Clinical Outcomes of Using Lasers for Peri-Implantitis Surface Detoxification: A Systematic Review and Meta-Analysis

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The aim of this systematic review is to compare the clinical outcomes of lasers with other commonly applied detoxification methods for treating peri-implantitis. An electronic search of four databases and a hand search of peer-reviewed journals for relevant articles were conducted. Comparative human clinical trials and case series with ≥6 months of follow-up in ≥10 patients with peri-implantitis treated with lasers were included. Additionally, animal studies applying lasers for treating peri-implantitis were also included. The included studies had to report probing depth (PD) reduction after the therapy.

Results: Seven human prospective clinical trials and two animal studies were included. In four and three human studies, lasers were accompanied with surgical and non-surgical treatments, respectively. The meta-analyses showed an overall weighted mean difference of 0.00 mm (95% confidence interval = –0.18 to 0.19 mm) PD reduction between the laser and conventional treatment groups (P = 0.98) for non-surgical intervention. In animal studies, laser-treated rough-surface implants had a higher percentage of bone-to-implant contact than smooth-surface implants. In a short-term follow-up, lasers resulted in similar PD reduction when compared with conventional implant surface decontamination methods. *J Periodontol 2014;85:1194-1202.*

KEY WORDS

Decontamination; dental implants; lasers; laser therapy; meta-analysis; peri-implantitis.

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Peri-implantitis is an inflammatory process that affects both the hard and soft peri-implant tissues.[1] It is characterized by progressive loss of supporting bone beyond biologic bone remodeling, and, if this is left untreated, it is very likely that peri-implantitis will lead to the failure of the affected implant.[2] A number of risk factors have been identified that may lead to establishment and progression of peri-implantitis, including the following: 1) previous periodontal disease; 2) poor plaque control; 3) residual cement; 4) smoking; 5) genetic factors; 6) diabetes; and 7) occlusal overload.[2] However, the American Academy of Periodontology white paper[2] concluded that peri-implantitis is mainly initiated by the bacterial insult. The increases in proportions of the main periodontal pathogens, *Porphyromonas gingivalis*, *Prevotella intermedia*, *Prevotella nigrescens*, *Tannerella forsythia*, *Treponema denticola*, and *Fusobacterium nucleatum*, are associated with the occurrence of peri-implantitis.[3,4] The pathogens form a biofilm that activates inflammatory cells, such as macrophages, neutrophil granulocytes, lymphocytes, and plasma cells. Activated immune cells release cytokines and enzymes that are harmful to host tissues. Plaque biofilm was reported to cover almost 60% of the infected implant surface.[5] In addition, the biofilm adheres more strongly to rough implant surfaces than to smooth ones.[6] These biofilms

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prohibit bone cells from reattaching to the implant surface. Therefore, when performing a surgical procedure, it is suggested to not only remove the inflamed tissue but also decontaminate the infected implant surfaces.[7]

Several implant decontamination methods have been proposed, including the following: 1) mechanical debridement; 2) chemical therapy; and 3) surgical procedures aimed at removing bacteria, smoothing implant surface, and decontamination/detoxification of the implant surface using chemical agents or laser beam.[8-10] A complete implant decontamination using mechanical and chemical procedures has been proven unsuccessful because of the following reasons: 1) limited access to implant microstructures; 2) the presence of resistant bacterial strains; 3) ineffective drug dosages[11]; and 4) inadequate bactericidal effect.[12] Subsequently, application of lasers has been considered for decontamination of implant surfaces. Several in vitro and in vivo periodontal studies reported the effectiveness of erbium:yttrium-aluminum-garnet (Er:YAG) laser for root surface debridement. This type of laser not only effectively removed subgingival calculus but also showed excellent effects on soft and hard tissue ablation with strong bactericidal and photobiomodulation effects.[13,14] Improved treatment outcomes could be expected because of the advantageous characteristics of lasers, such as their hemostatic effects, selective calculus ablation, and bactericidal effects against periodontal pathogens.[15,16] Once the implant surface detoxification has been performed, it may be necessary to correct the anatomic defects with surgical interventions to improve plaque control and eliminate potential environments for anaerobic bacteria.[17,18]

