Review Article

Deploying Diode Laser in Periodontics: An Evidence-Based Review

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Abstract

Lasers have completely changed the concept of dental treatment since three and half decades of 20th century. After the invention of ruby laser by Maiman in 1960, laser has become the most magnetizing technology in dentistry. Diode Lasers have been used in initial periodontal therapy, surgery, and also in implant treatment. In many countries Laser has become a part of the dental armamentarium. The included articles were searched from PubMed, Trip Database, Google scholar and Cocharane database. The purpose of this review article is to critically analyze the effectiveness of diode laser on soft and hard tissue in the field of Periodontics.

Keywords: Diode laser, periodontal surgery, periodontitis, periodontology, scaling and root planning

Introduction

One very exciting technology making great inroads into lot of areas of dentistry today is the LASER technology. Based on Albert Einstein's theory of spontaneous and stimulated emission of radiation, Maiman developed the first laser prototype in 1960. Maiman's device used a crystal medium of ruby that emitted a coherent radiant light from the crystal when stimulated by energy. Thus, the ruby laser was created. The application of a laser to dental tissue was reported by Stern and Sognnaes[1] and Goldman *et al*.[2] in 1964, describing the effects of ruby laser on enamel and dentin with a disappointing result. The laser is an acronym for the light amplification by stimulated emission of radiation.

The laser beam is essentially a beam of a light comprising excited photons. Laser is a device that converts electrical or chemical energy into light energy. In contrast to ordinary light that is emitted spontaneously by excited atoms or molecules, the light emitted by the laser occurs when an atom or molecule retains excess energy until it is stimulated to emit it. The radiation emitted by lasers including both visible and invisible light is more generally termed as electromagnetic radiation. Albert Einstein first proposed the concept of stimulated emission of light in 1917. He described three processes:[3]

1. Absorption
2. Spontaneous emission
3. Stimulated emission.

Laser Effects on Tissue

The light energy from a laser can have four different interactions with the target tissue, and these interactions will depend on the optical properties of that tissue. The first three interactions are used in periodontics. When radiant energy is absorbed by tissue, four basic types of interactions or responses may occur.[4]

Photochemical interaction

Biostimulation, which describes the stimulatory effects of laser light on biochemical and molecular processes that normally occur in tissues such as healing and repair.

Photo thermal interactions include

Photoablation or the removal of tissue by vaporisation and superheating of tissue fluids, coagulation and haemostasis.

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Table 1: Lasers used in dentistry

Type	Active medium	Wavelength	Clinical application
Gas lasers	Carbon dioxide	10,600	Soft tissue incision and ablation subgingival curettage
Solid state lasers	Diode lasers (Indium-Gallium, Arsenide-Phosphide, Gallium-Aluminium-Arsenide, Gallium-Arsenide)	655-810-980	Caries and calculus detection Soft tissue incision and ablation Subgingival curettage Bacterial decontamination
	Nd-YAG	1064	Soft tissue incision and ablation Subgingival curettage Bacterial decontamination
	Er: YAG	2940	Soft tissue incision and ablation Subgingival curettage Scaling and root debridement
	Er, Cr:YSGG	2780	Modification of hard tissue surfaces Hard tissue ablation Bacterial decontamination

Nd-YAG: Neodymium-doped yttrium aluminum garnet, Er: YAG: Erbium yttrium aluminum garnet, Er, Cr: YSGG: Erbium, chromium: yattrium-scandium-gallium-garnet

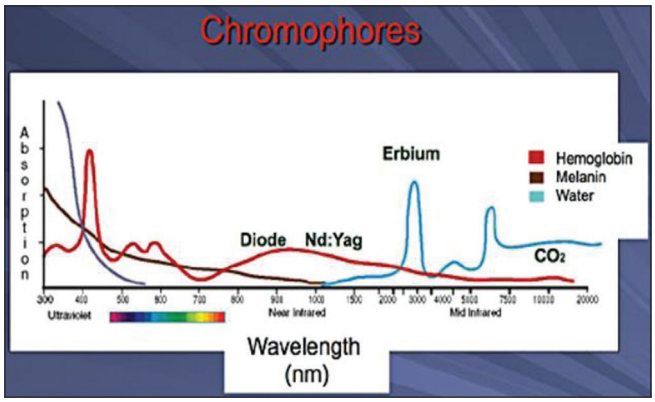

Figure 1: Laser/tissue interaction.

Photomechanical interaction include

Photo-disruption or photo-disassociation, which is the breaking apart of structures by laser light.

Photoelectrical interactions include

Photo plasmolysis which describes how tissue is removed through the formation of electrically charged ions and particles that exist in a semi-gasseous high energy state.

