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Original Research

Application of lasers in periodontal therapy

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ABSTRACT:
The launch of the first 'dental' laser, there was a lot of hype that led to confusion and frustration for dentists and researchers who then discredited or minimised many of the claims for clinical use. Unlike many fields of medicine and surgery, where laser treatment represents a sole source of remedy, in dentistry the use of a laser is considered adjunctive to many treatment modalities.[1]
One of the most challenging aspects for a dental professional in general practice is the delivery of appropriate dental care to a patient whose willingness is often compromised as the patient erroneously associates dental treatment with painful stimulus.
Most patients recoil at the thought of a high or low speed drill and those exposed to surgery find that the associated bleeding and tissue bruising interferes with normal speech and eating functions. Much of the hype surrounding laser use in dentistry has centred around the possibility to encourage patient uptake through the avoidance of peri and post-operative pain and discomfort. Certainly, today's lasers offer an opportunity to deliver hard and soft tissue treatments that, at least in outline, make the patient experience somewhat easier. [1] This review on the application of laser in periodontal therapy explore the history and development of lasers, provide a knowledge on the currently available laser wavelengths and devices, the integration of lasers into clinical periodontology and the published evidence of their performance with regards to various hard and soft tissue applications for the same.
Keyword: Laser, Nd:YAG laser, Application of laser in Non-surgical and surgical therapy, Laser-Assisted Treatment of Peri-Implantitis.

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INTRODUCTION

We have encountered in history of science, with a phenomenon such as laser invention which has attracted all people attention and reach of human dreams into reality. Currently laser is one of the most useful tools need in life. The use of laser in dentistry has been developed over the last three decades. Initially it was introduced as an alternative to traditional halogen curing light but now it has become the instrument of choice in many dental applications. Lasers are often propagated for their use in periodontal therapy. The use of lasers becomes more complicated when it comes to periodontal therapy because the periodontium consists of both hard and soft tissues.

HISTORY

Base on **Albert Einstein's** theory of spontaneous and stimulated emission of radiation, **Maiman** developed the first laser prototype in 1960. **Charles Townes** coined the term **'Laser'** which acronym for "light amplification by stimulated emission of radiation" in 1951. 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. Shortly thereafter, in **1961, Snitzer** published the prototype for the Nd:YAG laser. The first application of a laser to dental tissue was reported by **Goldman et al** and **Stern** and **Sognnaes.**[2]
The penetration of lasers in dentistry has seen a spectacular evolution, in comparison with other areas

of medicine, in which, a decade earlier, laser was already a consecrated instrument. Lasers such as the Er:YAG, Nd:YAG, Diode and CO2 are available for dental application. The subject of lasers in periodontics now encompasses a rapidly increasing and significant volume of published literature.

Despite the large number of publications, there is still controversy among clinicians regarding the application of dental lasers to the treatment of periodontal diseases. [3]

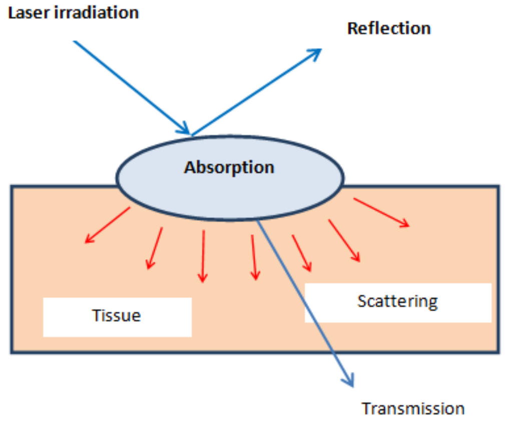
MECHANISIM AND TISSUE INTERACTION OF LASER

Laser can concentrate light energy and exert a strong effect, targeting tissue at an energy level much lower than natural light. The wave length of laser determines its characteristics. Once in contact with tissue, laser energy is reflected, scattered, absorbed, or transmitted to the neighbouring tissues. The water molecules, proteins, pigments, and other macromolecules present in biologic tissue are responsible for absorption, but absorption coefficient actually depends on the wavelength of the incoming laser irradiation.[4]

Pick RM et al, 1993 [1] suggested that CO2 and Nd:YAG lasers can be used for frenectomies, ablation of lesions, incisional and excisional biopsies, gingivectomies, gingivoplasties, soft tissue tuberosity reductions, operculum removal, coagulation of graft donor sites, and certain crown lengthening procedures. The advantages of lasers include a relatively bloodless surgical and post-surgical course, minimal swelling and scarring. Also there is better coagulation, vaporization and cutting, minimal or no suturing; reduction in surgical time and in a majority of cases much less or no post-surgical pain. Also, they observed that the CO2 lasers, compared to Nd:YAG lasers are faster for most procedures, with less depth of tissue penetration and a well-documented history .

