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Review Article

LASERS IN NON-SURGICAL PERIODONTAL THERAPY

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***ABSTRACT*:**
Lasers in dentistry offer a variety of advantages. Because lasers seal blood vessels, they offer a dry operating field and excellent visibility, reducing operative time. In addition, lasers seal lymphatic vessels, which yield minimal post-operative swelling. Lasers offer the ability to negotiate curves and folds in the oral cavity and depending on power settings and mode of delivery; they can vaporize, coagulate, or cut tissue.The use of lasers has become a topic of much interest and is a promising field in periodontal therapy. Science is the search for truth, and it is dynamic and constantly changing; in this regard, it is important that we keep an open mind to emerging technologies and apply therapies that are best for our patients.
Key words: Lasers, Periodontal therapy

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INTRODUCTION

Lasers range from those activated by natural gases, elements, molecules, or man made crystals to those that measure distances to the moon, create laser guided warfare, and record the price of our groceries. Over the past several years, we have seen the strong emergence of lasers in the field of dentistry. Lasers are not, however, new to the field, some of the first reports on in vitro studies, date back to the late 1960's.[1, 2]

Lasers in dentistry offer a variety of advantages. Because lasers seal blood vessels, they offer a dry operating field and excellent visibility, reducing operative time. In addition, lasers seal lymphatic vessels, which yield minimal post operative swelling. Lasers offer the ability to negotiate curves and folds in the oral cavity and depending on power settings and mode of delivery; they can vaporize, coagulate, or cut tissue.[3]

With the use of lasers, pain is reduced-to-absent 90% of the time, probably due to the sealing of nerve fibers. The other 10% of the time, patients will have pain of various intensities and duration. In some procedures, such as the maxillary midline frenectomy, it is almost certain that there will be no post operative pain. Lasers offer little chance for mechanical trauma, they cause minimal scarring and sutures are rarely needed. They cause reduction in bacterial counts, and in some areas they may sterilize the field as well. Therefore, for patients at high risk for bacteremias, the use of lasers may be especially beneficial. The future of dental lasers is bright. Some of the newest ongoing research addresses the use of dental lasers for GTR, connective tissue attachment, and tissue welding. Dental lasers of the future may make incisions, reflect flaps, perform osseous surgery, and weld the flaps into position. Multiple wave lengths (some of them perhaps not yet known) may be incorporated into a single unit.[4, 5]

CLASSIFICATION

Lasers are classified based on the potential of the primary laser beam or the reflected beam to cause biologic damage to the eyes or skin. There are four general classes of lasers; the higher the classification number, the greater the potential hazard. The classes are differentiated by a combination of the output power of continuous emission lasers or energy per pulse for pulsed lasers and the amount of time that the beam is viewed.

Class I

Lasers in this category working under normal operating conditions do not pose a health hazard. These devices usually are totally enclosed, and the beam does not exit the housing. The output power of a class I laser is measured in tenths of milliwatts.

Class II

Lasers in this category emit only visible light with low power output and do not normally pose a hazard because of the normal human blinking and aversion reactions. A supermarket bar code scanner, and some small laser pointers demonstrate this class. The maximum allowable output power of these devices is 1 mW. There are two subclasses:

- Class II a is hazardous when directly viewed for longer than 1000 seconds
- Class II b has a dangerous viewing time of one fourth of a second, which is the length of time of an ordinary blinking reflex.

Class III a

Lasers in this category can emit any wavelength and have output power less than 0.5 W of visible light or approximately 0.1 to 0.2 W in the other portions of the electromagnetic spectrum. In this class, when the laser light is viewed only momentarily (within the aversion response period or blinking reflex—one-fourth of a second), it will not harm the unprotected eye. These lasers have a caution label on them.

Class III b

These lasers can produce a hazard to the unprotected eye if viewed directly or viewed from reflective light for any duration. The output power can be no greater than 0.5 W of any electromagnetic radiation. Class III b lasers will not cause reflective hazards when using matted (not shiny) surfaces and do not normally produce fire hazards. An argon curing laser, only if set at less than 0.5 W, would exemplify this type of device. Low-level therapeutic lasers would be class III a or class III b, depending on the emission wavelength and the duration of exposure. Because these lasers usually have dental treatment time measured in minutes, eye protection must be used.

