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LASERS IN PERIODONTICS: REVIEW OF THE LITERATURE

By

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A thesis submitted to the Faculty of the
Orofacial Pain Graduate Program
Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
in partial fulfillment of the requirements for the degree of
Master of Science
in Oral Biology

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Bethesda, Maryland

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

Alex Smith

has been approved by the Examining Committee for the thesis requirement for the Master of Science degree in Oral Biology at the June 2015 graduation.

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ABSTRACT

Laser in Periodontics: Review of the Literature

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INTRODUCTION: While still considered a new technology, the use of lasers in dentistry is rapidly increasing in use and clinical success. The main question to ask is "Why lasers in Dentistry"? There are several reasons with the most common ones listed as follows: 1) new technology, cutting edge, 2) effective therapy, 3) positive clinical results, 4) economic return, and 5) satisfaction (dentist and patient) - such as minimal anesthesia, good coagulation, reduced pain, minimal swelling, and being able to complete the treatment more rapidly. This paper will focus primarily on the use of lasers in the specialty of periodontics.

OBJECTIVE: Review the evolution of laser technology into the practice of dentistry and more specifically its use in periodontics.

METHODS: Literature Review

RESULTS: Laser technology has been recognized as an adjunctive or alternative approach in periodontal and peri-implant therapy. Among lasers currently available, the Er:YAG laser seems to provide the most suitable characteristics for various types of periodontal treatment.

CONCLUSIONS: Further studies are encouraged to understand in more detail the effects of lasers on biological tissues, including the periodontium, in order to ensure their safe and effective application during periodontal treatment.

INTRODUCTION

While still considered a new technology, the use of lasers in dentistry is rapidly increasing in use and clinical success. With the first laser being developed by Maiman in 1960, numerous improvements and different types of lasers have emerged. The main question to ask is "Why lasers in Dentistry"? There are several reasons with the most common ones listed as follows: 1) new technology, cutting edge, 2) effective therapy, 3) positive clinical results, 4) economic return, and 5) satisfaction(dentist and patient) - such as minimal anesthesia, good coagulation, reduced pain, minimal swelling, and being able to complete the treatment more rapidly. This paper will focus primarily on the use of lasers in the specialty of periodontics.

OVERVIEW OF LASERS

Before any discussion of the specific uses of lasers in periodontics can proceed, a review of the different lasers available and their specifications will be presented. The word LASER is an acronym for light amplification by stimulated emission of radiation. Laser light is a form of electromagnetic radiation with a spectrum ranging from gamma rays to radio waves. Current dental laser wavelengths range between 488 and 10,600nm and are emitted in the form of nonionizing radiation, which, unlike ionizing radiation, is not mutagenic to cellular DNA components. Laser light is distinguished from ordinary light by two key properties. First, laser light is monochromatic and second, each wave of laser light is identical in size and shape. Different laser wavelengths have different absorption coefficients when in contact with different oral tissues; laser energy can be transmitted or absorbed based on the composition of target tissue (1). Depending on the type of wavelength that is emitted by a laser different tissue reactions will occur.

There are currently six types of lasers in use in dentistry today: 1) Argon, 2) CO2, 3) Diode, 4) Erbium, 5) Nd:YAG, and 6) Soft/low level. Each laser emits a different wavelength and each has its own advantages and disadvantages. Lasers are generally classified into two types, depending on their wavelength: first, those whose light penetrates the tissue more deeply (such as Nd:YAG and diode lasers), and second, those whose light is absorbed in the superficial layers(such as CO2 and Erbium lasers)(9). Depending on the penetration depth, the performance of each laser on soft tissue is different. With the CO2 lasers, the advantages are the rapid and simple vaporization of soft tissues with strong hemostasis. This produces a clear operating field and eliminates the need for suturing(10). Gingival hyperplasia is a typical indication for CO2 laser treatment, as well as small tissue irregularities seen after periodontal and peri-implant surgery requiring gingivoplasty. For cutting and reshaping soft tissues both Nd:YAG and diode lasers can be used (5, 11).