Furthermore, **Gold SI et al, 1994** [5] conducted a study to evaluate the efficacy of a low-power pulsed laser for the removal of pocket lining epithelium in humans with moderate periodontitis. Twenty four specimens of gingival tissue, from 6 patients, were studied microscopically following the application of a pulsed Nd:YAG laser (1064 nm). Most sections (83%) exhibited complete removal of epithelium except for traces of viable basal cell remnants at the coronal sulcular margin (17%). The results of this study supported the concept that the Nd:YAG laser used at 1.25 to 1.75W can effectively remove pocket lining epithelium without damaging the underlying connective tissue at the light microscopic level.

Fig.1 –Effects of laser irradiation on tissues.



BENEFITS OF LASER-TISSUE INTERACTION

A number of benefits of laser use in the treatment of soft and hard tissue can be listed as follows [1] ;

SOFT TISSUE

- Ability to cut, coagulate, ablate or vaporise target tissue elements
- Sealing of small blood vessels (dry field of surgery)
- Sealing of small lymphatic vessels (reduced post-operative oedema)
- Sterilising of tissue (due to heat build-up and production of eschar layer and
- destruction of bacterial forms)
- Decreased post-operative tissue shrinkage (decreased amount of scarring).

HARD TISSUE

- Ability to selectively ablate carious dental tissue (faster ablation due to higher water content)
- Reduced peri-operative cracking compared to rotary instrumentation
- Scope for minimally-invasive restorative treatment of early caries
- Reduced pulpal temperature rise
- Cavity sterilisation.

LIMITATIONS OF LASERS

- High financial cost of a laser apparatus is a significant barrier for laser utilization by periodontists.
- Additional training is required for the clinician as well as for the auxiliary staff for safe and efficient use of dental laser
- Each laser has different characteristics because of their different wavelengths. Thus, it is necessary for laser users to know the fundamental characteristics of each laser.
- Improper irradiation of teeth and periodontal pockets by lasers can damage the tooth and root surfaces as well as the attachment apparatus at the bottom of the pocket. Possible damage to the underlying bone and dental pulp should also be considered.

- Presently available dental lasers only emit energy from the tip of the delivery system; and, in that sense, they are all "end cutting," which usually means a modification of the practitioner's clinical technique.
- Clinician must prevent overheating the tissue and guard against the possibility of surgically produced air embolisms that could be produced by excessive pressure of air and water spray used during the procedure.
- Formation of the laser plume during ablation of the soft tissue leads to increased non beam risks for the operator.
- The use of laser subjects the operator to various laser beam risks such as optical hazards.
- For the use of lasers, a separate controlled area/room is required.

APPLICATION OF LASER IN PERIODONTAL THERAPY

The application of lasers in periodontology can be broadly classified into two categories as [6] ;

a) Non-surgical periodontal therapy
b) Surgical periodontal therapy

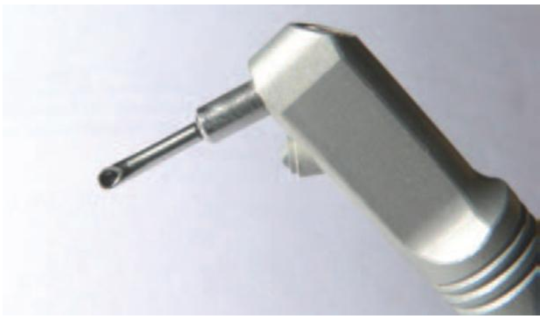
I. NON-SURGICAL PERIODONTAL THERAPY

Conventional treatment for periodontal disease is based on reducing pathogenic microbiota by scaling and root planing.[7] However, mechanical therapy alone may fail to eliminate pathogenic bacteria located in the soft tissues, and also in areas inaccessible to periodontal instruments, such as furcation areas and root depressions.[8] **Aoki A et al, (2004)**[9] reported the benefits of lasers, such as ablation, bactericidal and detoxification effects, as well as photo-biomodification and suggested the use of lasers as an adjunctive or alternative tool to conventional periodontal mechanical therapy.

1) CALCULUS REMOVAL

Er:YAG and Er,Cr:YSGG, together with near-UV wavelengths such as frequency-doubled alexandrite (FDA, 377nm), has given encouragement to the safe use of these lasers in calculus removal. In order to provide access to calculus deposits, specific laser hand-piece tips have been developed for use with the mid-infrared erbium wavelengths (Figure .2). The level of calculus removal by Er:YAG laser is similar to that of ultrasonic scaling, and the depth of cementum ablation has been generally reported to be around 15–30μm when the contact tip is applied obliquely to the root surface.[9]

Figure 2: Angled tip for use with Er:YAG laser in calculus removal .



