Review Article

Laser Treatment of Peri-Implantitis: A Literature Review

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Abstract:

Peri-implantitis is a state defined as an inflammatory reaction around osseointegrated implants, leading to progressive loss of supporting bone. Various treatment methods are suggested in the treatment of peri-implantitis and clinicians have to choose a method over a large number of treatment protocols. Lasers have shown promising therapeutic effect in treatment of peri-implantitis. However, some controversies have been found in clinical outcomes after using lasers. Therefore, we aimed to review the current literature over the past ten years for the use of lasers in treatment of peri-implantitis, via the Pubmed electronic database of the US National Library of Medicine. Fifteen human studies were reviewed. Er:YAG (Erbium-Doped Yttrium Aluminum Garnet), CO_2 (Carbon Dioxide Laser) and Diode lasers were used. Despite inconsistencies and disharmonies among studies in terms of study design, positive treatment outcomes were obvious among the majority of them. However, short period of follow-ups and poor control of plaque index, as a critical confounding factor, were the major problems which these studies suffered from. It seems that one session laser therapy is not adequate for achieving optimal clinical outcome. Further studies with longer periods of follow-ups, intense control of plaque index, and various sessions of laser treatments are needed to clearly illustrate the clinical privilege of laser therapy.
Keywords: peri-implantitides; lasers; dental implants

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Introduction

Dental implants seem to be successful treatments for partial or full edentulous patients. However, even an implant with a successful osseointegration can develop the most common late failure complication, known as peri implantitis.[1,2] Frequency of peri-implantitis has been reported in the range of 1–19%.[3]

Peri implantitis is an inflammatory disease that affects both hard and soft tissue and contributes to a progressive bone loss beyond the biologic remodeling around a functioning implant.[4-6]

Previous periodontal disease, poor oral hygiene, smoking, genetic traits, diabetes, residual cements and occlusal overload are counted as risk indicators which would make someone susceptible to develop peri implantatis, which are similar to those for periodontitis.[4,6] Microorganisms living on the implant surface are considered to be the initial cause of peri-implantitis.[7,8] These bacteria form a biofilm which establishes harmful inflammatory response in host and inhibits bone cells reattachment to the implant surface.[9] When treating this condition in order to reestablish health of the peri implant tissue, it is crucial to not only eliminate the inflamed tissue, but also decontaminate the infected implant surface.

Several approaches for implant decontamination are available, with the ideal one still remaining to be determined.[10] Mechanical debridement, disinfection with chemotherapeutic agents, smoothing implant surface and surgeries aimed to eliminate bacteria and laser therapy should be noted.[11-15] Mechanical debridement can be done with carbon, plastic or titanium currets, ultrasonic scaling or powder air abrasion.[16,17]. Chlorhexidine digluconate, tetracycline fibers and minocycline microspheres seem to have strong disinfecting and bactericidal potential.[18] Efficacy of mechanical or chemical modalities seems to be limited due to resistant bacterial strains, limited access to inflamed area and pharmacologic limitations like in site drug dosage or insufficient anti bacterial effect.[3, 19] Also mechanical strategies like metallic curetts, ultrasonic metal tip scalers and air powder abrasion may develop a roughened implant surface, which itself increases bacterial colonization and biofilm formation.[18]

Recently, a noticeable tendency has urged scientists toward application of laser in order to decontaminate periimplant inflamed area. Lasers can efficiently irradiate small areas of the implant surface which mechanical methods are unable to reach. Improved clinical outcomes are predictable due to selective calculus removal, bactericidal and haemostatic effects of lasers.[13, 20] In vitro models have proven the efficacy of Er:YAG(Erbium-Doped Yttrium Aluminum Garnet), CO_2 (Carbon Dioxide Laser) and Diode lasers in high or even complete elimination of bacteria loaded titanium disks.[21] Also microscopic evaluations have ensured that proper application of these lasers do not disturb titanium surface [22,23]

When considering utilization of lasers in treatment of peri implantitis, practitioner must take a number of decisions. Type of lasers which include Er:YAG, CO_2, Diode, Er,Cr:YSGG(Erbium, Chromium doped Yttrium Scandium Gallium Garnet) and Nd:YAG (Neodymium-Doped Yttrium Aluminium Garnet). Next is power setting which must disinfect the implant, while being safe for surface texture. Combining laser therapy with other treatment modalities might be indicated.

