Laser-Assisted Treatment of Peri-implantitis

24

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Abstract

Dental lasers are becoming a useful adjunct in the treatment of ailing and failing implants with their ability to remove diseased tissue, decontaminate implant surfaces, and stimulate growth factors, fibroblast attachment, and collagen deposition. When compared to conventional treatment outcomes, reported clinical improvements resulting from laser-assisted treatment of peri-implantitis include reductions in probing depth, bleeding, suppuration, and implant mobility, with evidence of bone formation and reosseointegration. Future research is expected to optimize clinical efficacy and predictability of laser treatment in the long term.

Since their initial intraoral use in the 1970s, lasers have emerged as an instrument of choice for many oral surgical procedures, including the treatment of periodontal disease, whether they are used alone or in conjunction with other treatment modalities (Shafir et al. 1977; Strong et al. 1979; Pick et al. 1985; White et al. 1991; Epstein 1992; Gold and Vilardi 1994; Watanabe et al. 1996; Schwarz et al. 2003; Flax and Radz 2004; Moritz et al. 1998; Borrajo et al. 2004; Kamma et al. 2009). Lasers are also being shown to be a useful adjunct in the treatment of peri-implantitis, as numerous published reports have helped to define the parameters and conditions for use to achieve safety and efficacy (Schwarz et al. 2003, 2005, 2006a, b, 2013; Flax and Radz 2004; Moritz et al. 1998; Borrajo et al. 2004; Kamma et al. 2009; Romanos et al. 2000, 2009; Dörtbudak et al. 2001; Persson et al. 2004; Giannini et al. 2006; Romanos 2006; Takasaki et al. 2007; Lee et al. 2008, 2011; Giannelli et al. 2009; Stübinger et al. 2010; Kim et al. 2010; 2011; Shin et al. 2011; Yamamoto and Tanabe 2013; Marotti et al. 2013; Shin et al. 2013; Nevins et al. 2014).

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24.1 Laser Characteristics and Mechanisms of Action

The applicability of lasers for periodontal treatment is dictated by a combination of factors, including their specific light wavelength (e.g.,

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660–10,600 nm), interaction with/absorption by specific components within the soft tissue (e.g., water, hemoglobin, melanin), laser light emission mode (e.g., pulsed or continuous wave) and duration of exposure, power level and density, vascularity of tissue, and presence of external cooling (e.g., water spray) (Pang et al. 2010).

In soft tissue procedures, a dental surgical laser's light – whether visible or invisible – produces a thermal reaction when absorbed by the tissue, which is largely composed of water. Ablation (i.e., cutting or vaporization) occurs when the soft tissue approaches 100 °C, the point of water vaporization (Knappe et al. 2004). Other thermal points above 50 °C inactivate nonsporulating bacteria (Russell 2003), while at temperatures above 60 °C, proteins begin to denature and coagulation occurs (Knappe et al. 2004).

Laser capabilities and mechanisms of relevance to their use in treating peri-implantitis include removal of diseased tissue and, as demonstrated in animal and in vitro studies, stimulation of fibroblast attachment, growth factors, and collagen deposition to support healing, bone formation, and osseointegration (Khadra et al. 2005; Yu et al. 1997; Guzzardella et al. 2003; Boldrini et al. 2013; Naka and Yokose 2012; Omasa et al. 2012; De Vasconcellos et al. 2014; Massotti et al. 2015).

A number of in vitro investigations have also examined the capabilities of lasers to reduce the bacterial population. Harris and Yessik (2004) assessed the relative bactericidal effectiveness of an 810-nm pulsed diode laser and a 1064-nm pulsed Nd:YAG laser. The researchers lased the pigmented *Porphyromonas gingivalis* grown on blood agar plates to quantify the efficacy of ablation (tissue removal). Results indicated the Nd:YAG laser was able to ablate the bacteria without visible effect on the blood agar, whereas the diode laser destroyed both the pathogen and the gel. Clinically, the investigators concluded that the pulsed Nd:YAG laser may selectively destroy pigmented pathogens and leave the surrounding tissue intact; the diode laser may not demonstrate this selectivity due to its greater absorption by hemoglobin and/or much longer pulse duration.