Currently lasers are accepted and widely used as a tool for soft tissue management (1, 2, 3). Hemostasis, bacteriocidal properties, and ease of ablation of tissues are some of the advantageous properties of lasers. The most popular procedures carried out using lasers are gingivectomy, gingivoplasty, and frenectomy (4). 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. Laser surgery sometimes does not require any local anesthetic (5). Other advantages of laser surgery that are not observed in scalpel surgery include minimal scarring and minor wound contraction (7). In one study comparing lasers with conventional scalpel surgery, laser surgery produced less pain and morbidity (6). Decreased post-operative pain has been observed by clinicians, but this has not yet been scientifically shown (8).

Lasers can be applied in esthetic procedures such as re-contouring or re-shaping of gingiva and in crown lengthening. The Erbium laser is very safe and useful for esthetic periodontal soft tissue management because this laser is capable of precisely ablating soft tissues using various fine contact tips. In addition, wound healing is fast and favorable owing to minimal thermal alteration of the treated surface (9,12, 13). Depigmentation is also another indication for laser use in esthetic treatments. The CO_2, diode and Nd:YAG lasers have been shown to be effective treatment for melanin pigmentation (14, 15, 16). The CO_2, Nd:YAG, diode, and Erbium lasers are widely accepted as useful tools for esthetic surgery in general (8).

NON-SURGICAL THERAPY

Periodontal treatment requires an interrelationship between the care of the periodontium and other phases of dentistry. The concept of total treatment is based on the elimination of gingival inflammation and the factors that lead to it (eg. plaque accumulation favored by calculus and pocket formation, inadequate restorations, and areas of food impaction). The benefits of lasers, such as ablation, bacteriocidal and detoxification effects, as well as photo-biomodification, have been reported to be useful for periodontal pocket therapy, and the application of lasers has been suggested as an adjuctive or alternative tool to conventional periodontal mechanical therapy(9). Within the periodontal pocket, conventional mechanical therapy by itself does not completely remove bacterial deposits and their toxins from the root surface (18). In addition, access to areas such as furcations and grooves is limited owing to the complicated root anatomy. Furthermore, conventional mechanical debridement using curets is very technically demanding and time-consuming, and power scalers sometimes cause discomfort and stress in patients as a result of noise and vibration. Thus, laser therapy has beneficial significance in periodontal pocket therapy (8).

Clinical studies regarding the application of lasers in the nonsurgical pocket treatment of periodontitis began with the use of the Nd:YAG laser (8). These studies of the application of the Nd:YAG laser alone in the nonsurgical treatment of periodontal pockets have shown varying results, with the Nd:YAG laser generally showing less effectiveness for root debridement than conventional mechanical therapy. In July 2009 a systematic review by Slot et al. concluded that there was no beneficial effect of a pulsed Nd:YAG laser compared to conventional therapy (ultrasonics and/or hand instrumentation) in the initial treatment of patients with periodontitis (21). That literature review suggested that there is no evidence to support the superiority of the Nd:YAG laser over traditional modalities of periodontal therapy.

However, one of the possible advantages of laser treatment of periodontal pockets is the debridement of the soft tissue wall. Recently, use of an Nd:YAG laser in a laser-assisted new attachment procedure (LANAP) has been advocated to remove the diseased soft tissue on the inner gingival surface of periodontal pockets. Yukna, et al. reported that the LANAP could be associated with cementum mediated new connective tissue attachment and histologically verified periodontal regeneration on previously diseased root surfaces in humans (19). In an animal study, treatment with the Er:YAG laser also seemed to induce new cementum formation after pocket irradiation (20). Thus, adjunctive or alternative use of laser treatment in periodontal pockets may promote more periodontal tissue regeneration than conventional mechanical treatment.

When it comes to subgingival calculus removal, the Erbium family of lasers seems to provide the most beneficial effects. The level of calculus removal with the Erbium laser has been shown to be similar to that of ultrasonic scaling (9). Some studies demonstrate that when a suitable energy is selected, the diseased root surface, after the Erbium laser irradiation, seems to offer better conditions for the adherence of fibroblasts in vitro than that after mechanical scaling alone (18, 21, 22). The Er:YAG laser has been proposed not only as adjunctive therapy, but also as an alternative to mechanical instrumentation for nonsurgical periodontal therapy. The favorable results of in vitro studies have led researchers to expect promising results from its clinical application. Following the first report by Watanabe et al. (13), which showed the safety and usefulness of Er:YAG laser therapy for subgingival calculus removal in nonsurgical pocket therapy, several randomized, controlled clinical studies reported the effectiveness of Er:YAG laser irradiation in comparison to conventional methods using hand curets or ultrasonic scalers. In contrast however, Schwarz et al.(23) reported that similar or better results were obtained following conventional scaling and root planing therapy in terms of reduction of bleeding on probing, pocket depth and improvement of clinical attachment levels, and that these clinical improvements could be maintained over a 2-year period (24).