Inconsistencies in previous studies concerning clinical outcomes and in the settings with which the lasers were operated, led us to review the current literature and provide a concise summary to help while planning treatment strategies.

Methods

To compile this review, a search of the PubMed database of the US National Library of medicine was carried out. The literature search was done on articles published from March 2004 to March 2014. International peer reviewed journal articles related to the use of lasers in the treatment of peri-implantitis were searched. The key words used in this search were: peri-implantitis or periimplantitis or peri implantitis or periimplant or peri-implant or periimplant lesions) and (laser or lasers)

During the search in PubMed database, the following filters were applied:

1. Language: English language.
2. Human studies
3. Type of article: randomized-controlled trial, clinical trial, controlled clinical trial, case study, meta-analysis

The search identified a total of 125 articles. Abstracts were read by the authors, and studies, investigating the effect of laser therapy on peri-implantitis were included. Animal studies and review articles were excluded; however bibliographies were searched for any relevant articles. This resulted in 15 articles to analyze.

The following information was extracted from the selected studies:

- Publication details (title, author(s), journal, year, volume, issue number, pages)
- Number and type of implants
- Laser settings
- Experimental Procedures
- Follow up period
- Bleeding on probing
- Plaque index
- Probing depth
- Clinical attachment level
- Gingival recession
- Bone level

Results

Fifteen human studies were selected for review. A multitude of treatment regimens, including laser irradiation, had been used. Human studies included 9 studies on Er:YAG laser, 3 studies on CO_2 laser and 3 studies on Diode laser. Most of the studies presented positive clinical outcomes in 6 months follow-up.

