effects of LLLT in periodontal and implant therapy.

Subgingival calculus detection

Correct diagnosis of the presence and extent of subgingival calculus is critical in planning treatment procedures and re-assessment following periodontal therapy. The laser fluorescence method is a promising tool for easy and precise subgingival calculus detection based on differences in fluorescent light emission between subgingival calculus and cementum. An effective system for subgingival root debridement that combines an Er:YAG laser with diode laser fluorescence spectroscopy is already being marketed mainly in European countries (Key Laser III TM; KaVo, Biberach, Germany) (10). This includes a calculus detection device based on laser fluorescence from mineralized tissues which incorporates a feedback driven treatment mode. But the treated surfaces present micro-irregularities which may be due to the mechanical ablation effect of Er:YAG laser (38). Further clinical studies are needed to validate the accuracy and reliability of this method and its expected superiority over conventional non-surgical therapy.

LASER SAFETY

The laser safety guidelines are summarized in Table 3.

Table 3: Laser safety guidelines (10)

1. Adverse effects of periodontal laser therapy	2. Precautions to be taken before and during irradiation	3. Precautions to prevent thermal injury during procedure
• Ablation of gingiva and root surfaces during pocket irradiation • Destruction of the periodontium at the base of pockets during the procedure • Bone and root surface alterations caused by laser radiation • Damage to tooth enamel by accidental irradiation	• Patient, operator and assistants should use glasses for eye protection • Wet gauze sponges should be used to prevent inadvertent irradiation and reflection from shiny metal surfaces • Intra oral sites apart from the target site should be protected • Clinicians must exercise accurate foot pedal control • High speed evacuation should be ensured to capture the laser plume	• Clinician must have understanding of the critical penetration depth of each laser • Thermal injury to the root surface, gingival tissue, pulp and bone tissue should be minimized • Heat generation should be minimized by constant irrigation during the whole procedure

LIMITATIONS OF LASER THERAPY

Despite the purported benefits of using lasers in treatment of periodontal disease, it is not devoid of shortcomings. Considerable debate continues as to the efficiency of lasers and its benefits over conventional treatment modalities like SRP. Current evidence shows that lasers have little or no benefit beyond SRP alone when used for subgingival debridement, curettage, reduction of subgingival bacterial levels and treatment of peri-implantitis (39, 40). The Er:YAG laser has been shown*, in vitro*, to remove calculus and to negate endotoxin. But there is potential for root surface damage during the process of *in vivo* calculus removal. Clinical data on attachment level changes when compared to SRP alone are conflicting, with some studies showing a slight benefit while others show no benefit (39). In addition to the high cost of laser treatment, the difficulties in establishing a series of protocols, addressing differences in pocket architecture, presence and extend of disease and deposits along with the usage of correct laser parameters demands skill on part of the operator. Therefore the use of lasers should be preferably adjunctive and the clinician should have thorough knowledge of potential damaging factors associated with its application (41).

FUTURE TRENDS

The Laser armamentarium is continuously evolving with definite benefits in treatment outcomes to periodontal patients. Waterlase system is a revolutionary dental device that utilizes laser energized water to ablate soft tissues. Periowave, a photodynamic disinfection system uses a photosensitizer combined with low intensity lasers to produce singlet oxygen mediated bacterial destruction (42). Laser assisted new attachment procedure (LANAP) can be utilized for cementum mediated new CT attachment that helps in periodontal regeneration of diseased root surfaces. The Alexandrite (Chromium doped: Beryllium-Aluminium-Oxide chrysoberyl) laser is widely accepted for clinical use as it has the excellent property of selectively removing calculus without ablating the enamel or cementum from tooth surfaces (43, 44). Laser doppler flowmetry has been utilized to analyse blood circulation of gingiva following flap surgeries by Retzepi et al. (45). Optical coherence tomography is also expected to emerge in to the ever-expanding armamentarium utilizing lasers.

CONCLUSION

As technology advances, newer arenas of treatment options using lasers are expected to mushroom in the coming decades. The laser treatment is expected to serve as an alternative or adjunct to conventional mechanical periodontal treatment. Among the various types of lasers currently in use, Er:YAG and Er:YSGG lasers possess characteristics most suited to dental treatment due to its dual ability to ablate soft and hard tissues with minimal damage. The bactericidal effects of lasers with elimination of bacterial LPS and its ability to remove bacterial plaque and calculus with the irradiation effect being limited to an ultra thin layer of tissue along with faster bone and soft tissue repair make it a promising tool for periodontal treatment. Application of photodynamic therapy &low level laser therapy are promising new approaches which are currently under research. The decision to use a laser should be based on the proven benefits of haemostasis, reduced surgical time and the general experience of less post operative swelling. Special laser technologies combining different photonic properties of lasers allowing the clinicians to choose the most adequate system for each necessity is expected to evolve in the coming decades.

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