Class IV

This category of lasers is hazardous from direct viewing and may produce hazardous diffuse reflections. Any output power greater than 0.5 W measured in either continuous wave or pulsed emission constitutes a class IV laser. These devices also produce fire and skin hazards. The lasers presently used in dentistry are class III b or class IV; therefore, they present the possibility of serious eye and skin damage. Class IV lasers also may ignite flammable objects (such as alcohol-moistened gauze) and may create hazardous airborne contaminants. It must be emphasized that the human blinking and aversion reflexes will not serve as eye protection when using dental laser instruments.[6-9]

APPLICATION OF LASER IN PERIODONTAL THERAPY

The history of laser therapy as applied to periodontics began in the early 1960's with the development of the argon, carbon dioxide and Nd: YAG laser. In 1965, Kinersly et al reported the possibility of removing dental calculus by ruby laser. However they warned that the limiting vaporization selectively to calculus without damaging the underlying tooth might present clinical problems. Both soft and hard tissues are always targeted while using lasers for the treatment of periodontal lesions. The commonly used high power laser CO2 and Nd: YAG is capable of excellent soft tissue ablation and has adequate haemostatic effect. Until the beginning of the 1990's the use of laser systems in periodontal therapy was limited to soft tissue procedure such as gingivectomy and frenectomy as application to periodontal hard tissue had previously proved to be clinically unpromising.[6]

In the early and mid 1990's the scientific research began on root surface debridement and pocket curettage using ND: YAG laser. Meanwhile Hibst et al 1988 and Keller et al 1989 reported the possibility of dental hard tissue ablation by Er: YAG laser irradiation which is highly absorbed by water. Later in mid 1990's Aoki et al and Keller et al began investigate the application of Er:YAG laser for periodontal hard tissue procedure such as dental calculus removal and decontamination of diseased root surface .application of ER:YAG for bone surgery has also been studied in vitro and in vivo. Development of this laser brought the prospect of hard tissue treatment in periodontics, operative dentistry including pediatric density ND: YAG, CO2, diodes, ER CR: YSGG, argon and excimer and alexandrite are also being used.[7]

Development of this laser brought the prospect of hard tissue treatment in periodontics. The diode lasers as well as Nd:YAG lasers are currently used for pocket curettage by clinicians because of their flexible fiber delivery system, which is suitable for pocket insertion.

However, to date, there is a shortage of basic and clinical research providing scientific support for these procedures. In the field of dentistry, Nd:YAG, CO2, diodes, Er: YAG, Er,Cr:YSGG, Argon, excimer and alexandrite lasers are being studied in vitro or are in clinical use.[8]

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However, they warned that limiting the vaporization selectively to calculus without damaging the underlying tooth might present clinical problems. Since the periodontium is composed of gingiva, periodontal ligament, cementum, and alveolar bone, both soft and hard tissues are always targeted when using lasers for the treatment of periodontal lesions. The commonly used high power lasers CO2 and Nd:YAG are capable of excellent soft tissue ablation, and have an adequate haemostatic effect.[11]

Until the beginning of the 1990s, the use of laser systems in periodontal therapy was limited to soft tissue procedures, such as gingivectomy and frenectomy as application to periodontal hard tissues had previously proved to be clinically unpromising. In the early and mid 1990s, scientific research was begun on root surface debridement and pocket curettage using an Nd:YAG laser. The clinical application of the Nd:YAG laser had already been tried by general practitioners because its convenient, flexible fiber optic delivery system made it appropriate for use in periodontal pockets. Meanwhile, in Hibst et al. 1988 and, in Keller et al 1989 reported the possibility of dental hard tissue ablation by Er: YAG laser irradiation, which is highly absorbed by water. Since then, numerous studies on hard tissue treatment using the Er:YAG laser have indicated the ability of this laser to ablate dental hard tissues and caries lesions without producing major thermal side effects. Promising results in basic and clinical application have been demonstrated in the field of caries therapy. Later, in the mid 1990s, Aoki et al. and Keller et al. began to investigate the application of the Er:YAG laser for periodontal hard tissue procedures, such as dental calculus removal and decontamination of the diseased root surface. A number of basic studies on Er:YAG laser application to root surface treatment followed and, recently, promising results have been reported in clinical studies on nonsurgical pocket therapy. Application of the Er:YAG laser for bone surgery has been also studied in vitro and in vivo.[12- 14]