Table 1. Clinical human studies using Er:YAG laser on oral implant surfaces

	Authors-year	Type of laser	Number of patients and implants	Implant type	Laser characteristic	Experimental procedures	Follow up	BOP	Plaque index	Pocket probing depth	Clinical attachment level	Gingival recession	Bone level	Comments
1	Renvert et al. 2011[29]	Er: YAG	42 patients, 100 implants	Not reported (laser Group: machined surface: 41, medium rough surface: 14, Control group: machined surface: 29, medium rough surface: 16)	100 mj Pulse 10 HZ 12.7 (j/cm2)	Removal of Implant supra structures ± Submucosal Glysine (Powder air polishing) ± Laser irradiation	6 months	Base=100% of implants 6m=No BOP in 31% (p<0.001) (But no difference by intervention)	Reduced plaque index (but not statistically significant)	Mean 0.8±0.5 mm reduction (p<0.05)	Not reported	Not reported	No significant change	Significant BOP reduction was observed in both groups, however, Pocket probing depth reduction was not significant.
2	Schwarz et al. 2006 A[30]	Er: YAG	12 patients 12 implants 2 patients and 2 implants at each time interval	Titanium implants (Sandblasted and acid etched (SLA), Screw Vent, Screw Line, Ticer, Frialit))	100 mj Pulse 10 HZ	supragingival professional implant/ tooth cleaning +open flap debriment using plastic currets+ Augmentation+ Laser irradiation	1, 3, 6, 9, 12, 24 months	Mean reduction 0-24 m Mean increase 6-24 months	increased mean values of PI as observed between 6 and 24 months	Mean decrease to 6 months Increase from 6-24 months	Mean gain at 6 months Decrease from 6-24 months	Mean increase from 1-24 months	No decrese in radiolucency	Although plaque index increased between Baseline to 3 months, all other variables improved.
3	Schwarz et al. 2006 B[31]	Er: YAG	20 patients 40 implants 20 patients and 20 implants in each group (parallel design)	Titanium implants (SLA and Titanium plasma sparayed (TPS) surface Straumann) (Intramobile Cylinder (IMZ))	100 mj Pulse 10 HZ	Implant scaling (plastic curette) + chlorhexidine (0.2%) irrigation ± chlorhexidine gel in pocket ± Laser irradiation	3, 6, 12 months	Reduction after 3, 6, 12 m (p<0.01 and 0.001)	Plaque index was significantly higher at 12 months as compared to baseline in both groups	Reduction after 3, 6, 12 (p<0.01)	Gain after 3 m and 6 m (p<0.01) 12 months no significant difference (p>0.05)	Decrease after 3 m (p<0.05) Then remained stable in next follow ups (p>0.05)	Not reported	In group (a) ; 2 patients with 4 implants were discontinued from the study due to persisting pus between 4 and 12 weeks
4	Schwarz et al. 2005[32]	Er: YAG	20 patients 32 implants 10 patients and 16 implants in each group (parallel design) All rough surface.	Titanium implants (Straumann) 17 SLA 15 TPS	100 mj Pulse 10 HZ	Plastic curette + chlorhexidine irrigation (0.2%) + chlorhexidine gel in pocket or laser irradiation	6 months	Baseline=83% 6 m = 31%	Unchanged (PI increased at 3 months and was unchanged at 6 months)	Baseline: 5.4±1.2 mm 6m: 4.6±1 mm (p<0.001)	Base line: 5.8±0.9 mm 6 m: 5.1±0.9 mm (p<0.001)	No significant change	Not reported	In spite of unchanged Plaque index, both therapies resulted in significant improvements of BOP, Pocket depth and Clinical attachment level
5	Badran et al. 2011[24]	Er: YAG	Case study, 1 implant	Not reported	120 mj/Pulse 10HZ	Stage 1: non-surgical ultrasonic scaling Stage 2: surgical exposure, granulation tissue curettage synthetic bone grafting	6 months	Total reduction. no BOP after 3 m	Not reported (The patient had maintained satisfactory oral hygiene.)	2-5 mm reduction 6 m after non-surgical therapy. Additional 0-2 mm reduction 3 m after augmentation	Not-reported	Mild Recession occured 1-2 mm	Radiographic evidence of bone formation	

Table 1. Continued

	Authors-year	Type of laser	Number of patients and implants	Implant type	Laser characteristic	Experimental procedures	Follow up	BOP	Plaque index	Pocket probing depth	Clinical attachment level	Gingival recession	Bone level	Comments
6	Schwarz et al. 2011[28]	Er: YAG	32 patients, 38 implants	Titanium Implants (Ankylos, Astra, Branemark, Camlog, ITI, (International team for implantology) KSI (Nobel Replace, Tapered Screw Vent, Xive)	100 mj/ Pulse 10 HZ, 11.4 J/cm2	Surgical exposure, granulation tissue removed+ implantoplasty with diamond burs+Augmentation with natural bone mineral and collagen membrane ± plastic curets plus cotton pellets and sterile saline± Laser irradiation	6 months	47.8±35.5% Reduction (p<0.001)	Plaque index reduced at 6 months (p<0.01)	Reduction of 1.7±1.4 m (p<0.001)	Increase of 1.5±1.4 mm (p<0.001)	0.2±0.2mm recession (p<0.05), but no significant difference between groups.	Increased radioopacity in 14/15 implants	Short term improvements in clinical characteristics were observed
7	Schwarz et al. 2012[27]	Er: YAG	24 patients, 26 implants	Titanium Implants (Ankylos, Astra, Branemark, Camlog, ITI, KSI, Nobel Replace, Tapered Screw Vent, Xive) (21 rough surface, 5 smooth surface)	100 mj/ Pulse 10 HZ, 11.4 J/cm2	Surgical exposure, granulation tissue removed+ implantoplasty with diamond burs+ Augmentation with natural bone mineral and collagen membrane ± plastic curets plus cotton pellets and sterile saline± Laser irradiation	24 months	75.0±32.6% reduction (p<0.001)	Plaque index reduced at 24 months, but not significant	1.7±1.2 mm reduction in 12 months (p<0.001) But not significant reduction in 24 months (1.1±2.2 mm)	1.3±1.2 mm reduction in 12 months (p<0.01) But not significant reduction in 24 months (1.0±2.2 mm)	0.4±0.2 mm recession in 12 months (p<0.01) But not significant recession in 24 months (0.1±0.4 mm)	Not reported (Reduced radioopacity in 4 implants with BOP>50% and/or suppuration)	Although significant improvements in Pocket probing depth, BOP and Clinical attachment level was observed in 12months, but only BOP remained significantly better in 24months.
8	Persson et al. 2011[26]	Er: YAG	42 patients, 100 implant	30 rough surface, 70 smooth surface	100 mj/Pulse 10 HZ 12.7J/cm2	Air abrasion or Laser irradiation	6 months	42.4 % reduction, but not significant	Not reported	0.9±0.8mm reduction, but not significant	Not reported	Not reported	No significant change	Although there was some bactericidal effects in Laser group, but at 6 months, there was no bacterial reduction
9	Yamamoto et al. 2013[25]	Er: YAG	1 patient, 5 treated implants (case report)	Not reported	50 mJ, 20 Hz	Removal of granulation tissue by laser irradiation+ decontamination of implant surface by laser	3 years	Not reported	Not reported	Not reported	Not reported	Not reported	After 3 years, apparent bone regeneration was radiologically confirmed.	Er: YAG can be a treatment alternative for peri-implantitis.