Lasers with different wavelengths, which primarily determine tissue affinity and the degree of penetration, have been developed to optimize various clinical indications.[19] For example, the energy emitted by the carbon dioxide (CO_2) laser is strongly absorbed by pure, homogeneous water and by biologic tissues high in water content.[20] The Er:YAG laser is strongly absorbed by hydroxyapatite, for which it is efficient for hard tissue preparation.[21] Because of the high bactericidal ability, the CO_2 and Er:YAG lasers have also been used to decontaminate implants surfaces.[10,22] The focused, monochrome light contains high energy that is lethal to bacteria. Inconsistencies in the literature existed regarding the clinical outcomes of the laser therapy for treating peri-implantitis. Therefore, the primary aim of this systematic review is to compare the clinical outcomes as a result of using laser therapy and other commonly applied methods for implant surface decontamination. The second aim is to identify a specific type of laser that resulted in superior clinical outcomes.

MATERIALS AND METHODS

Selection Criteria and Search Strategy

Both prospective and retrospective human clinical trials published in English from January 1980 to April 2013 were screened. To be included, studies had to adhere to the following inclusion criteria: 1) ≥10 patients diagnosed with peri-implantitis and treated with lasers surgically or non-surgically; 2) a follow-up period of ≥6 months; and 3) probing depth (PD) reduction reported after the therapy. Because of the limited number of human studies, preclinical studies with a follow-up period ≥6 months were also included and analyzed separately from the human studies. The following were exclusion criteria: 1) studies published as editorials, letters, or comments and non-English citations; 2) simulating/in vitro studies; 3) review articles; and 4) case reports/series with <10 patients. The literature search was conducted by a health science librarian (MM). Four databases were searched: 1) Ovid MEDLINE; 2) PubMed; 3) EMBASE; and 4) Dentistry and Oral Sciences Source.

The search conducted in PubMed was as follows: (‘‘peri-implantitis’’[mesh] OR ‘‘peri-implant’’[title/abstract] OR ‘‘peri-implants’’[title/abstract] OR ‘‘peri-implantitis’’[title/abstract] OR peri-implant [title/abstract] OR periimplants[title/abstract] OR periimplantitis[title/abstract]) AND (“laser therapy”[mesh] OR “lasers, solid-state”[mesh] OR laser[title/abstract] OR lasers[title/abstract]) AND English[language] NOT (letter[publication type] OR comment[publication type] OR editorial[publication type]).

For the search in EMBASE, the search terms, in which ab represented abstract and ti represented title, ‘lim’ represented limits, ‘it’ represented publication types, ‘exp’ represented explode, which expands a subject heading to include its related with more specific terms, were as follows: “peri-implantitis”/exp OR “peri-implant”:ab,ti OR “peri-implants”:ab,ti OR “peri-implantitis’’:ab,ti OR peri-implant*:ab,ti AND (“laser”/exp OR “solid state laser”/exp OR laser*:ab,ti) AND [english]/lim NOT ([animals]/lim NOT [humans]/lim) NOT (“letter”/exp OR “editorial”/exp OR note:it OR erratum:it).

For searching in Dentistry and Oral Sciences Source, in which AB represented abstract, TI represented title, and SU represented subject terms. The search was as follows: (SU “PERI-implantitis” OR TI “peri-implant*” OR AB “peri-implant*”) AND (SU “Lasers” OR TI “Laser*” OR AB “Laser*”).

The search terms used for the search in Ovid MEDLINE are listed in supplementary Figure 1 in online *Journal of Periodontology*.