Lasers have tended to be big, clunky, hard to use, expensive machines that were largely ignored. Affordable, effective, user-friendly diode lasers (DLs) have only arrived on the scene since the early 1990s. The DL, in a very short time, has proven itself to be the ideal soft-tissue handpiece.[5] The DL is a solid-state semiconductor laser that generally uses a combination of Gallium (Ga), Arsenide (Ar) and other elements such as Aluminium (Al) and Indium (In) to change electrical energy into light energy. The wavelength ranges from about 800 to 980 nm. It is emitted in continuous-wave and gated-pulsed modes and is usually operated in a contact method using a flexible fibre optic delivery system.

Laser light at 800–980 nm is poorly absorbed in water but highly absorbed in haemoglobin (Hb) and other pigments [Figure 1]. Since the DL basically does not interact with dental hard tissues but is an excellent as soft-tissue surgical laser, indicated for cutting and coagulating gingiva and oral mucosa, and for soft-tissue curettage or sulcular debridement.

Search strategy

The articles reviewed were from PubMed, Trip Database, Google scholar and Cocharane database; relevant studies were identified from January 1987 to July 2017. The MeSH terms used were ‘lasers, semiconductor’ (MeSH Terms) OR (‘lasers’ [All Fields] AND ‘semiconductor’ [All Fields]) OR ‘semiconductor lasers’ (All Fields) OR (‘diode’ [All Fields] AND ‘laser’ [All Fields]) OR ‘diode laser’ [All Fields]) AND (periodontal [All Fields] AND (‘therapy’ [Subheading] OR ‘therapy’ [All Fields] OR ‘treatment’ [All Fields] OR ‘therapeutics’ [MeSH Terms] OR ‘therapeutics’ [All Fields]. Only randomised control trials (RCTs), clinical control trial, systematic review and meta-analysis were included as evidences in this review. *In vitro* studies, animal studies and case reports were excluded.

Discussion

Many of these lasers have been shown to provide periodontal treatment benefits [Table 1]. To achieve an element of clarity and simplicity on this very complex topic, the following discussion exclusively addresses the use of the DL for periodontal treatment [Table 2].

In scaling and root planning

The use of DL is one of the most promising new technical modalities for nonsurgical periodontal treatment and has an advantage of reaching sites that cannot be approached by conventional mechanical instrumentation.[6] In a randomised, parallel, controlled clinical trial, Saglam *et al*.[7] assessed the clinical and biochemical efficacy of DL as an adjunct to scaling and root planning (SRP) in the treatment of

Table 2: Studies with level of evidence on application of diode laser in periodontics

Study, Year	Type of study	Level of evidence*
Scaling and root planing		
Saglam *et al*., 2014[7]	RCT	1b
Qadri *et al*., 2015[8]	Systematic review	1a
Nguyen *et al*., 2015[9]	RCT	1b
Gupta *et al*., 2016[6]	RCT	1b
Alzoman and Diab, 2016[10]	RCT	1b
Koçak *et al*., 2016[11]	RCT	1b
Hypersensitivity		
Dilsiz *et al*., 2010[12]	Case control study	3b
Yilmaz *et al*., 2011[13]	RCT	1b
Photodynamic therapy		
Birang *et al*., 2015[14]	RCT	1b
Teymouri *et al*., 2016[15]	Clinical trial	1b
Depigmentation		
Suragimath *et al*., 2016[17]	RCT	1b
Gingivectomy		
Sobouti *et al*., 2014[18]	Controlled clinical trial	3b
In crown lengthening		
To *et al*., 2012[19]	RCT	1b
Ize-Iyamu *et al*., 2014[20]	RCT	1b
Operculactomy		
Sabra *et al*., 2014[22]	Case control study	3b
Sripathi Rao *et al*., 2016[23]	RCT	1b
Frenectomy		
Patel *et al*., 2015[25]	RCT	1b
Gandhi and Gandhi, 2017[26]	Case control study	3b
Open flap surgery		
Lobo and Pol, 2015[28]	RCT	3b
Aena *et al*., 2015[29]	RCT	1b
Peri implantitis		
Papadopoulos *et al*., 2015[31]	RCT	1b
Arısan V *et al*., 2015[32]	Systematic review	1a

*According to Centre for Evidence-Based Medicine. RCT: Randomized control trial

chronic periodontitis (CP). The 6-month follow-up results showed a significant reduction in plaque Index (PI), gingival index (GI), bleeding on probing, probing pocket depth (PPD) and clinical attachment level (CAL) in patients treated with SRP and DL therapy as compared with patients who received SRP alone.

A systematic review conducted by Qadri *et al*.[8] concluded that treatment of CP patients with probing the depth of ≥5 mm was more effective in DL s and SRP plus DL (800–980 nm) group as compared to SRP group alone. In contrast, Nguyen *et al*.[9] found that adjunctive use of the DL to SRP did not enhance clinical outcomes compared to SRP alone in the treatment of inflamed sites with ≥5 mm probing depth.