However these initial outcomes seemed not to be everlasting and found to be similar to conventional therapies, at longer periods of follow-up.

Er:YAG laser for treatment of Human peri-implantitis (Table 1)

Nine studies used Er:YAG laser in treatment of peri-implantitis, while four of them used it in combination with surgical exposure.(Table 1) Laser characteristics used in these studies were almost similar (100 mj, pulse mode, 10 Hz), except Badran et al. (120 mj, pulse mode, 10 Hz)[24] and Yamamoto et al. (50 mj, pulse mode, 20Hz)[25]. Only four studies reported energy density which was either 11.4 j/cm2 or 12.7 j/cm2.[26-29] Distance from which laser was irradiated or time of exposure was not mentioned in the studies. At the start of the interventions, all studies provided a healthy hygiene ranged from detailed instructions and demonstrations to professional supragingival cleaning, except Yamamoto study[25]. But only seven out of eight studies tried to maintain that during the screening period and scheduled to reinforce hygiene maintenance.[24, 27-32] Schwarz et al. in 2012 [27] scheduled a recall appointment 12,18 and 24 months after the surgery and provided a professional supragingival implant/tooth cleaning. Implantoplasty of the exposed threatened areas of the implant was carried out using diamond burrs and a planished surface was achieved in Schwarz studies in 2011 and 2012.[27-28]

I would like to stress that plaque index (PI) was only reduced significantly in one study at 6 months follow-up.[28] Two studies had not significant reduction in PI [27, 29], one had unchanged PI [32], two higher than baseline [30,31] and three of them did not report it [24-26]. Bleeding on probing (BOP) was brought down in all of the studies and was statistically significant in 5 of them. Even Badran et al.[24] reported a total elimination of BOP. All studies excluding Persson et al[26] and Yamamoto et al[25] reported a significant reduction in pocket probing depth (PPD). However, it has to be highlighted that Schwarz et al in 2012 [27] reported that although PPD reduction was significant through first 12 months of observation, it was not significant any more as they assessed in month 24. Clinical Attachment Level (CAL), was decreased in three of the studies [27, 30, 32] and gained in two studies [28, 31]. It`s interesting that Schwarz et al. studies in 2012 and 2006 [27, 31], exhibited no significant difference at long term follow-up (24m and 12m respectively). Bone level was either not reported or showed signs of bone formation on radiographic examinations.