Most recently it has been shown that Er:YAG laser therapy exhibited significant clinical improvements for 6 months following therapy, which were similar to those following use of the ultrasonic scaler alone (25). However, a recent clinical study demonstrated that treatment with the Er:YAG laser resulted in significantly higher pocket depth reduction and clinical attachment level gain at 2 years post-therapy in comparison to treatment with an ultrasonic scaler (26). One important finding of this study was that at 1 year post-treatment, there was an increase of pocket depth and attachment loss in the ultrasonic group, whereas stability of Er:YAG laser-treated site was noted until 2 years following treatment (26). Regarding bacterial reduction, in a recent clinical and microbiological study, equivalent reduction in bacterial number was observed following treatment with the Er:YAG in comparison to ultrasonic scaling (27). In a study evaluating Er:YAG laser in a periodontal maintenance program, faster healing (pocket depth reduction and clinical attachment level gain) and less discomfort during treatment were observed in the group treated with the Er:YAG laser (28). The Er:YAG laser might be a potential approach to provide comprehensive treatment for both soft and hard tissues within periodontal pockets and intrabony defects. However, there are no clear trends that demonstrate superiority of the laser to conventional mechanical treatment. More studies evaluating periodontal healing following nonsurgical treatment of periodontal lesions using lasers need to be performed to assess the value of lasers in debridement of microbial deposits on root surfaces (8). The Er:YAG laser may hold the most promise for root surface debridement such as calculus removal and decontamination, as an adjunct or alternative to mechanical debridement.

SURGICAL POCKET THERAPY

It is necessary for the root surface and bone defect to be completely debrided and decontaminated for any type of periodontal surgical procedure to be successful with optimal tissue regeneration (8). Laser application is effective in debriding areas of limited accessibility, such as deep intrabony defects and furcation areas where mechanical instruments cannot eliminate microbiological etiologic factors. Laser irradiation can facilitate complete debridement of the defect as a result of its ablation effect as well as improved accessibility when there is contact of the tip of the laser. Crespi et al (29) used the CO2 laser for the treatment of experimentally induced Class III furcation defects in dogs following flap surgery and reported that laser treatment promoted the formation of new periodontal ligament, cementum and bone compared to conventional mechanical therapy. In addition, the CO2 laser has been shown to increase the effectiveness of periodontal therapy through an epithelial exclusion technique in conjunction with conventional flap surgery procedures (30).

During surgical procedures the Er:YAG laser has also been shown to be effective and easy to use for granulation tissue removal and root surface debridement. In a study on dogs, Mizutani et al. demonstrated effective and safe granulation tissue removal and root debridement using an Er:YAG laser during flap surgery. Histologically, new bone formation was significantly more pronounced in the laser-treated group than in the curet-treated group after 12 weeks of healing (31). In clinical studies Sculean et al. (32) reported that application of the Er:YAG laser during the treatment of periodontal intrabony defects with access flap surgery is effective and safe with significant clinical improvements at six months following surgery, however, the laser treatment was equally effective as the mechanical debridement alone. In a recent study, Gaspirc et al. (33) reported the long-term clinical outcome comparing the Er:YAG laser-assisted periodontal flap surgery with conventional treatment using the modified Widman flap procedure. The reduction of pocket depth and gain of clinical attachment level were significantly greater in the laser group at up to 36 months after surgery. Schwarz et al. (34) also confirmed that regeneration therapy using an enamel matrix protein derivative was equally effective on the root surface irradiated with an Er:YAG laser when compared with the conventional procedure using enamel matrix protein derivate with EDTA root conditioning. Therefore, application of the Er:YAG laser for surgical degranulation is a promising approach, and its effectiveness and safety have been demonstrated clinically. Recently there has been a broader clinical use of lasers in flap surgery procedures (33). Further investigations are required to establish the reliability of this procedure using lasers and to clarify the additional benefits obtained by laser application (8).