Gupta *et al*.[6] evaluated the effectiveness of DL on PI, GI, PPD and CAL and microbial count in CP patients and compared the outcome with SRP alone. He stated that the DL at a higher, but clinically safe frequency (940 nm) at repeated intervals showed a better efficacy in ensuring a better periodontal heath as compared to SRP alone. Alzoman and Diab[10] in a RCT showed the reduction in the percentage of *Porphyromonas gingivalis*-positive sites in the SRP + DL group after laser irradiation. Koçak *et al*.[11] evaluated effect of non-surgical periodontal therapy with/without DL on clinical parameters, the levels of interleukin-1β (IL-1β), IL-6, IL-8, intercellular adhesion molecule and vascular cell adhesion molecule in gingival crevicular fluid and metabolic control (HbA1c) in CP patients with diabetes mellitus type 2 (DM2). The SRP + DL group provided better result in relation to clinical and immunological parameters. SRP especially in combination with DL shows improvement of glycemic control for DM2 patients with CP.

In desensitisation

Dentine hypersensitivity (DH) is a common painful clinical problem arising from exposed dentine which can be as a result of the gingival recession, periodontal treatment such as scaling, root planing and also improper tooth brushing, which cannot be attributed to any other dental pathology. Dilsiz *et al*.[12] randomly divided into two groups: the test group, which received treatment with desensitiser toothpaste and GaAlAs (diode) laser, and the control group, treated with desensitiser toothpaste. The result showed a higher degree of desensitisation in teeth with gingival recession in the test group than did the control group. Yilmaz *et al*.[13] concluded that GaAlAs laser irradiation was effective in the treatment of DH, and it is a more comfortable and faster procedure than traditional DH treatment.

In photodynamic therapy

The presence of bacterial biofilms is the major cause of gingivitis and periodontitis, their mechanical removal is not often enough. Therefore, laser therapy (LT) and photodynamic therapy (PDT) can be effective as adjunctive treatment. Birang *et al*.[14] did a study to compare SRP alone with an adjunct to LT and PDT and found that adjunctive LT or PDT shows more improvement in term of CAL gain compared to SRP alone (3 months follow-up). Regarding PPD reduction, adjunctive LT was more efficient than adjunctive PDT or SRP alone ($P < 0.05$) A similar study done by Teymouri *et al*.[15] concluded that laser and PDT reduces the inflammatory mediators (IL-1β and IL-17) and improves the clinical symptoms (PPD and CAL).

In depigmentation

Among the various techniques for depigmentation, lasers offer a promising therapeutic option since it is simple, painless due to formation of protein coagulum and leaves blood less field by sealing small blood and lymphatic vessels as a result of the heat generation. Another hypothesis for painless procedure was that there may be an increase in pain threshold after LT resulting in

neural blockade, specifically inhibition of A and C neural fibres. This inhibition may be mediated by altering the axonal flow or by inhibiting neural enzymes). In addition, data suggest an increase in endorphin production and opioid receptor binding through opioid containing leucocytes.[16] In a RCT (2016),[17] the authors found the clinical efficacy of gingival depigmentation procedure was effective with both scalpel and laser techniques. However, the laser treated sites showed reduced pain experienced by the patient and better operator comfort. Slight melanin repigmentation was observed in three subjects treated with scalpel depigmentation procedure at the end of 1 year.

In gingivectomy

Poor oral hygiene induced inflammatory hyperplasia and/or altered passive eruption can affect several key elements of the smile such as tooth proportionality, proper gingival architecture, and even gingival display on smiling. The excision created by a soft-tissue DL can be more precise, with sterilising the wound, maintaining a clearer and clean surgical field when compared with using a scalpel. This finding was refuted by Sobouti *et al*.[18] in their study.

In crown lengthening

Periodontal tissues should be prepared properly before restorative treatment to ensure good form, function, and aesthetics of the masticatory apparatus, as well as patient comfort. To *et al*.[19] compared the effectiveness of the DL gingivectomy as an adjunct to nonsurgical periodontal treatment in the management of periodontal health among patients receiving fixed orthodontic appliance therapy (FOAT) and concluded that both treatments can be effective in the management of gingival health problems among patients receiving FOAT but, the adjunctive use of lasers can produce an earlier and greater improvement in gingival health. Ize-Iyamu *et al*.[20] conducted an RCT and reported that orthodontic patients treated with the DL required less infiltration anaesthesia, had reduced bleeding during and after surgery, rapid post-operative haemostasis, elimination of the need for sutures and an improved post-operative comfort and healing.