Encouraging laboratory investigations of the antimicrobial effects of various laser wavelengths on contaminated titanium implants or disks demonstrate the ability of diode, Nd:YAG, Er:YAG, and CO_2 lasers to reduce the bacterial numbers (Hauser-Gerspach et al. 2010; Gonçalves et al. 2010; Kreisler et al. 2002; Kato et al. 1998). Future clinical studies will determine the extent to which these in vitro findings may apply to the treatment of peri-implantitis in human patients.

24.2 Case Studies

Various lasers have been used clinically or in laboratory experiments in conjunction with other therapies for the treatment of peri-implantitis, as demonstrated in a representative selection of published reports.

24.2.1 Photodynamic Therapy with Low-Level Diode Lasers

A laser-based technique, photodynamic therapy (PDT), has been investigated for its therapeutic potential. PDT refers to the interaction of certain wavelengths of light with a photosensitizing agent that is bound to target cells. In the presence of oxygen, the interaction produces cytotoxic free radicals that selectively destroy the targeted cells.

Bassetti and colleagues (2004) compared adjunctive local drug delivery (minocycline microspheres) to adjunctive PDT in assessing the clinical outcomes in patients presenting with peri-implantitis. For the PDT, they used a low-level 660-nm diode laser at 100 mW in conjunction with a photosensitive dye, phenothiazine chloride, applied submucosally to peri-implant pockets. Both treatment modalities were used subsequent to mechanical debridement with titanium curettes and a glycine-based power air polishing system. At 12 months posttreatment, they observed no statistically significant differences between groups with respect to clinical, microbiological, and host-derived parameters. They concluded that nonsurgical mechanical debridement with adjunctive PDT was equally effective in reducing mucosal inflammation as with adjunctive local drug delivery.

Deppe et al. (2013) performed a 6-month clinical pilot study of the efficacy of nonsurgical antimicrobial photodynamic therapy in moderate and severe peri-implant defects. Involved were 16 patients with a total of 18 untreated ailing implants; 10 implants demonstrated moderate (less than 5 mm) bone loss and 8 showed severe (5–8 mm) defects. All implants received antimicrobial PDT without surgical intervention. After a 3-min residence duration within the peri-implant pocket, the photosensitizer phenothiazine chloride was activated with a 660-nm diode laser at 100 mW for 10s at each of six sites per implant for a total exposure of 1 min. Peri-implant health was evaluated at baseline and at 2 weeks, 3 months, and 6 months after therapy. Their findings indicated that the nonsurgical PDT treatment could stop bone resorption in moderate peri-implant defects but not in severe defects. They recommended surgical treatment of severe peri-implantitis defects, especially in esthetically important sites.

The Bombeccari group (2013) used an 810-nm diode laser at 1 W with the photosensitizer toluidine blue O in their randomized comparative case-control study of 20 patients and 20 controls to compare the efficacy of antimicrobial PDT with surgical therapy in patients with peri-implantitis. Conventional open-flap surgery was performed on both sets of patients, with scaling of implant surfaces and debridement of granulation tissue. Then, the photosensitizer was applied to patients in the PDT group, and they received five separate 20s irradiation exposures along the surfaces of the peri-implant defect, for a total exposure of 100. Microbiologic testing of all patients was done before and after treatment and at 12 and 24 weeks. Results revealed no significant difference in total counts of bacteria between the PDT and conventionally treated patients at 24 weeks. However, the PDT group showed a significant decrease in bleeding on probing and inflammatory exudation.

24.2.2 Diode Lasers

Roncati and colleagues (2013) report a case study of a 45-year-old male presenting with pain and swelling at a mandibular implant site. Clinical evaluation revealed a 7-mm pocket and bleeding on probing with suppuration and gingival inflammatory edema at the implant site. Radiographic evidence showed bone loss of five fixture threads. An 810-nm diode laser was used to treat the site, followed by hand instrumentation with a curette and piezoelectric ultrasonic device and application of chlorhexidine gel. Maintenance debridement visits were scheduled at 3-month intervals. Compared to initial clinical data, the patient showed a decreased probing pocket depth and a negative bleeding-on-probing index. After 5 years of follow-up visits, radiographic evidence showed rebound of the bone level. The authors concluded that conventional nonsurgical periodontal therapy with the adjunctive use of an 810-nm diode laser may be a feasible alternative approach for the management of peri-implantitis.