OSSEOUS SURGERY

Bone recontouring and reshaping are often part of periodontal surgical therapy to establish the physiologic anatomy of the alveolar bone and to allow for an optimal gingival contour after surgery (35). The most commonly employed conventional instruments for bone surgery are mechanical rotary instruments that use carbide or diamond burs, and hand instruments such as chisels and files. Where access is limited, or where large amounts of bone must be removed, rotary instruments are indicated. Ultrasonic instruments have also been reported as an effective method for selective ablation of bone tissue (36, 37). In addition to these instruments, in recent years, the use of Erbium lasers has become increasingly popular for bone surgery. Erbium lasers in general offer more precision and better access than mechanical instruments. They reduce the risk of collateral damage, particularly when compared with rotary instruments that may become entangled with soft tissues (eg. the reflected flap). Lasers also improve the 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. In addition, the lack of vibration at the handpiece increases surgical precision. Nevertheless, despite the advantages of lasers over mechanical instruments, some issues still hinder a broader use of lasers in bone surgery. These include the reduced cutting efficiency of lasers compared with mechanical instruments, lack of depth of control and the effects of the laser on the surrounding irradiated tissue.

Recently, clinical applications for the Er:YAG laser in osseous surgery have been reported (38, 39, 40). Although in procedures involving large amounts of bone removal, the cutting efficiency of the Er:YAG laser has been reported to be lower than conventional drilling (8). Er:YAG laser irradiation with water cooling for removal of impacted teeth and intra-oral bone grafting showed good clinical results with precise bone ablation without any visible, negative, thermal side effects impairing the wound healing. However, the lack of depth control when cutting bone immediately above critical structures such as nerves or larger blood vessels, and longer treatment time of laser osteotomy, were deemed limitations to routine clinical application. Although the use of lasers for bone surgery offers some advantages over conventional mechanical instruments, the concerns raised by some studies are still justifiable for the general practitioner. Currently, the Er:YAG laser is safe and useful for periodontal bone surgery in procedures such as osseous removal or recontouring, when used concomitantly with saline irrigation (8).

IMPLANT THERAPY

Dental implants have been widely used in clinical practice for the replacement of missing teeth in the rehabilitation of fully and partially edentulous patients, and have become an option in comprehensive periodontal treatment plans. Various lasers have been applied in the field of implant dentistry for uncovering the submerged implant (second-stage) prior to placement of the healing abutment (8). Use of lasers in these procedures may have several advantages, including improved hemostasis, production of a fine cutting surface with less patient discomfort during the postoperative period, and favorable and rapid healing following abutment placement, thus permitting a faster rehabilitative phase (41, 42). Furthermore, because of the ability of the laser to produce effective bone tissue ablation, some researchers have suggested using the Er:YAG laser to prepare osteotomies in the bone tissue (osteotomy) in order to achieve faster osseointegration of the placed implants and to produce less tissue damage in comparison to conventional bur drilling (43, 44, 45, 46). Although these studies demonstrated uneventful wound healing of the laser-prepared fixture holes and effective osseointegration, the results are still controversial and there was no consensus regarding the superiority of the application of lasers. In most of these studies, no superior results were reported regarding the speed of osseointegration, with similar levels of wound healing in comparison with the drill (46, 47, 48). Also, the preparation time when using the Er:YAG laser was much longer than when using conventional drilling (46). However, Kesler et al. (49) reported a statistically significantly higher percentage of early bone-to-implant contact following the use of the Er:YAG laser in comparison with the conventional methods. Thus, the favorable results of the application of lasers in the first and second stages of implant surgery suggest their potential in the field of implant dentistry. Currently, the use of lasers is generally limited to the second stage soft tissue procedures (8).

Recently lasers have been used in the treatment of peri-implantitis. The term peri-implantitis describes the bone loss around an implant. The loss may be induced by stress, bacteria, or a combination of both (50). Conventional mechanical instruments, such as steel curets or ultrasonic scalers, are not completely suitable for granulation tissue removal and implant surface debridement because they readily damage the implant titanium surfaces (51) and thus may interfere with the process of bone healing. Therefore, non-metal mechanical means for implant debridement, such as the use of plastic curets and carbon fiber curets, have been recommended (52, 53). However, these methods are apparently ineffective for complete debridement of the bone defect as well as the contaminated implant surface (54, 55). Mechanical debridement around implants may also be time-consuming. Furthermore, implants with micro-structured surfaces have been recently clinically employed to improve anchorage to alveolar bone and to increase the bone-to-implant contact, resulting in better osseointegration (56, 57). Accordingly, in the case of peri-implantitis, complete removal of contaminants such as bacteria and their products, and soft tissue cells from the rough surface, has become much more difficult when using mechanical debridement alone (55, 58, 59).