Development of this laser brought the prospect of hard tissue treatment in periodontics. The diode lasers as well as Nd:YAG lasers are currently used for pocket curettage by clinicians because of their flexible fiber delivery system, which is suitable for pocket insertion. However, to date, there is a shortage of basic and clinical research providing scientific support for these procedures. In the field of dentistry, Nd:YAG, CO2, diodes, Er: YAG, Er,Cr:YSGG, Argon, excimer and alexandrite lasers are being studied in vitro or are in clinical use.[15- 17]

MECHANISM OF ACTION

Lasers are also used for soft tissue periodontal applications. The Nd: YAG was the first laser wavelength to be compared to the scalpel for treating periodontal pocketsand controlling bacteremia and gingival bleeding. The probing pocket depth and bleeding index scores were reduced using the pulsed Nd: YAG laser. Furthermore, clinical evaluation of soft tissue biopsies taken from human subjects using the Nd: YAG laser versus a curette presented a complete removal of the epithelium of the pocket after use of the pulsed Nd: YAG laser compared to the curette. Similar effects presented in pig jaws (in vitro) after the use of a 980 nm diode laser with 2–4 W power settings and continuous wave compared to the conventional curette.

There are advantages in the postsurgical outcomes with the removal of pocket epithelium. A recent clinical study in India showed that the modified Widman flap with removal of the pocket epithelium was more effective in reducing mean probing depth compared to access flap with intrasulcular incision. It showed greater gain of clinical attachment and demonstrated less gingival recession.

When deep periodontal pockets are present, removal of the pocket epithelium using a glass laser fiberoptic offers benefits. With or without flap elevation and a conventional periodontal access flap procedure, the pocket epithelium will be removed from the inner and the outer part of the pocket. Depending on how the patient heals, the epithelium can later be ablated every 7–10 days from the outer part of the pocket, usually under the use of topical anesthesia, in order to control apical migration. This can result in long-term, stable connective tissue attachment, without gingival recession.[12- 16]

USE OF LASER IN NON-SURGICAL PERIODONTAL THERAPY

The initial and most important stage of periodontal therapy is the nonsurgical mechanical debridement of periodontally diseased root surfaces. The use of lasers is in three areas of treatment

- Removal of calculus deposits and root surface detoxification.
- Removal of diseased pocket lining epithelium
- Bactericidal effect of lasers on pocket organisms[18]

In periodontal pockets, the root surfaces are contaminated with an accumulation of plaque and calculus,as well as infiltration of bacteria and bacterial endotoxins into cementum .Complete removal of these harmful substances is essential for the healing of periodontal tissue. As lasers can achieve excellent tissue ablation with strong bactericidal and detoxification effects, they are one of the most promising new technical modalities for nonsurgical periodontal treatment. Another advantage of lasers is that they can reach sites that conventional mechanical instrumentation cannot. Laser irradiation has been reported to exhibit bactericidal and detoxification effects without producing a smear layer, and the laser treated root surface may therefore provide favorable conditions for the attachment of periodontal tissue.[19]

STUDIES ON CALCULUS REMOVAL

Fluorescence emission measurements on samples exhibiting calculus and dentin were performed. The fluorescence measurements revealed that calculus favorably absorbs wavelengths up to 420 nm and that dentin is much less absorbing in that wavelength spectrum.A window of wavelengths for selective ablation of calculus was found, demonstrating its benefits.[20]