In operculactomy

The laser is a less-invasive method for operculectomy compared with the conventional techniques because it produces little cell destruction and less bleeding due to its haemostatic properties and requires the patient a reduced number of sessions and less chairside time for the most applications.[21] Sabra[22] conducted a clinical study comparing healing process of impacted mandibular molar after removal of the pericoronal flap with surgical knife and DL. Healing increased in surgical knife group as 48%, 64%, 72% and 84% and in DL group as 60%, 72%, 80% and 96% on the 1st, 3rd, 5th and 7th day, respectively. Laser method showed faster elimination of pericoronitis symptoms and enhanced the healing process of soft tissues. Sripathi Rao *et al*.[23] concluded that The use of DL in excision of operculum has several advantages over surgical knife such as enhanced haemostasis, less post-operative pain and a better post-operative healing.

In frenectomy

An aberrant frenum encroaches the gingival health when it is attached too closely to the gingival margin, either due to interference in the plaque control or due to a muscle pull. DLs are used to treat such conditions to overcome the disadvantage of conventional therapy which includes post-surgical pain and discomfort, which is further aggravated when sutures come in contact with food. A clinical study of 25 patients, reported the lack of swelling, bleeding, pain or scar tissue formation with good wound healing and overall satisfaction after 4 weeks of follow up in the clinical application of laser-assisted frenectomy.[24] Patel *et al*.[25] in a RCT reported the degree of post-operative pain and healing experienced by patients during frenectomy procedure with surgical scalpel and DL. Results showed that patients treated with the DL had less post-operative pain and required fewer analgesics as compared to patients treated with the conventional scalpel technique. Wound healing at the 7th day and after 1 month for both the groups showed statistical significant difference with better outcome in laser group. Gandhi and Gandhi[26] compared the results of scalpel, electrocautery and DL in the treatment of frenectomy indicated that patients treated with the DL had less post-operative pain and required fewer analgesics. Wound healing at 7th day and after 1 month for all the groups showed statistical significant difference with better outcome in DL group.

In open flap surgery

Lasers have several potential benefits such as antibacterial effect and stimulation of wound healing. In addition, haemostasis and delaying epithelial migration may facilitate the outcome of flap surgery. In a clinical and microbiological study, DL was used as an adjunct to open flap debridement**.** The bactericidal effect of the DL was clearly evident by greater reduction of colony forming unit of obligate anaerobes in the test group than in the control group.[27] In an another randomised trial, Lobo and Pol[28] concluded that, the DL can be safely and effectively used as an adjunct to the treatment of CP with the advantage of decreased gingival inflammation. Aena *et al*.,[29] in a randomised clinical trial reported that the use of an 810 nm DL provided additional benefits to Modified Widman Flap surgery in terms of clinical parameters such as papillary, bleeding Index and gain in CAL at 6 and 9 months.

In peri-implantitis

Peri implantitis is an inflammatory disease that affects both hard and soft tissue and contributes to a progressive bone loss beyond the biologic remodeling around a functioning implant.[30] Papadopoulos *et al*. (2015)[31] stated that surgical treatment of peri-implantitis by access flaps leads to improvement of all clinical parameters studied while the additional use of DL does not seem to have an extra beneficiary effect. Arısan V *et al*.[32] in a clinical trial concluded that adjunct use of DL did not yield any additional positive influence on the peri-implant healing compared with conventional scaling alone.

Low-level laser therapy

Low-level LT (LLLT) is a light source treatment that generates light of a single wavelength. The output powers range from 50 to 500 mW with wavelengths in the red and near infrared of the electromagnetic spectrum (630–980 nm) with pulsed or continuous-wave emission. The low-level lasers do not cause temperature elevation within the tissue, but rather produce their effects from photo biostimulation effect within the tissues. Laser enhanced biostimulation has been reported to induce intracellular metabolic changes, resulting in faster cell division, proliferation rate, migration of fibroblasts and rapid matrix production.[33]

Low level lasers do not cut or ablate the tissue. LLLT devices include the gallium arsenide, gallium aluminium arsenide infrared semiconductor (gallium-aluminium-arsenide), and helium-neon lasers. The application of LLLT has become popular in a variety of clinical applications in periodontics including promotion of wound healing and reduction of pain and bone regeneration following non-surgical[34,35] and surgical procedures (Amorim *et al*., 2006).[36]

Conclusion

The vivid use of DL in periodontology has led to a different approach to the treatment aspect for periodontal disease ranging from prophylaxis to treating advanced periodontal disease. There has been enough evidence on scaling and root planing. PDT, crown lengthening, open flap debridement, frenectomy and periimplantits. However, there is still a need for more data for the procedure such as gingivectomy and operculactomy. In general, the assessment and use of the DL could explore further benefits of the intervention in periodontal disease; which may pave the way for future research in this subject.

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Conflicts of interest

There are no conflicts of interest.

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