Among the lasers applied in dentistry, the Er:YAG laser is considered to possess the best property for both degranulation and implant surface decontamination as a result of its dual actions of both soft and hard tissue ablation without causing thermal damage of the adjacent tissue. Irradiation using the Er:YAG laser seems to cause no change to the titanium surface (60, 61), and the irradiated titanium surface appears not to influence the attachment rate of osteoblasts on its surface (61). However, irradiation at high energy outputs may cause distinct surface changes of titanium (60). Irradiation using the Er:YAG laser facilitates effective removal of calculus and plaque from contaminated abutments and biofilms grown on sand-blasted and acid-etched titanium surfaces(59, 60). Furthermore, a high bacteriocidal potential on the implant with different surface characteristics, even at low energy densities, is obtained following Er:YAG laser irradiation (62). Decontamination of the titanium surface by Er:YAG laser therapy in vitro has been reported to be more effective than application of plastic curettes with adjunctive rinsing with chlorhexidine digluconate or an ultrasonic system (59). A recent study demonstrated that treatment of P.gingivalis-contaminated sand-blasted and acid-etched titanium implant surfaces using Er:YAG laser irradiation is capable of allowing attachment of osteoblast cells(8). In another study, it was reported that Er:YAG laser irradiation treatment of P.gingivalis-contaminated rough titanium surfaces resulted in greater fibroblast proliferation on the implant surfaces when compared with sterile specimens (63). In addition, no temperature elevations at the implant-bone interface during implant surface decontamination with the use of the Er:YAG laser in vivo were reported (64). In a recent animal study for the treatment of peri-implantitis in a circumferential crater-like bone defect, Schwarz et al. (65) reported that application of Er:YAG laser irradiation during flap surgery resulted in improvements in all investigated parameters, and that laser treatment seemed to be more suitable for promoting re-osseointegration when compared with plastic curet instrumentation followed by subgingival application of an antibiotic agent and ultrasonic debridement. However, no significant differences in the bone-to-implant contact between both laser treatment and plastic curet instrumentation were observed.

Most recently, Takasaki et al. (66), demonstrated safe and effective application of Er:YAG laser irradiation for degranulation and implant surface debridement in the treatment of experimentally induced peri-implant infections in dehiscence-type defects in dogs. Degranulation and implant surface debridement was easier to perform using Er:YAG laser irradiation than using plastic curet instrumentation. Histologically, after 24 weeks of healing, the newly formed bone was more coronally-positioned on the laser-treated implant surface in comparison to mechanical treatment. The Er:YAG laser-treated implant surface did not inhibit the formation of new bone, suggesting that the laser achieved decontamination of the implant surface with increased biocompatibility. Overall, though most previous clinical studies have not shown significant differences between laser and conventional therapies, laser treatment generally showed tendencies for better results in animal studies. Further clinical and animal-comparative studies between different treatment approaches with laser treatment are necessary to prove the superiority of the application of lasers in the treatment of peri-implantitis. Nevertheless, based on previous reports, it can be concluded that application of lasers holds great promise as an alternative or adjunctive tool in the treatment of peri-implant diseases (8).

OTHER USES

Correct diagnosis of the presence and extent of subgingival calculus is important in periodontal treatment planning and re-assessment following periodontal therapy (17). Also, complete removal and/or selective removal of subgingival calculus is important in order to achieve favorable wound healing. However, this objective is difficult to accomplish because the clinician has to rely on tactile feeling to judge the morphology and roughness of the root surface using conventional, manual methods such as a periodontal probe. Therefore, a more effective and accurate method of detecting subgingival calculus, especially when the calculus is located in the deepest portion of the pocket or on the root surface with complex anatomical contours, would be beneficial. Recently, lasers have been used to detect subgingival calculus. Several studies demonstrated that irradiation with a 655-nm diode laser induces significantly more fluorescent light emission in subgingival calculus than in cementum. Fluorescence detectors of wavelengths between 633-635 and 700nm have been employed for the clinical detection of subgingival periodontopathic conditions (67, 68). Increased values of laser fluorescence seem to be strongly related to the presence of calculus and those values seem to decrease after scaling. Based on those studies, it can be suggested that the application of laser fluorescence might be a useful tool for simple and precise detection of subgingival calculus.