Certain degree of relapse can be observed among the studies with longer period of follow-up. It could be concluded that single dose of Er:YAG laser irradiation might have short term efficiency and multiple sessions of application might bring some clinical plus points. Also as mentioned earlier, plaque index as confounding factor was not efficiently controlled and this could adversely affect the treatment outcomes.

CO_2 laser for treatment of Human peri-implantitis (Table 2)

The number of three studies found on topic of using CO_2 for treatment of peri-implantitis (Table 2), with only one of them being a clinical trial.[33] The others were a case series and a case study.[34,35]Power of the laser was in a range of 2w to 4w, mostly around 2w. Continuous mode of application was used in two of them, while Romanos et al. study [34] did not determine the mode. Duration of laser emission was 1 minute in Romanos et al. [34] study and twelve episodes of 5 second laser exposures in Deppe et al. [33] study. None of them noted the distance at which laser was applied. Deppe et al. [33] provided comparison groups of air abrasion and bone augmentation. All of the studies, exposed defect area surgically and removed granulation tissue.

Except for Romanos et al. [35], in which Plaque index was not reported, other studies showed reduced PI at the end of the monitoring, but they were not significant. Deppe et al. [33] reported a significant decrease in PI after 4 months, but it was not maintained until the last follow-up and a slight increase was obvious. Out of three reviewed studies, only Deppe et al.[33] managed to maintain the oral hygiene, by reminding instructions and demonstrations during the study.

Romanos et al. studies in 2008 and 2009 [34,35] found CO_2 laser to be an effective method for decontamination of implant surface, based on initial positive clinical outcomes they achieved. BOP and PPD was significantly reduced and an acceptable rate of bone fill was achieved in Romanos et al. [34] study, however width of keratinized mucosa did not increase significantly. They just reported a comparison of indices at baseline with final with a follow-up range of 27±17.83 months, thus it`s not clear that there was any change in pattern of healing or not. Romanos study in 2009 [35] did not include any measured indices about soft tissue and assessment was only based on radiographic evidences of healing. Besides, no follow-up was reported.

Deppe et al.[33] found that despite noticeable improvement

Table 2. Clinical human studies using CO_2 laser on oral implant surfaces

	Authors-year	Type of laser	Number of patients and implants	Implant type	Laser characteristic	Experimental procedure (Procedures prior to and post irradiation)	Control procedure	Follow up	BOP	Plaque index	Pocket probing depth	Clinical attachment level	Gingival recession	Bone level	Comments
1	Romanos et al. 2009[35]	CO_2	1 patient (case study)	Not reported	2-4 w continous	Surgical exposure granulation tissue curetted	(case study)	Not reported	Not reported	Not reported	Not-reported	Not-reported	Not-reported	Good healing and new bone formation compared to base line	No clinical conclusion can be inferred.
2	Romanos and Nentwig 2008[34]	CO_2	15 patients, 19 implants (case series)	Titanium implants (Ankylos, ITI, IMZ) 19 rough surface	2, 3, 4 W (Mean 2.84± 0.83w) For 1 min	Surgical exposure+ granulation tissue curetted+ Xenogenic or autogenous grafting	(case series)	27.1±17.83 months	Sulcus bleeding index reduced from 2.76±0.35 to 1.03 ±0.85 (P<0.01)	Plaque index was slightly reduced, but not significant	Mean reduction from 6.0±2.03mm to 2.48±0.63mm (P<0.01)	Slight, but not significant increase in width of keratinized mucosa.	Not-reported	Complete fill with xenogenic grafting. 2/3 fill with autogenous grafting	Pocket Depth and Sulcus Bleeding index has reduced during long term observation. Decontamination of the implant surfaces with CO_2 in combination with augmentive techniques could be a good way of treating peri-implantitis.
3	Deppe et al. 2007[33]	CO_2	32 patients, 73 implants	Titanium implants (IMZ, Frialit, Branemark, ITI) 67 rough surface, 6 smooth surface	1060 nm 2.5 w Continuous mode, 5 second exposure	Removal of granulation tissue, supra crestal cleaning with air-powder abrasive+Laser ± bone augmentation	Removal of granulation tissue, supra crestal cleaning with air-powder abrasive ± bone augmentation	1) 4 months 2) 5 to 59 after initial surgery	Sulcus bleeding index reduced dramatically after 4m, but was slightly decreased in last followup compared to baseline - Reduction of 42.4±52.2 % (p value not reported)	Plaque index was reduced dramatically after 4m, but was slightly decreased in last followup compared to baseline.	3.2±0.52mm reduction (p value not reported)	3.6±0.47mm gain (p>0.05)	Not reported	40.8% bone fill (p>0.05)	Laser seems to accelerate treatment of periimplantitis, according to initial clinical parameters, but long term observations revealed no significant difference.