Histological investigations were performed on teeth extracted due to severe periodontitis and on freshly surgically removed impacted third molars. Light microscopic evaluations revealed that selective calculus removal is possible using a laser (Rechmann et al 2002). The experiments revealed that dark-coloredsubgingival and light-coloredsupragingival deposits are easily removed. Moreover, experiments showed that bacteria-laden microbial plaque could easily be removed with laser providing an additional hint that bacteria might be the main absorbing agent.[21]

Total calculus removal was demonstrated using electron microscopic studies at the higher magnification in previous studies. Scanning electron microscope examination revealed that the low Nd:YAG laser energy levels did not cause any heat damage to the root surface, but failed to improve the clinical and microbiological parameters of periodontal disease as compared to scaling and root planing. Previous authors compared the in vivo effects of conventional scaling plus Nd:YAG laser at 0.8–1.5 W (100 mJ/pulse, 8–15 Hz) treatment with those of scaling alone on root cementum and levels of periodontopathic bacteria in 150 sites from 14 patients. The post-treatment reduction of levels of periodontopathic bacteria in the conventional scaling followed by laser treatment group was significantly greater than the scaling alone control. However, scanning electron microscope examination of the specimens treated with the Nd:YAG laser exhibited different root surface alterations.[22, 23]

More recent studies of the biocompatibility of CO2 laser–treated surfaces, even when used at low energy densities, have yielded conflicting results.Other in vitro studies have reported a lack of positive effect on attachment of periodontal ligament cells to root surfaces following low-level irradiation (1Wfor 20 seconds) with the GaAlAs diode laser Kreisler et al 2001 or detrimental ultrastructural changes that could potentially lead to disturbances in collagen synthesis. Despite these reports another group of authors reported that low-level irradiation with the GaAlAs diode laser (10mWfor 75, 150, and 300 seconds) had a stimulatory effect on the proliferation of periodontal ligament fibroblasts in vitro. Given the findings of these studies, one might conclude that differing levels of power and times of exposure produce different interactive results that, in turn, indicate an irradiation threshold above which cell damage is likely to occur.[24, 25]

Previous authors performed Nd:YAG laser irradiation to the periodontally diseased root surface of extracted teeth, and reported that the Nd:YAG laser at 0.3–0.5 W (30–50 mJ/pulse, 10 Hz,2–4 s) could inactivate the endotoxin in the superficial layer of the root surface. Previous authors explored the in vitro effectiveness of the Nd:YAG laser for the elimination of cementum-bound endotoxin by measuring interleukin (IL)-1b changes in stimulated monocytes. Nd:YAG laser varying between 50 mJ/ pulse and 10 Hz and 150 mJ/pulse and 20 Hz for 2 min did not seem to be effective in destroying diseased cementum endotoxin. Previous authors compared subgingival application of the Nd:YAG laser with conventional scaling and root planing. The subgingival application with the Nd:YAG laser was equally or more effective than scaling and root planing in reducing or inhibiting recolonization of specific bacterial species.[25]

Another set of authors compared the effectiveness of the Nd:YAG and CO2 laser treatment to that of ultrasonic scaling in periodontal pockets of chronic periodontitis patients. The 41 sites of 18 patients were randomly assigned for treatment with the Nd:YAG laser alone the CO2 laser alone or ultrasonic scaling alone. Decreased inflammation and probing depth were observed in all three groups after treatment. There were significant decreases in both Porphyromonasgingivalis and the amount of gingival crevicular fluid in the Nd:YAG and scaling groups. The Nd:YAG group also showed a decrease in IL-1 level.[26]