2) ROOT SURFACE TREATMENT

Morlock BJ et al, (1992) reported that with Nd:YAG laser, surface pitting and crater formation with charring, carbonization, melting and crater production after irradiation was observed in vivo.[10] Although the Nd:YAG laser-treated root surface appears to be unfavourable for fibroblast attachment in vitro, the alterations of the irradiated surface are reversible, and additional root treatment, such as root planing or polishing, can restore the biocompatibility of the root surface.

3) BACTERICIDICAL AND DETOXIFICATION EFFECTS

Ando A and Aoki A, (1996)[11] demonstrated significant reduction in the activity of both Porphyromonas gingivalis and Aggregatibacter actinomycetemcomitans using the Erbium family of lasers. **Neill ME and Mellonig JT (1997)**[12] compared the clinical efficacy of Nd:YAG laser to scaling and root planing. The authors observed that the gingival inflammation and the levels of Porphyromonas gingivalis and Prevotella intermedia continued to be subdued as compared to the scaling root planing group at 3 months.

4) PERIODONTAL POCKET TREATMENT

The laser probe or fibre is measured to a distance of one to two millimetres short of the pocket depth and is inserted at an angle to maintain contact with the soft tissue wall at all times. Using laser power values sufficient to ablate the epithelial lining (approximately 0.8W CW diode, 100 mJ/20 pps, 2.0W Nd:YAG and Er:YAG/YSGG, 1.0W CW CO_2), the laser probe is used in a light contact, sweeping mode to cover the entire soft tissue lining. Ablation should commence near the base of the pocket and proceed upwards, by slowly removing the probe from the pocket.[1] **Gold & Vilardi (1994)** reported the safe application of the Nd:YAG laser (1.25 and 1.75W, 20Hz) for removal of the pocket-lining epithelium in periodontal pockets without causing necrosis or carbonization of the underlying connective tissue in vivo.[5] the adjunctive application of Nd:YAG laser irradiation to conventional scaling and root planing resulted in significantly greater improvements in gingival index and bleeding on probing at specific time-points following therapy; however, differences in improvements of attachment level were not observed between groups. -**Neil ME and Melloning JT (1997)** [12]

II. SURGICAL PERIODONTAL THERAPY

A. SOFT TISSUE APPLICATION

a) GINGIVAL SOFT TISSUE PROCEDURES

Gingivectomy, gingivoplasty and frenectomy are the most popular procedures carried out using lasers. When compared to the conventional scalpel, 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.

The thermal effects on teeth and tissues are still a concern when using deeply penetrating types of lasers (shorter wavelengths) such as diode or Nd:YAG. With longer wavelengths (Er,Cr:YSGG, Er:YAG and CO2), tissue penetration is considerably less, but there is potential for char build-up (carbonised products of ablation).[1] With the CO2 laser, the advantages are, rapid and simple vaporization of soft tissues with strong haemostasis, which produces a clear operating field and requires no suturing.[13] Gingival hyperplasia is a typical indication for CO2 laser treatment. The CO2 laser is also effective in performing gingivoplasty for small tissue irregularities seen after periodontal and peri-implant surgery. The deeply penetrating lasers, such as the Nd:YAG and diode lasers, can be used to cut and reshape soft tissues;[14] however, these lasers have greater thermal effects, leaving a relatively thicker coagulation area on the treated surface than the lasers where the light is absorbed in the superficial layers of tissue.[9]

b) AESTHETIC GINGIVAL PROCEDURES

Aesthetic gingival procedures such as crown lengthening and recontouring or reshaping of gingiva can be carried out using lasers. Compared to traditional mechanical instruments, the use of lasers allows for a better control over the depth and amount of soft tissue ablations. Er:YAG laser in particular has been very safe and useful for aesthetic periodontal soft tissue management. Er:YAG laser is capable of precise soft tissue ablation using various fine contact tips and the post-surgical healing is fast and favourable.[9]

c) FRENECTOMY

Gargari M et al, (2012) presented a case report, wherein the authors used a 940nm diode laser for frenectomy procedure with mandibular labial frenum. During the procedure haemostasis was achieved due to use of laser. The authors also reported that the post-operative healing was uneventful and the patient did not experience any post-operative pain or discomfort. [15]

d) SURGICAL DEBRIDEMENT

Centty et al, (1997) in a randomised controlled study, with a split mouth design showed that the CO2 laser (8W and 20Hz) increases the effectiveness of periodontal therapy through an epithelial exclusion technique (guided tissue regeneration) in conjunction with conventional flap surgery procedures. Lasers significantly eliminate more sulcular epithelium in comparison with conventional periodontal surgery.[16]

B) HARD TISSUE APPLICATION

a) OSSEOUS SURGERY

- Bone recountouring and reshaping are often a part of periodontal surgical therapy. The most commonly employed conventional instruments for bone surgery are mechanical rotary.
- In recent years, the use of erbium lasers is becoming increasingly popular for bone surgery. The advantages of lasers over conventional mechanical instruments for bone surgery are as follows [17]:
- More precision and better access than mechanical instruments
- Reduced risk of collateral damage compared to the use of rotary instruments
- Increased comfort of both patients and surgeons by markedly reducing the noise and eliminating the vibration associated with the mechanical cutting and grinding of bone tissue
- Lack of vibration of the handpiece increases surgical precision

Inspite of these advantages over mechanical instruments, there are some disadvantages of laser, which are as follows:

- Reduced cutting efficiency
- Lack of depth control
- Effects of the laser on the surrounding irradiated tissue.