In their treatment of peri-implant infection in the posterior maxilla of a 55-year-old female, Kutkut and fellows (2011) used an 810-nm diode laser to decontaminate the implant surfaces. The patient presented with a fistula related to implants at sites #11 and 12, and severe bone loss was detected around implants at sites #11, 12, and 14. A full-thickness flap was reflected to access the peri-implant defect, and granulation tissue was removed with hand instruments. The exposed implant surfaces were irradiated with the laser, followed by a 2-min application of tetracycline paste. An allograft of particulate bone substitute was placed in the defected areas, and the graft was covered with a resorbable collagen membrane. At 4 months, signs and symptoms of infection were eliminated, soft and hard tissues regained their natural appearance, and primary implant stability was confirmed. The authors indicated that open debridement, in combination with surface decontamination and the use of a diode laser, can achieve substantial reosseointegration with new bone regeneration of the defects.

In 2014 Papadopoulos and colleagues (2015) reported the results of a randomized clinical trial that compared the effectiveness of open-flap debridement alone with additional use of a 980-nm diode laser for the treatment of peri-implantitis. Nineteen patients were randomly assigned to two groups. In both the control and laser groups, full-thickness flaps were raised, granulation tissue was removed, and mechanical instrumentation of the implant surface was performed. The laser group then received 0.8 W of pulsed laser irradiation with simultaneous sterile saline irrigation to disinfect the exposed implant surface. Pocket depth, clinical attachment level, bleeding on probing, and plaque index were evaluated at baseline and at 3 and 6 months after treatment. Results revealed that the two treatment methods appeared to be equally effective in reducing pocket depth, bleeding on probing, and plaque index. Clinical attachment level improved significantly in the laser group after 3 months only. The investigators concluded that the additional use of a diode laser did not seem to have an added beneficiary effect in the treatment of peri-implantitis.

24.2.3 Erbium Lasers

In 2008 Azzeh (2008) reported on the use of a 2,780-nm Er,Cr:YSGG laser to treat peri-implantitis. A 28-year-old male presented with 2-mm gingival recession and 7-mm probing depth around an implant in the area of the upper left central incisor. An Er,Cr:YSGG laser was used at different power, water, and air settings to open a flap, remove the granulation tissues, perforate the bone, and clean the implant surface. A bone graft and bioabsorbable membrane were used for bone regeneration. At 3, 6, and 12 months postoperatively, no complications were reported; clinical observations revealed probing depths of 3–5 mm, less than 1 mm of recession, no bleeding or implant mobility, and good bone formation. At 18 months probing depth was 2 mm, recession was less than 1 mm, and no bleeding, mobility, or discharge was evident. Azzeh concluded that the laser enabled regenerative osseous surgery around the implant with no complications and with a high level of patient and clinician satisfaction.

The Al-Falaki group (2014) conducted a retrospective analysis of 28 implants with peri-implantitis in 11 patients treated with an Er,Cr:YSGG laser. Implants with probing depths of at least 4 mm and radiographic evidence of bone loss were included. The laser and titanium curette were used to degranulate the pocket epithelium and bony walls, and then the laser was used to irradiate the tissue outside the pocket to disrupt the epithelium around the implant by a distance of at least 5 mm from the gingival margin. Probing depths and bleeding on probing were assessed at baseline and after 2 and 6 months. Reductions in mean pocket depths at baseline (6.64 ± 1.48 mm), after 2 months (3.29 ± 1.02 mm), and after 6 months (2.97 ± 0.7 mm) were statistically significant. Reductions in bleeding from baseline to both 2 and 6 months were also significant. The authors recommended that well-designed randomized controlled trials of the use of Er,Cr:YSGG laser in the nonsurgical management of peri-implantitis be conducted to validate their clinical findings.

Badran and cohorts (2011) reported in 2011 on the clinical management of severe peri-implantitis with adjunctive use of a 2,940-nm Er:YAG laser. Clinical examination of a 70-year-old female showed inflamed mucosa, 5–9 mm pockets, bleeding on probing, and suppuration on the distal surface. The first stage of treatment included ultrasonic scaling and Er:YAG laser debridement with sterile water irrigation. The second stage of treatment included elevation of a full-thickness access flap, ultrasonic and laser debridement of the implant surface, elimination of granulation tissue from the bony defect with bone curettes, and placement of synthetic bone substitute. At 6 months radiographic examination revealed bone formation around the implant. The researchers concluded that nonsurgical treatment with ultrasonic scaling and laser debridement failed to establish acceptable healing, despite reductions in probing depth and bleeding. A surgical approach (including access flap, laser debridement and decontamination of the exposed implant surface, and placement of bone substitute) provided radiographic evidence of newly formed bone.