in PPD and CAL at fourth month observation, these result did not last until next follow-up. PI and BOP measures followed a meaningful pattern in accordance with latter findings, which decreased significantly, but increased at the next follow-up.

An overall conclusion on utilization of CO_2 laser implies that unstable clinical outcomes concurrent with uncontrolled plaque index still holds this laser in a vague situation and further clinical trials are needed to achieve a certain verdict.

Diode Laser for treatment of Human peri implantitis (Table 3)

Three studies were found, implementing Diode laser in a photodynamic therapy.(Table 3) Two were clinical trials [36, 38] and one was a case report.[37] Two studies used similar laser characteristics, including implementation of a 660 nm diode laser with 100mW power for 10 seconds.[36, 38] Mode of application was not mentioned in neither of them. One study used a 810 nm diode laser with 1.96 W power in continuous mode for 6 minutes.[37] Distance from which laser was applied was only mentioned in Roncati et al.[37]study which was 1mm from the most apical portion of the pocket. During all three studies, hygiene instructions were given to the patients and reinforcement of oral hygiene was followed until 1 to 2 months.

Schar et al.[36] and Bassetti et al.[38] used diode laser with exactly the same instructions, including laser irradiation in combination with Phenothiazine chloride (HELBO), 3minutes after hand curettage, air powder abrasion and irrigation with hydrogen peroxide. Adjunctive PDT (Photodynamic Therapy) was carried out one week later.

Plaque index was only reported in two studies, presented as modified plaque index (mPlI).[36, 38] mPlI was statistically reduced at the end treatment follow ups (6 and 12 months). Schar et al.[36] reported a plaque free environment in the laser group at month 6.

BOP was significantly reduced at the end of follow ups in all three studies. Roncati et al.[37] and Schar et al.[36] reported some cases with no BOP positive sites.

PPD was reduced in all three studies. However, in Roncati et al.[37] study, 4mm PPD reduction was ascribed to formation of long junctional epithelium. Also, in Bassetti et al.[38] study, PPD reduction was not statistically significant any more at month 12. CAL was only reported in two studies [36, 38] which did not show any significant change in both studies. These two studies showed remarkable reduction in mucosal recession until month 6 and 9. However, this significant reduction was not stable until month 12 in Bassetti et al.[38] study. ($p>0.05$)

There was no report on hard tissue assessments, except radiologic assessments of Roncati et al.[37] study, which showed only some improvement of the bone level.

Conclusively, diode laser seems to have some advantages in treating peri-implantitis. However, positive clinical outcomes appear to last for short periods of time. Also, hard tissue examinations are needed to prove efficacy of this treatment option in treating bony lesions.

Discussion

Through the assiduous search that has been performed, a disharmony was found in studies regarding application of laser in treatment of peri-implantitis. Study designs had a significant diversity. Clinical parameters and indices were different in some cases, thus a clear and reliable inference could not be made. Some studies used a combination of laser therapy and other procedures. The relative effect of the laser application could therefore not be assessed.

Some studies suffered from small number of patients which might be relevant to low incidence of peri-implantitis. Sample size calculation to estimate minimal number of patients and implants are needed to achieve a statistically significant positive therapeutic outcome, and were only reported in a few studies. Blinding of the examiner was only documented in a few studies. Smoking is identified as a confounding factor that adversely affects results of periodontal therapies [39] and according to our survey, some studies did not even notice the smoking situation of the patients. However, some excluded smoker patients and some tried to distribute them in a random way.