C) APPLICATION OF LASERS IN IMPLANTOLOGY

Surgical lasers can be used in a variety of ways in implantology, such as

- Placement of implant.
- Second stage recovery and gingival management.
- Treatment of peri-implantitis.

a) LASER-ASSISTED OSTEOTOMY SITE PREPARATION

Er:YAG (2940 nm) and Er,Cr:YSGG (2780 nm) are the two lasers in current clinical practice that are used for osseous procedures. In a study of tissue healing by **Kesler et al, (2006)** [18] a 2-mm diameter osteotomy was performed in the tibiae of rats and titanium implants were placed. A histomorphometric analysis was performed using KsLite (Kontron Elektronik, Eching/ München, Germany) image analysis software and the bone-implant contact values were scored. The measured parameter demonstrated greater value of bone-implant contact in the sites prepared with an Er:YAG laser compared to the control.

b) LASER-ASSISTED SECOND-STAGE RECOVERY OF IMPLANTS

Based on laser-tissue interaction characteristics, all laser wavelengths are suitable for the second stage recovery of implants, provided care is exercised to avoid contact with the implant body. The ablation of soft tissue leads to precise and predictable healing and often this procedure can be carried out using topical anaesthesia. The prime advantages of laser use in this procedure would be haemostasis, facilitating easier visual access to the cover screw, production of a protective coagulum as an aid to healing and patient comfort during and after treatment.[19]

c) LASER-ASSISTED THERAPY IN PERI-IMPLANTITIS

Conventional treatment modalities such as the use of mechanical instruments like steel curettes and ultrasonic scalers are not suitable for the removal of granulation tissue and debridement of implant surface because they readily damage the implant titanium surfaces.[20] and thus may interfere with the process of bone healing and re-osseointegration. Thus the use of plastic curettes and carbon fibre curettes, have been recommended.

Table 1: Protocol for Laser-Assisted Treatment of Peri-Implantitis[19]

Step	Considerations
Pre-treatment assessment	Etiological factors – oral hygiene, occlusion, host local and general response factors, smoking. Establishment of cause of infection or trauma.
Access / surgical technique	Debridement of granulation tissue – curette / laser-assisted
Disruption of biofilm	Examples: sodium lauryl sulfate, chlorhexidine, polyhexamethylene biguanide (PHMB), triclosan
Pathogen reduction (part 1)	• Laser wavelength of choice. • Minimal power levels – Average power 0.7 to 1.0 Watt. • Use of water spray. Exposure of treatment site (10 to 15 seconds, repeated with intervals as required (maximum 3 passes)
Pathogen reduction (part 2)	PDT(Photodynamic therapy)
Reestablishment of biocompatibility / new bone growth	Guided bone regeneration procedure/ membrane
Continuing care / maintenance	Professional review/ radiographs/ hygienist/ home care.

CONCLUSION

The application of lasers in periodontology has been recognised as an adjunctive or alternative approach in periodontal and peri-implant therapy. Lasers have been shown to be superior to conventional mechanical treatment in terms of ablation, haemostasis, tissue response, decontamination and reduction of bacterial counts, lesser post-operative pain and better patient acceptance.

Lasers such as CO2, Nd:YAG, Erbium family and diode are safe and efficient for soft tissue surgery like frenectomy, gingivectomy, gingivoplasty, crown lengthening and gingival depigmentation. Laser assisted pocket therapy; root surface debridement and calculus removal are gaining acceptance in the field of periodontics. Lasers for hard tissue application and osseous surgery are considered unsuitable except for Er:YAG laser. Application of lasers in implantology looks promising and further research is still needed to prove its effectiveness. When used efficaciously and ethically, lasers are an exceptional modality of treatment for many clinical conditions that dentists treat on a daily basis. But lasers should not be considered as the "magic wand" that many people have hoped for. It has got its own limitations. Currently the application of lasers in the field of periodontology is being extensively research. The future of the application of laser technology in the management and treatment of various periodontal problems looks promising. Newer treatment modalities and applications are constantly being developed. Clinicians who include lasers in their practice and tend to utilize this technology for patient care are going to benefit clinically and financially. Proper practice management strategies is the key for achieving success.

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