Another set of authors performed Nd:YAG laser curettage in vivo, and studied microscopically 24 specimens of gingival tissue from six patients following the laser application at 1.25 and 1.75 W (62.5 and 87.5 mJ/ pulse, 20 Hz). The pulsed Nd:YAG laser removed pocket-lining epithelium in moderately deep periodontal pockets without causing necrosis or carbonization of the underlying connective tissue. Another set of authors performed a double-blind, randomized, controlled clinical trial for sulcular debridement on 186 teeth from 10 patients using a split-mouth design to compare the adjunctive use of the pulsed Nd:YAG laser at 2 W (80 mJ/pulse, 25 Hz) to scaling and root planing alone in the nonsurgical treatment of moderate to advanced adult periodontitis. The reduction of probing depth for 6 months after treatment was similar between the scaling and root planing plus laser therapy and scaling and root planing alone, but the scaling and root planing plus laser therapy showed significantly greater improvements in gingival index and gingival bleeding index at specific time points.[26- 28]

LOW-LEVEL LASER THERAPY

A number of applications of low-level laser light have emerged, which utilise either the specific wavelength/chromophore relationship, or the inherent accuracy of a collimated beam. The most significant uses are listed as follows:

- Photobiostimulation
- Composite resin curing
- Caries detection
- Photo-activated disinfection (PAD)
- Laser scanning (restorative dentistry,orthodontics)[29]

Low-level laser therapy (photobiostimulation) involves the use of visible red and near-infrared light with tissue in order to stimulate and improve healing, as well as reduce pain. The incident wavelength determines the effect – visible light is transmitted through the superficial cellular layers (eg the dermis, epidermis and the subcutaneous tissue). Light waves in the near-infrared ranges potentially penetrate several millimetres and these wavelengths are used to stimulate deep cellular function. Light energy is absorbed within living tissue by cellular photoreceptors, egcytochromophores. The incident electromagnetic energy is converted by cellular mitochondria into ATP (adenosine tri-phosphate),a product of cytochrome c-oxidase activity and the Krebs cycle. Consequently, the stimulated increase in ATP production would suggest an increased cellular activity in eg fibroblasts, involved in tissue healing. In addition, the conversion of some of the incident energy into heat would suggest an increase in local micro-circulation through vasodilation.[28- 30]

The stimulatory effects of LLLT include the following:

- Proliferation of macrophages
- Proliferation of lymphocytes
- Proliferation of fibroblasts
- Proliferation of endothelial cells
- Proliferation of keratinocytes
- Increased cell respiration/ATP synthesis
- Release of growth factors and other cytokines
- Transformation of fibroblasts into myofibroblasts
- Collagen synthesis

The use of LLLT helps to control the symptoms and condition of periodontitis. The anti-inflammatory effect slows or stops the deterioration of periodontal tissues and reduces the swelling to facilitate the hygiene in conjunction with other scaling, root planning, curettage, or surgical treatment. As a result, there is an accelerated healing and less post-op discomfort. Studies report stimulation of human periodontal fibroblasts, reduced gingivitis index, pocket depth, plaque index, gingival fluid, and metalloproteinase-8 levels, and there are positive results after gingivectomies. In the latter study, biometrical evaluation showed improvement of healing for the period of 21 and 28 days in the lased group. Clinical evaluation showed better reparation mainly after the third day for the active group.[30- 32]

Advantages of using lasers in the periodontal therapy include

- Less pain
- Less need for anesthetics (an advantage for medically compromised patients)
- No risk of bacteremia

- Excellent wound healing; no scar tissue formation
- Bleeding control (dependent on the wavelength and power settings);
- Usually no need for sutures
- Use of fewer instruments and materials and no need for autoclaving (economic advantages)
- Ability to remove both hard and soft tissues
- Lasers can be used in combination with scalpels (however, the laser is a tool and not a panacea).

Disadvantages of using lasers

- Relatively high cost of the devices
- A need for additional education (especially in basic physics)
- Every wavelength has different properties
- The need for implementation of safety measures (i.e. goggle use, etc.)[10-16]

CONCLUSION

The use of lasers has become a topic of much interest and is a promising field in periodontal therapy. A laser is an expensive capital equipment purchase and dentists must do their own research to determine n e which laser wavelength and manufacturer will meet the needs of their practice, their patients, and their pocketbook. Science is the search for truth, and it is dynamic and constantly changing; in this regard, it is important that we keep an open mind to emerging technologies and apply therapies that are best for our patients.

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