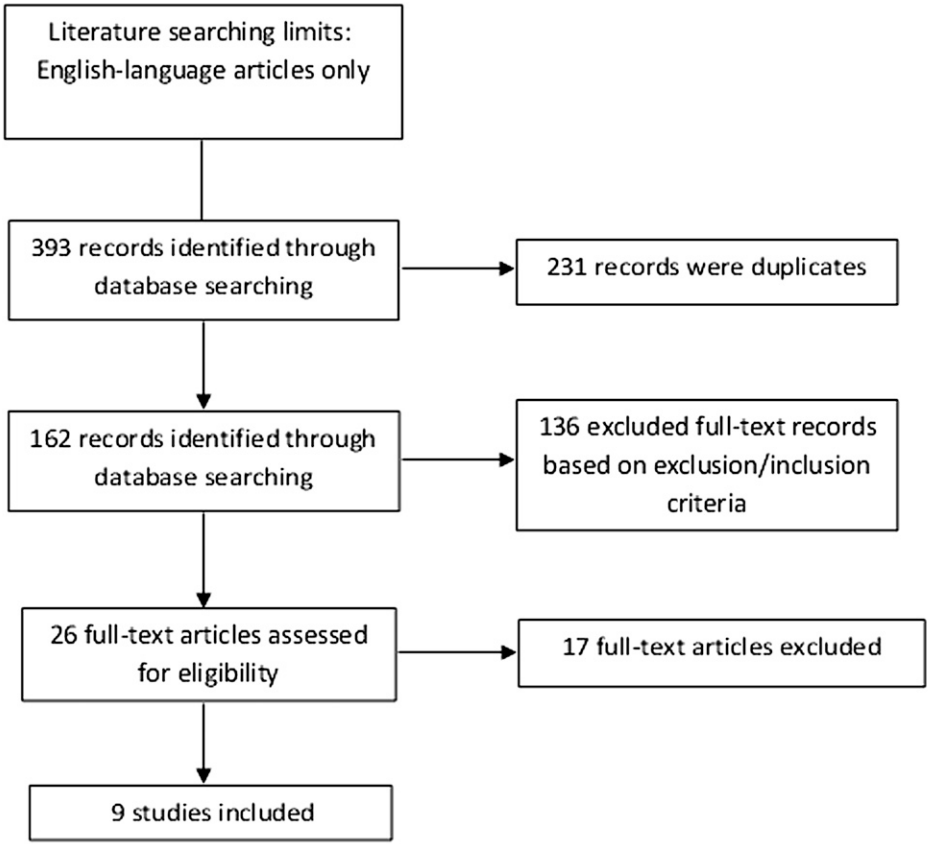

Figure 1.
Flowchart of the screening process.

A hand search was also performed for all offline journals (from January 1980 to April 2013). Furthermore, a search in the references of included papers, as well as the related systematic reviews, was conducted for publications that were not electronically identified. Potential articles were examined in full text by two reviewers (JM and H-LC), and their eligibility for this review was confirmed after discussion. The level of agreement between the reviewers regarding study inclusion was calculated with κ statistics.

Risk of Bias Assessment

The following criteria modified from the randomized controlled trial (RCT) checklist of the Cochrane Center[23] and the CONSORT (Consolidated Standards of Reporting Trials) statement[24] were used: 1) representative of general population; 2) allocation concealment method; 3) masking of the examiner; 4) intra/interexaminer calibration; 5) defined inclusions/exclusions; 6) participants drop-out, which indicated no loss of patient during follow-up period; and 7) analysis accounts for patient losses. The degree of bias was categorized as follows: 1) low risk if all the criteria were met; 2) moderate risk when only one criterion was missing; and 3) high risk if two or more criteria were missing.

Data Analyses

The primary outcome comprised the differences in PD reduction, and the secondary outcome comprised the changes of the other peri-implant parameters, including the clinical attachment level (CAL) gain, percentage of bleeding on probing (BOP) reduction, and radiographic bone gain. For comparative studies, the pooled weighted mean differences (WMDs) and the 95% confidence interval (CI) of each variable were calculated using a computer program.‡ Random-effects meta-analyses of the selected studies were applied to avoid any biases caused by methodologic differences among studies. Forest plots were formulated to graphically represent WMD and 95% CI in primary and secondary outcomes for the included comparative studies using the implant as the analysis unit. Heterogeneity was assessed with the χ^2 test and the I^2 test, which ranges from 0% to 100%, with lower values representing less heterogeneity. The reporting of the meta-analyses adhered to the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) statement.[25] In addition, the funnel plot was used to assess the presence of the publication bias.

RESULTS

The flowchart of the literature search is presented in Figure 1. The searches from the four databases yielded a total of 393 citations; after eliminating duplicates, 162 unique citations remained. After reviewing the titles and abstracts, 26 papers were further evaluated for eligibility with full text. Seventeen articles[5,8,26-40] were excluded, and the reasons for exclusion are listed in supplementary Table 1 in online *Journal of Periodontology*.