An effective system for subgingival root debridement that combines an Er:YAG laser with diode laser fluorescence spectroscopy is also already being marketed in the European countries. This Er:YAG laser-based substrate detection device incorporates a feedback-driven treatment mode and has been proven to be a viable alternative to previous subgingival scaling methods. This novel system holds great promise because the degree of root debridement can be assessed and subgingival root cleaning with the Er:YAG laser can be optimized with the aid of laser fluorescence spectroscopy (69). Because this system has been reported to perform selective removal of subgingival calculus (70), this system does not seem to achieve additional improvements in the clinical outcome of nonsurgical periodontal treatment using an Er:YAG laser alone (69). However, in can be assumed that laser fluorescence, following technological improvements and further research, may be a potentially valuable tool for the clinical detection of subgingival calculus in the near future. Therefore, further clinical studies are necessary to validate the reliability of the detection of subgingival calculus using laser-induced fluorescence, and to demonstrate whether there is any superiority of using laser-fluorescence in nonsurgical therapy (8).

Lasers have been extensively applied in the treatment of periodontal disease. However, the various biological effects that lasers can produce on oral tissues are still not fully understood. Among the many physiological effects, it is important to recognize that the biostimulatory effects which laser irradiation produces on cells of the tissue during laser therapy might be beneficial by fostering faster wound healing in the process of periodontal tissue repair, which may not occur during conventional mechanical therapy (8). It has been suggested that low-level laser energy is responsible for these biomodulatory effects (8). Low-level laser therapy has been proposed as a new treatment approach for several diseases in the field of medicine. Low-level laser therapy has also been widely applied as part of the treatment of oral disease in dentistry. Low-level laser therapy uses a light source that generates extremely pure light with a single wavelength. The effects that it can produce on the cell are related to photochemical reactions within cells, rather than thermal effects, although the mechanisms behind this are still unclear (8). Nevertheless, biostimulatory effects of laser irradiation, such as higher cell proliferation and wound healing, may have interesting applications to augment or even modify current therapy approaches.

Use of the biostimulatory effect of low-level laser therapy in postoperative therapy has recently been proposed owing to several possible benefits, such as the reduction of discomfort or pain (71), promotion of wound healing (72) and bone regeneration (73), and the suppression of inflammatory processes (72). Previous in vitro studies showed that low-level laser irradiation enhances the activation of human gingival fibroblasts and periodontal ligament cells to proliferate and release growth factors in vitro (74, 75). Low-level laser therapy also decreases the amount of inflammation and accelerates wound healing by changing the expression of genes responsible for the production of inflammatory cytokines in vivo (76). In a recent clinical study it was reported that following gingivectomy, the treatment of gingival tissue by low-level laser therapy led to accelerated wound healing compared to sites not treated with low-level laser therapy (77). Also, in another study, treatment with adjunctive low-level laser irradiation of periodontal pockets following scaling and root planing showed reduced gingival inflammation in comparison to scaling and root planing alone (78). Another study demonstrated that the additional application of low-level laser therapy during and after periodontal surgical-regenerative therapy using enamel matrix protein derivate alone resulted in greater improvement of clinical parameters and reduced postoperative pain (79).

Regarding osteogenesis, several in vitro studies have suggested that low-level laser therapy could promote new bone formation by inducing the proliferation and differentiation of osteoblasts (80, 81). It has been reported in vitro that low-level laser therapy increased the alkaline phosphatase activity (80) and mRNA expression of osteoblastic differentiation markers, such as osteopontin (81), osteocalcin (80) and bone sialoprotein (81), in osteoblasts and promoted bone nodule formation (80). Therefore, low-level laser therapy has been recently applied in the field of implant dentistry. Several animal studies investigated the additional effects of low-level laser therapy when applied additionally in sites treated by conventional methods, expecting increased and faster osseointegration of implants of implants following irradiation. In fact, increased bone-to-implant contact and weight percentages of calcium and phosphorus were observed at the sites treated by additional low-level laser therapy compared with nonirradiated sites (82). In another study, osteocyte viability was significantly higher at early stages of healing in the bone sites irradiated by laser prior to implant placement than in nonirradiated implant sites(83). Also, low-level laser therapy appears to stimulate the proliferation and attachment of fibroblasts and osteoblasts cultured on titanium disks (84, 85).