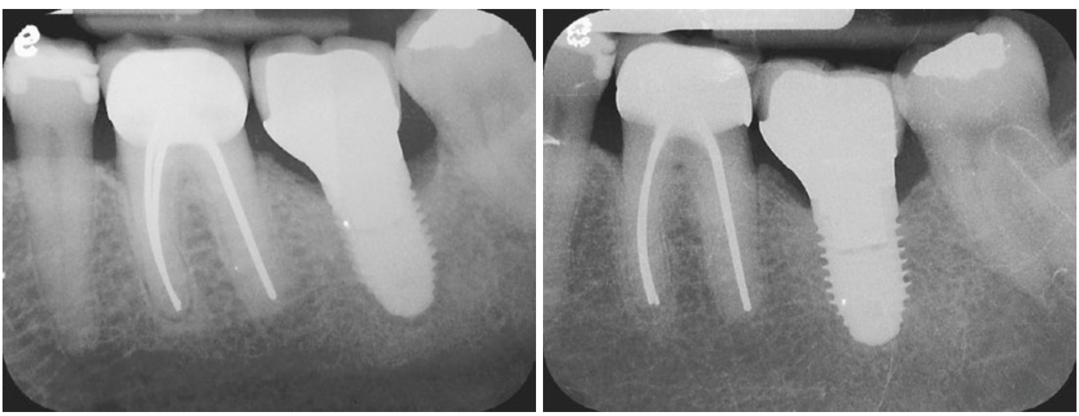
In 2011 Renvert et al. (2011) reported the results of a randomized clinical trial for the treatment of severe peri-implantitis using an Er:YAG laser or an air-abrasive device for implant debridement. The laser group included 21 subjects with a total of 55 implants; the air-abrasive group had 21 subjects with 45 implants. At 6-week and 3- and 6-month posttreatment examinations, there were no statistically significant differences in the gingival index, plaque scores, or bleeding on probing scores. Both treatment methods resulted in a reduction of probing depth and the frequency of suppuration and bleeding. Their results showed that overall clinical improvement was limited: approximately 50% of the subjects in both groups showed improved clinical conditions.

24.2.4 Nd:YAG Lasers

Nicholson and a group of private practitioners (2014) collaborated on a human clinical study in which a pulsed 1,064-nm Nd:YAG laser was used to treat patients presenting with peri-implantitis and peri-mucositis. Follow-up data collection occurred between 8 and 36 months after laser treatment. Radiographic analysis of 16 cases included in the study revealed an increase in crestal bone mass around the implant and, when reported, reductions in probing depth. In their 2014 published account, all clinicians reported control of infection, reversal of bone loss, and rescue of the incumbent implant. Data also indicated that healing (bone deposition) is not linear; large defects heal rapidly at first, but the healing process gradually slows as the defect disappears. Complete recovery took 1–3 years depending on the size of the lesion. The authors reported a definite trend for larger lesions to heal faster (Figs. 24.1 and 24.2, 24.3, 24.4, 24.5, 24.6 and 24.7).

24.2.5 Carbon Dioxide Lasers

Deppe et al. (2007) assessed the efficacy of a 10,600-nm CO_2 laser-assisted peri-implantitis therapy compared to conventional methodology. The investigation included 32 patients with 73 failing implants. In the laser group, 22 implants were treated with soft tissue resection following laser decontamination, and in 17 implants, bone augmentation was performed with the concomitant use of β-tricalcium phosphate. For the control group, soft tissue resection after conventional decontamination was performed in 19 implants and augmentation in 15 implants. Results were evaluated 4 months after surgery and then at final follow-up (mean duration of 37 months, 5 months minimum, 59 months maximum). Results showed that treatment of peri-implantitis may be accelerated with the use of a CO_2 laser concomitant with