The κ value for interreviewer agreement for potentially relevant articles was 0.95 (titles and abstracts) and 0.99 (full-text articles), indicating

‡ Review Manager (RevMan) v.5.0., The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark.

an "almost perfect" agreement between the two reviewers according to the criteria of Landis and Koch.[41] Nine papers (seven human clinical trials[10,20,22,42-45] and two animal studies[9,46]) that met the inclusion criteria were included for data analyses.

Human Clinical Trials

Among the seven human clinical trials,[10,20,22,42-45] lasers were used as an adjunct to surgeries in four studies;[20,22,42,43] in the other three studies,[10,44,45] lasers were used with a non-surgical approach. All surgical groups used bone grafting materials, including autografts,[22,42] xenografts,[22,43] and alloplasts.[20] Membranes were also applied, including non-resorbable[20,42] and absorbable[22,43] membranes. Most of the treated implants in the surgical groups were rough-surface implants, whereas smooth-surface implants were more commonly found in non-surgical laser-treated groups. All implants were treated with either CO_2[20,22] or Er:YAG[10,43-45] lasers in the test groups. In the control groups, mechanical hand curettage with plastic curets[10,20,43] or air abrasives[44,45] was applied. The follow-up period ranged from 9.5[42] to 60[20] months in the surgical groups and 6 months in all non-surgical groups. Patients showed a PD and BOP reduction and CAL gain when treated surgically or non-surgically. Higher mean PD reduction was generally achieved in the groups with augmentation using bone grafting materials and membranes. Comparable radiographic bone fill was observed in surgical treatment with lasers and hand instruments.[20] When compared with conventional hand instrumentation, the laser-treated group failed to achieve higher PD/BOP reduction and CAL gain (P >0.05) (Table 1), except for in one study,[10] which showed significantly more BOP reduction in the laser group with a non-surgical approach (Table 2).

Animal Studies

Of the two included animal studies, implants were placed bilaterally in four healthy beagle dogs to examine the efficacy of CO_2 laser[9] and Er:YAG laser[46] in the treatment of ligature-induced peri-implantitis. Flap surgeries were performed to decontaminate implant surfaces by means of laser (experimental groups) or mechanical instrumentation (control groups) without using any bone grafting and/or membrane materials.[9,46] CO_2 laser achieved higher CAL gain in rough-surface implants than in smooth-surface implants.[9] In addition, laser-treated rough-surface implants had a higher percentage of bone-to-implant contact than smooth-surface implants and control groups (Table 3).[9,46] However, when compared with conventional hand instrumentation, no significantly superior outcomes were detected (P >0.05) with the use of lasers.[46]

Table 1.

Studies on Surgical Laser Decontamination of Peri-Implantitis

								GBR Methods		Outcomes							
Reference	Study Design	No. of Patients/ Animals	No. of Implants	Follow-Up (months)	Implant Surfaces	Group	Decontamination Type	Bone Grafts	Membrane	Mean PD Reduction ± SD (mm)	Significance Level	Mean CAL Gain ± SD (mm)	Significance Level	Mean BOP Reduction ± SD (%)	Significance Level	Mean Bone Fill (%)	Significance Level
Deppe et al. (2007)[20]	QE	32	73	60	67 (R)/6 (S)	T	CO_2 laser	β-TCP	NR	3.2 ± 0.52	NA	3.6 ± 0.47	P >0.05	42.4 ± 52.2	NA	40.8	P >0.05
						C	Hand curettage			2.6 ± 0.55		3.0 ± 0.34		8.7 ± 39.7		36.5	
Schwarz et al. (2012)[43]	RCT	24	26	24	21 (R)/5 (S)	T	Er:YAG laser	XG	CM	1.1 ± 2.2	P >0.05	1.0 ± 2.2	P >0.05	75.0 ± 32.6	P >0.05	NA	NA
						C	Hand curettage			1.5 ± 2.0		1.2 ± 2.2		54.9 ± 30.3		NA	
Haas et al. (2000)[42]	CS	17	24	9.5	24 (R)	T	Soft laser with TB	AG	NR	NA	NA	NA	NA	NA	NA	36.4	NA
Romanos and Nentwig (2008)[22]	CS	15	19	45	19 (R)	T	CO_2 laser	AG/XG	CM	3.52 ± 0.49	NA	NA	NA	66.5 ± 59.9	NA	NA	NA

QE = quasi experiment; CS = case series; R = rough surface; S = smooth surface; T = test group; C = control group; TB = toluidine blue O; β-TCP = beta-tricalcium phosphate; XG = xenograft; AG = autograft; NR = non-resorbable; CM = collagen membrane; NA= not applicable.