Basic studies evaluating the effects of low-level laser therapy on periodontal tissues are still lacking and to date there are only a few published clinical studies regarding the effects of adjunctive low-level laser therapy in periodontal therapy. Thus, at present, the superiority of this novel treatment approach compared with conventional treatment has not been clearly demonstrated. Therefore, further clinical studies are needed to demonstrate the real beneficial effects of low-level laser therapy in periodontal and implant therapy.

Photodynamic therapy has been widely applied for the treatment of carcinomas in the field of medicine. Photodynamic therapy is based on the principle that a photoactivable substance, the photosensitizer, binds to the target cell and can be activated by light of a suitable wavelength. During this process, free radicals are formed, thereby initiating tumor necrosis. The application of systemic antibiotics in conjunction with mechanical therapy has been widely performed in periodontal therapy and is considered a valuable tool in the treatment of some forms of periodontal disease. However, it is now established that bacteria growing in biofilms are less susceptible to antibiotics as a result of protection within the plaque matrix (86). Also, frequent application of antibiotics may potentially increase the risk of bacterial resistance (87). Therefore, there is significant interest in the development of alternative antimicrobial concepts. Recently, photodynamic therapy has been used to treat localized microbial infections because the free radicals that are formed during photodynamic therapy might have a toxic effect on the bacteria. Researchers have proposed that this new therapeutic modality could be applied in periodontal therapy and it might have promise as a novel method of eliminating bacterial infection from periodontal pockets in the nonsurgical treatment of periodontitis (8).

Several studies have demonstrated the high bactericidal effect of photodynamic therapy and that it may be a valuable alternative to conventional mechanical approaches (88, 89, 90). Microbiological reduction was observed in vivo following photodynamic therapy in the treatment of peri-implantitis in dogs (91, 92). Also, it was reported in an animal model that photodynamic therapy can reduce periodontal disease progression and periodontal tissue destruction in experimentally induced periodontal disease (93). Recently, Sigusch et al. (94) demonstrated a reduction in the signs of periodontal inflammation in beagle dogs following treatment with photodynamic therapy. Also, it has been demonstrated that scaling and root planing combined with photodisinfection, or the application of photodynamic therapy alone, leads to reduction of pocket depths and in clinical attachment gain in the nonsurgical treatment of periodontitis (95). Although the application of photodynamic therapy in the treatment of periodontitis and peri-implantitis is an interesting therapeutic approach, current reports have not shown significant superior effects of photodynamic therapy compared with conventional mechanical therapy. Therefore, the potential effects of photodynamic therapy should be studied more extensively to establish the optimal conditions during clinical application. However, photodynamic therapy holds promise as a novel, non-invasive treatment method that might be beneficial when applied alone or in conjunction with conventional mechanical periodontal and peri-implant therapy.

In summary, the application of lasers has been recognized as an adjunctive or alternative approach in periodontal and peri-implant therapy (1). The advantages of easy ablation, decontamination and hemostasis, as well as decreased surgical and postoperative pain of laser treatment over conventional treatment are well documented. Soft tissue surgery is one of the major indications for laser treatment and the CO2, Nd:YAG, diode, Er:YAG and Er,Cr:YAG lasers are generally accepted as useful tools for these procedures. Laser or laser-assisted pocket therapy is expected to become a new technical modality in periodontics. The Er:YAG laser shows the most promise for root surface debridement, such as calculus removal and decontamination. Concerning the use of lasers for bone surgery, CO2 and Nd:YAG lasers are considered unsuitable because of carbonization and degeneration of hard tissue. Currently, the Er:YAG is safe and efficient for periodontal bone surgery when used concomitantly with water irrigation. Application of lasers has also been considered in implant therapy. Based on previous reports, lasers, especially the Er:YAG laser, hold promise as an alternative treatment in the treatment of peri-implantitis. Application of photodynamic therapy in the treatment of periodontitis and peri-implantitis is a novel approach. However, to date the real superiority of photodynamic therapy for clinical improvements has not been demonstrated.

Further studies are encouraged to understand in more detail the effects of lasers on biological tissues, including the periodontium, in order to ensure their safe and effective application during periodontal treatment. Among lasers currently available, the Er:YAG laser seems to provide the most suitable characteristics for various types of periodontal treatment(8).

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