Figs. 24.1 and 24.2 Fifty-nine-year-old healthy female complaining of discomfort at the #18 implant site. Nine millimeters of distal peri-implant probing depth (PIPD) with bleeding and suppuration on probing were noted. Peri-implantitis was diagnosed and treated with a free-running pulsed Nd:YAG laser (PerioLase MVP-7, Millennium Dental Technologies, Cerritos, Calif., USA) and the LAPIP protocol (8-1-2012). Follow-up radiograph (6-3-2013) shows excellent healing, and clinically the site now measures 4 mm PIPD with no bleeding or suppuration. Patient JB (Courtesy, Dr. Edward A. Marcus)

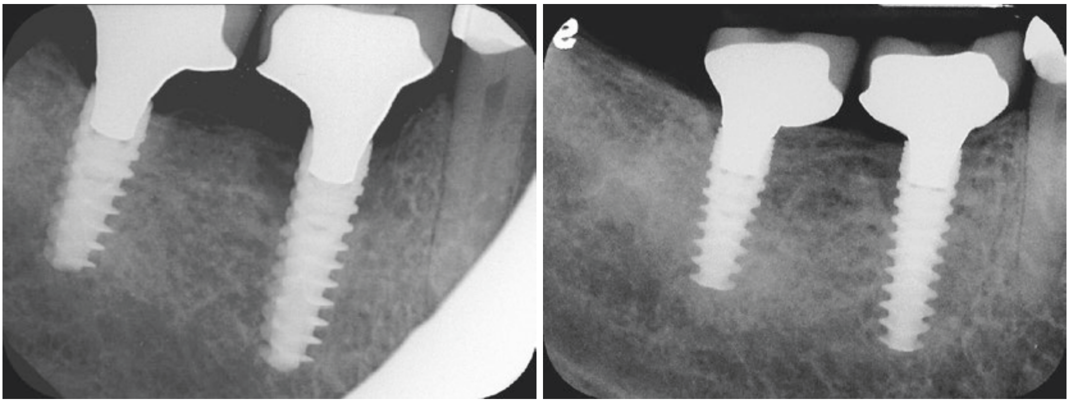
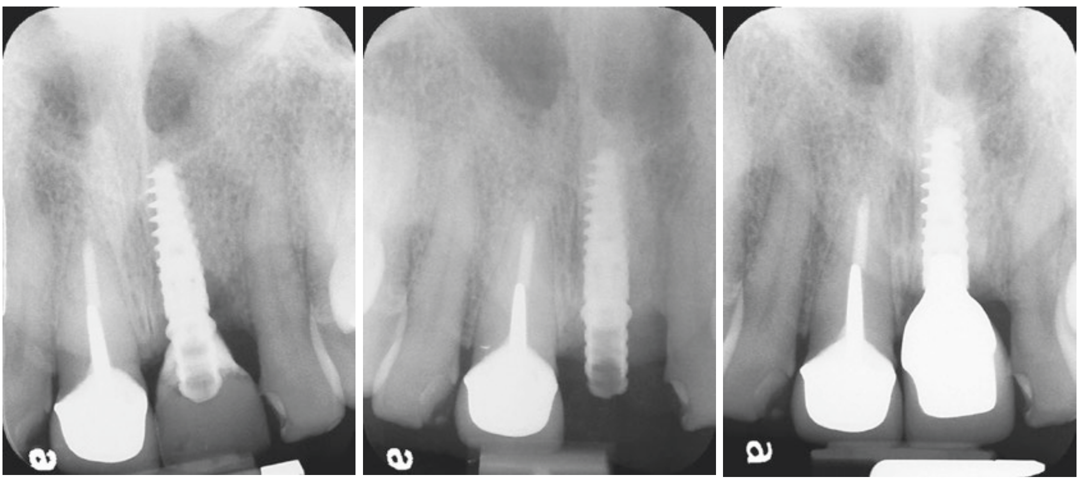


Fig. 24.3 and 24.4 Sixty-two-year-old healthy male referred by his general dentist who noted bone loss on the #30 implant. Clinical examination showed 7–8 mm of PIPD circumferentially with bleeding and suppuration on probing. Peri-implantitis was diagnosed and treated with a free-running pulsed Nd:YAG laser (PerioLase MVP-7, Millennium Dental Technologies, Cerritos, Calif., USA) and the LAPIP protocol (3-9-2013). Follow-up radiograph (7-2-2014) shows excellent healing, and clinically the site now measures 3–4 mm with no bleeding or suppuration. Patient BS (Courtesy, Dr. Karen E. Marcus)