Table 2.

Studies on Non-Surgical Laser Decontamination of Peri-Implantitis

Reference	Study Design	No. of Patients/ Animals	No. of Implants	Follow-Up (months)	Implant Surfaces	Group	Decontamination Type	GBR Methods		Outcomes							
								Bone Grafts	Membrane	Mean PD Reduction ± SD (mm)	Significance Level	Mean CAL Gain ± SD (mm)	Significance Level	Mean BOP Reduction ± SD* (%)	Significance Level	Mean Bone Fill (%)	Significance Level
Schwarz et al. (2005)[10]	RCT	20	32	6	32 (R)	T	Er:YAG laser	NA	NA	0.8 ± 0.41	P >0.05	0.9 ± 0.5	P >0.05	52.1 ± 19	P <0.05	NA	NA
						C	Hand curettage + 2% CHX	NA	NA	0.7 ± 0.53		0.8 ± 0.5		21.6 ± 10		NA	
Persson et al. (2011)[44]	RCT	42	100	6	30 (R)/70 (S)	T	Er:YAG laser	NA	NA	0.9 ± 0.8	P >0.05	NA	NA	42.4	NA	NA	NA
						C	Air abrasive	NA	NA	0.8 ± 0.5		NA		29.2		NA	
Renvert et al. (2011)[45]	RCT	42	100	6	30 (R)/70 (S)	T	Er:YAG laser	NA	NA	0.8 ± 0.5	P >0.05	NA	NA	NA	NA	NA	NA
						C	Air abrasive	NA	NA	0.9 ± 0.8		NA		NA		NA	

R = rough surface; S = smooth surface; T = test group; C = control group; CHX = chlorhexidine; NA = not applicable.
* SD provided when available.

Table 3.

Animal Studies on Laser Decontamination of Peri-Implantitis

Reference	Study Design	No. of Patients/ Animals	No. of Implants	Follow-Up (months)	Implant Surfaces	Group	Decontamination Type	GBR Methods		Outcomes							
								Bone Grafts	Membrane	Mean PD Reduction (mm)	Significance Level	Mean CAL Gain ± SD (mm)	Significance Level	Mean BOP Reduction ± SD (%)	Significance Level	Mean Bone Fill ± SD (%)	Significance Level
Persson et al. (2004)[9]	NA	4	24	6	12 (R)/ 12 (S)	T	CO_2 laser	NA	NA	NA	NA	S: 0.46 ± 0.14; R: 1.13 ± 0.32	NA	NA	NA	S: 59.3 ± 8.4; R: 72.1 ± 12.4	NA
						C	Cotton pellet + saline	NA	NA	NA		S: 0.42 ± 0.13; R: 1.22 ± 0.35		NA		S: 67.6 ± 10.3; R: 62.9 ± 2.1	
Takasaki et al. (2007)[46]	NA	4	16	6	16 (R)	T	Er:YAG laser	NA	NA	NA	NA	NA	NA	NA	NA	69.7 ± 15.2	P >0.05
						C	Hand curettage	NA	NA	NA		NA		NA		39.4 ± 11.7	

NA = not applicable; R = rough surface; S = smooth surface; T = test group; C = control group.

Risk of Bias Assessment

The results of risk of bias assessment for included RCTs are summarized in supplementary Table 2 in online *Journal of Periodontology*. Three studies[10,43,44] had a low risk of bias, and one study[45] was considered to have a moderate risk of bias. However, it is worth noting that only one RCT[43] provided postoperative clinical photographs to demonstrate the stability of the peri-implant tissues. The other RCTs[10,44,45] depicted the postoperative conditions in a descriptive manner.

Results of the Meta-Analyses

Data on PD reduction were provided in one RCT[43] with surgical interventions and three RCTs[10,44,45] with non-surgical interventions (Fig. 2). For surgical interventions, the WMD of PD reduction was –0.40 mm (95% CI = –2.09 to 1.29 mm, P = 0.64). For non-surgical interventions, the WMD was 0.00 mm (95% CI = –0.18 to 0.19 mm, P = 0.98). The comparisons presented a low heterogeneity among the selected studies with non-surgical interventions (P value for χ^2 test = 0.58 and I^2 test = 0%). The results of the funnel plot presented a symmetrical distribution of included studies for PD reduction, indicating a potentially low risk of publication bias (see supplementary Fig. 2 in online *Journal of Periodontology*).