The most important part that should be discussed is that a healthy periodontal environment is absolutely required after decontamination of implant surface to achieve desirable treatment outcomes. Failure in controlling plaque index in most of the studies can be a serious confounding factor that led to inconsistencies in the results. Enormous efforts are needed to motivate patients in order to maintain their oral hygiene and follow instructions. Regular maintenance sessions are to be scheduled.

Despite the inconsistencies in results of the previous studies, therapeutic potential of the lasers has to be noted. Positive treatment outcomes provide a foundation for future research to tune a delicate and efficient treatment protocol.

Table 3. Clinical human studies using Diode laser on oral implant surfaces

	Authors-year	Type of laser	Number of patients and implants	Implant type	Laser characteristic	Experimental procedures	Follow up	BOP	Plaque index	Pocket probing depth	Clinical attachment level	Gingival recession	Bone level	Comments
1	Schar et al. 2013[36]	Diode laser + Phenothiazine chloride (HELBO)	40 patients, 40 implants	ITI (SLA)	660 nm 100 mw 10 seconds (repeated 1 week later)	Mechanical debridement with titanium curettes and glycine-based powder air polishing and irrigation with 3% hydrogen peroxide ±Photodynamic treatment (Diode laser and HELBO) ± Local delivery of minocycline microspheres	6 months	63% reduction in BOP sites, at 6 months. 30% of the cases were free of inflammation.	Significant and complete reduction in modified plaque index was observed, at 6 month. (p<0.03)	0.36 mm reduction at 6 months (p<0.005)	No significant change in attachment level. (p>0.05)	Significant reduced mucosal recession at month 6. (p<0.02)	Not reported	PhotoDynamic Therapy can be a treatment alternative in management of initial peri-implantitis
2	Roncati et al. 2013[37]	Diode laser	1 patient, 1 implant	Titanium implant (Nobel Biocare)	810-nm, 0.5 W, 1.96 J/cm2 continuous mode total time of 360 sec	0.2% Chlorhexidine mouthwash+ laser irradiation + titanium curettage + ultrasonic device with plastic tip+ 0.5% Chlorhexidine gel in sulcus (all procedure repeated at day 2)	5 years	No BOP	Not reported	PPD reduced from 7mm to 3 mm.	Not reported	Not reported	Some improvement of the bone level	Laser can be an alternative modality in treating peri implantitis. However, reduction of the pocket seems to be related to re-epithelialization, with formation of a long junctional epithelial attachment.
3	Bassetti et al. 2013[38]	Diode laser + Phenothiazine chloride (HELBO)	40 patients, 40 implants	ITI (SLA)	660 nm, 100mW, 10 seconds (repeated 1 week later)	Mechanical debridement with titanium curettes and glycine-based powder air polishing and irrigation with 3% hydrogen peroxide ±Photodynamic treatment (Diode laser and HELBO) ± Local delivery of minocycline microspheres	12 months	57% to 63 % reduction of BOP sites in laser groups after 12 months	Statistically significant reduction after 12 months.	PPD reduction at 9 months was significant (0.30 mm) (p<0.04), but at 12 months, it was not significant. (0.11mm) (p>0.2)	No statistically significant changes (P > 0.05) were observed over time	Significant reduced mucosal recession at month 6. (p<0.02), but not stable till month 12. (p>0.05)	Not reported	PhotoDynamic Therapy may represent an alternative approach in the non-surgical treatment of initial peri-implantitis

Conclusion

Lasers showed an initial positive outcome after a 6 months follow-up. Longer periods of follow-up revealed that initial results were somehow unstable and some degrees of relapse were reported. According to the review, Er:YAG seems to have more reliable documentation and application. Treatment outcome of CO_2 and Diode laser needs to be more addressed. Future studies should have a long period of examination and follow-up for at least one year and plaque control policies should be strictly followed.

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