Figs. 24.5, 24.6 and 24.7 Fifty-one-year-old healthy female with a single provisionalized implant at the #9 site which developed peri-implantitis during integration healing. Eight millimeters of distal pocketing with bleeding and suppuration were noted. The site was treated with a new provisional restoration and the free-running pulsed Nd:YAG laser (PerioLase MVP-7, Millennium Dental Technologies, Cerritos, Calif., USA) using the LAPIP protocol (4-5-2012). Follow-up radiograph (2-6-2013) shows excellent healing, and clinically the site now measures 4 mm with no bleeding or suppuration. A posttreatment 3-year follow-up radiograph shows a stable result. Patient JD (Courtesy, Dr. Edward A. Marcus)

soft tissue resection. However, no difference was seen between laser and conventional decontamination with respect to long-term results in augmented defects.

Romanos and Nentwig (2008) evaluated the ability of a 10,600-nm carbon dioxide laser to decontaminate failing implants in 15 patients. A full-thickness mucoperiosteal flap was elevated to access peri-implant bony defects. Titanium curettes were used to remove granulomatous tissue. Then a CO_2 laser was used to irradiate the exposed implant surfaces and promote blood coagulation in the bony defect. Augmentation with autogenous bone grafting material or xenogenic bone grafting material was used, and bone grafts were covered with a collagen membrane.

After 27 months, almost complete bone fill in the peri-implant defect was accomplished. Their results suggest that decontamination of implant surfaces with a CO_2 laser in combination with augmentation techniques can effectively treat peri-implantitis.

24.3 Precautions

Of particular interest when lasers are used around implants (such as for second-stage recovery or treatment of peri-implantitis) is an awareness of the potential for altering the surface characteristics of the implant itself or for overheating the implant, which could lead to undesirable thermal damage to adjacent tissues and ultimately to implant failure.

Several in vitro examinations elucidate the concerns. For example, scanning electron microscopic evaluation of titanium surfaces exposed to an 810-nm diode laser showed scattered markings of a circular nature approximately 50 μ in diameter (Kilinc et al. 2012). Melting, loss of porosity, and other surface alterations were observed on plasma-sprayed and hydroxyapatite-coated titanium dental implants exposed to Nd:YAG laser irradiation (Block et al. 1992). Zirconia implants irradiated by a CO_2 laser at various power settings revealed material cracking and melting, and an Er:YAG laser penetrated through the specimen disks (Stübinger et al. 2008).

Other in vitro studies have investigated surface temperature increases in implants exposed to various levels of 810-nm and 980-nm diode, 1,064-nm Nd:YAG, 2,940-nm Er:YAG, and 10,600-nm CO_2 lasers. All tested wavelengths resulted in temperature increases of varying degrees, depending on the power level and exposure duration used (Leja et al. 2013; Kreisler et al. 2003; Geminiani et al. 2011, 2012; Wilcox et al. 2001; Wooten et al. 1999).

Numerous steps can be taken to mitigate such concerns: Carefully adhering to proper clinical technique, following the manufacturer's recommendations for use, choosing laser parameters judiciously, limiting direct laser exposure to the implant itself, allowing sufficient time for the implant to cool, and using water spray to cool the surgical site (Mouhyi et al. 1999; Monzavi et al. 2014) are some of the methods that can be employed clinically to minimize the potential for inadvertent damage.

Conclusion

Lasers have been used successfully for more than 35 years for various oral and periodontal surgical procedures. When used with appropriate parameters and proper clinical technique, lasers are now demonstrating their utility as adjunctive instruments for the treatment of peri-implantitis.

Based on the findings of numerous in vitro and animal studies in implantology, various laser types have been evaluated for their effectiveness in treating peri-implantitis in human patients. Outcomes assessed included probing depth, bleeding, suppuration, control of infection, bone formation and deposition, reestablishment of reosseointegration, and implant mobility. Overall, results show varying degrees of clinical improvement.

The role of lasers in treating peri-implantitis continues to be a fertile area for future research to optimize clinical efficacy and predictability in the long term.

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