DISCUSSION

The present study found that only CO_2 laser and Er:YAG laser were used in treating peri-implantitis lesions. The specifications of these lasers are summarized in Table 4. This may be explained by the fact that these two types of lasers did not significantly increase implant body temperature during their application.[37,47] Interestingly, neodymium: yttrium-aluminum-garnet (Nd:YAG) laser was not reported in any study; a possible explanation is that Nd:YAG laser ablates titanium irrespective of output energy.[48] Similarly, the use of diode laser irradiation on implant surfaces showed increase of temperature above the critical threshold (10°C) after only 10 seconds[49] and was ineffective in removing calcified deposits.[50] Therefore, Nd:YAG and diode lasers may be contraindicated for the treatment of peri-implantitis because of increased temperature and the melting effect of titanium.[48,49] Furthermore, bactericidal effects on textured implant surfaces were only reported for CO_2 and Er:YAG lasers.[51,52]

In human clinical trials, all patients with peri-implantitis showed reduction in PD and BOP when treated with lasers surgically or non-surgically. The reduction of PD and BOP scores in the laser group might be explained by the high bactericidal effect of lasers.[37] Furthermore, several studies reported the antimicrobial effects against periodontopathic bacteria and the removal of lipopolysaccharides by laser radiation.[13,53] However, when compared with conventional hand instrumentation, the laser-treated group failed to reveal higher PD/BOP reduction and CAL gain. With regard to the promotion of radiographic bone fill, a previous study[20] reported that 40% of bone fill was achieved when using CO_2 lasers in combination with bone grafting material. It was also demonstrated that CO_2 lasers possessed the ability to enhance bone regeneration when used as a detoxification tool in the treatment of experimentally induced peri-implantitis.[30] The treatment modality for peri-implantitis, which combined implant decontamination by means of soft laser and a photosensitizing substance with guided bone regeneration (GBR), has also been reported.[42] The applied treatment concept was shown to be very effective, with 36.4% bone fill, for peri-implant bony defects. However, all types of lasers exhibited a radiographic bone fill comparable with that of other commonly used surface detoxification methods.[20,42,43]

In the laser-treated group, meta-analyses showed no significant PD reduction when it was compared with the control

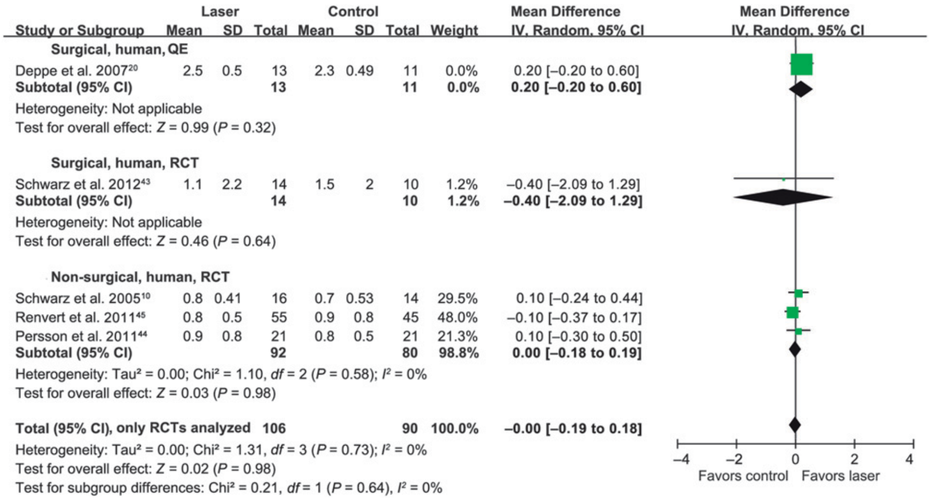

Figure 2.
Meta-analysis for PD reduction among selected studies. For surgical interventions, the WMD is –0.40 mm (95% CI = –2.09 to 1.29 mm, P = 0.64). For non-surgical interventions, three RCTs were included, and the WMD was 0.00 mm (95% CI = –0.18 to 0.19 mm, P = 0.98). QE = quasi experiment.

Table 4.

Laser Setting Parameters

Reference	Laser Type	Mode	Watt	Energy	Duration/Frequency
I. Regenerative treatment using laser					
Deppe et al. (2007)[20]	CO_2	Continuous	2.5	175 J/cm^2	12 × 5 seconds
Schwarz et al. (2012)[43]	Er:YAG	Pulsed	NA	11.4 J/cm^2	10 pulses/second
Haas et al. (2000)[42]	Soft with TB	NA	NA	NA	NA
Romanos and Nentwig (2008)[22]	CO_2	NA	2.84 ± 0.83*	NA	1 minute
II. Non-surgical treatment using laser					
Schwarz et al. (2005)[10]	Er:YAG	Pulsed	NA	12.7 J/cm^2	10 pulses/second
Persson et al. (2011)[44]	Er:YAG	NA	NA	12.7 J/cm^2	NA
Renvert et al. (2011)[45]	Er:YAG	NA	NA	12.7 J/cm^2	NA
III. Animal study					
Persson et al. (2004)[9]	CO_2	Pulsed	8	NA	20 pulses/second for 5 seconds
Takasaki et al. (2007)[46]	Er:YAG	Pulsed	NA	30 to 350 mJ/pulse	30 pulses/second; 200 µs

TB = toluidine blue O; NA = not applicable.
* Mean ± SD watts.

group (WMD = 0.00 mm, 95% CI = –0.18 to 0.19 mm, P = 0.98). This was in agreement with the European Workshop of Periodontology 2008 consensus report,[54] which stated that, in peri-implantitis lesions, non-surgical therapy was not found to be effective, and only minor effects of laser therapy of peri-implantitis have been shown. It might be hypothesized that the long-term stability of the clinical results obtained in the present study is primarily dependent on proper oral hygiene.[13] For the surgically treated group, the results could not be compared because of an insufficient number of studies with the same design.

The result of the present study corroborates the previous data analysis reported by Esposito et al.[55] The authors failed to show any benefit of using an Er:YAG laser over manual debridement with plastic curets and concluded that there was no reliable evidence suggesting which interventions could be most effective for treating peri-implantitis. However, it should not be interpreted that currently used interventions may not be effective.[55] Khoury and Buchmann[17] evaluated 41 peri-implant defects in 25 patients treated with flap surgery and citric acid for implant decontamination, followed by GBR procedures. Six months before surgical treatment, all patients received non-surgical therapy, including implant scaling and systemic antimicrobial therapy. Although the study showed that non-surgical therapy resulted in a temporary improvement of the outcome measures because decontamination of the implant surfaces could not be achieved sufficiently, surgical treatment revealed significant changes in PD reduction and intrabony defect fill and mobility score improvement at 3 years postoperatively.[17] Behneke et al.[18] also reported positive results of treating peri-implantitis with a surgical approach.[18] Intrasurgery observations showed that the median defect depth decreased from 6.9 to 0.7 mm (P = 0.001), corresponding to a 90% bone repair.[18]

Surgical treatment of peri-implantitis using Er:YAG laser versus plastic curets for implant surface decontamination has also been studied.[43] The results revealed that mean BOP, PD, and CAL values were significantly reduced in both groups. However, comparisons between groups failed to achieve statistically significant differences in PD and CAL changes at 12 and 24 months (P >0.05). Based on this observation, it might be considered that methods used for surface decontamination were not a crucial factor significantly influencing the outcome of surgical therapy of peri-implantitis.[43]

Limitations of this meta-analysis included inconsistencies in methodologies and treatment modalities, the limited number of RCTs included, the small sample size, short follow-up periods, and heavier contributions from the same research group to the results of this meta-analysis.

CONCLUSIONS

Within the limitations of this study, the following conclusions could be drawn. 1) Research on the effect lasers have when treating peri-implantitis is inadequate; CO_2 and Er:YAG lasers are the most studied lasers. 2) Lasers could be an adjunct in the treatment of peri-implantitis; however, the amounts of PD reduction, CAL gain, and radiographic bone fills as a result of the laser therapy seemed identical to other commonly used surface detoxification methods.

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