Concise Review

Diode Laser as an Adjunctive Treatment for Peri-implant Mucositis: A Systematic Review and Meta-analysis

Momen A. Atieh [a,b*], *Israa Fadhul* [a], *Maanas Shah* [a], *Haifa Hannawi* [a,c], *Nabeel H.M. Alsabeeha* [c]

[a] *Mohammed Bin Rashid University of Medicine and Health Sciences, Hamdan Bin Mohammed College of Dental Medicine, Dubai Healthcare City, Dubai, United Arab Emirates*
[b] *Sir John Walsh Research Institute, Faculty of Dentistry, University of Otago, Dunedin, New Zealand*
[c] *Dental Services Department, Emirates Health Services, Dubai, United Arab Emirates*

ARTICLE INFO

Article history:
Received 22 April 2022
Received in revised form
24 June 2022
Accepted 28 June 2022
Available online 2 August 2022

Key words:
Dental implants
Diode laser
Meta-analysis
Peri-implant mucositis
Systematic review

ABSTRACT

The early detection and management of peri-implant mucositis may help in reducing inflammatory parameters and arrest disease progression to peri-implantitis. The potential therapeutic benefits of different adjunctive therapies, such as the diode laser, are still not completely understood. The objective of this systematic review and meta-analyses was to assess the outcomes of using diode laser on the management of peri-implant mucositis in terms of changes in periodontal parameters. Electronic databases were searched to identify randomised controlled trials (RCTs) that compared the combined use of mechanical debridement and diode laser with mechanical debridement alone. A specific risk-of-bias tool was used to assess the risk of bias. Data were analysed using a statistical software programme. In total, 149 studies were found. A meta-analysis of 3 RCTs showed no statistically significant differences in probing pocket depths (mean difference [MD], −0.36; 95% confidence interval [CI], −0.88 to 0.16; $P = .18$) or bleeding on probing (MD, −0.71; 95% CI, 1.58–0.16; $P = .11$) between the 2 groups at 3 months. In the management of peri-implant mucositis, the combined use of diode laser and mechanical debridement did not provide any additional clinical advantage over mechanical debridement alone. Long-term, well-designed RCTs are still needed.

Introduction

Successful and predictable long-term dental implant treatment outcomes are well established.[1] However, implant failure and peri-implant diseases (ie, peri-implant mucositis and peri-implantitis) occur in a significant proportion of patients.[2-7]

Peri-implant diseases are diagnosed based on the routine monitoring of dental implants using clinical and radiographic parameters. Mucosal condition, plaque assessment, peri-implant probing pocket depth (PPD), peri-implant sulcular fluid analysis, suppuration, peri-implant keratinised tissue width, implant mobility, discomfort, resonance frequency analysis, and radiographs are some of the parameters that can be used to assess the presence of peri-implant disease and its severity.[8] Several definitions were previously described in the literature to define peri-implant diseases. In 2011, Heitz-Mayfield et al[9] described the condition as peri-implant mucositis when the criteria of inflammation such as bleeding on probing and no bone loss are present. Whilst Porras et al.[10] used the diagnostic criteria of modified bleeding index, plaque score, and PPD of less than 5 mm, Felo et al.[11] used bleeding on probing, plaque score, and PPD of less than 3 mm to diagnose peri-implant mucositis. The lack of consistency in outlining case definitions for peri-implant diseases in the literature makes it difficult for researchers to investigate the natural history, pathophysiology, and etiology of peri-implant diseases and for clinicians to appropriately

* *Corresponding author*. M.A. Atieh, Mohammed Bin Rashid University of Medicine and Health Sciences, Hamdan Bin Mohammed College of Dental Medicine, Dubai Healthcare City, Dubai, United Arab Emirates, Sir John Walsh Research Institute, Faculty of Dentistry, University of Otago, Dunedin, New Zealand.
E-mail address: maatieh@gmail.com (M.A. Atieh).

https://doi.org/10.1016/j.identj.2022.06.026

diagnose and treat patients. Therefore, a classification scheme was recently introduced to overcome the wide variety of peri-implant disease definitions.[12]

As per the new classification, peri-implant mucositis is a reversible plaque-induced inflammatory disease of the peri-implant soft tissues surrounding a functioning osseointegrated dental implant. Its diagnosis is based on clinical signs of inflammation without any radiographic marginal bone loss. Peri-implantitis, on the other hand, is a plaque-induced inflammatory diseases of both the soft and hard tissues surrounding a functioning osseointegrated dental implant. Beside the clinical signs of inflammation, radiographic marginal bone loss beyond initial bone remodeling is present.[13] Depending on case definitions and threshold of marginal bone loss, it has been estimated that peri-implant mucositis can occur in 63.4% of patients and 30.7% of implants, whilst peri-implantitis can occur in 18.8% and 9.6% of patients and implants, respectively.[3]

Dental biofilms around dental implants play a key role in the initiation of peri-implant mucositis that could progress to peri-implantitis if left untreated.[14,15] The main aim of peri-implant disease treatment, particularly peri-implant mucositis, is removing the biofilm surrounding the implant without changing or jeopardising implant surface characteristics, with the goal to establish a healthy peri-implant tissue.[16] This would lead to the prevention of its progression to an irreversible and often challenging-to-treat peri-implantitis.[15] The effectiveness of oral home care measures and nonsurgical treatment approaches in the management of peri-implant mucositis can improve the clinical signs of inflammation. However, complete resolution may not always be achievable due to the complexity of implant surface designs and characteristics preventing adequate removal of dental biofilm.[17] The use of adjunctive therapies, such as topical antiseptics,[10,11] local and systemic antimicrobials,[18] air-abrasive devices,[19] and lasers,[20] have been suggested to improve the efficacy of conventional mechanical debridement. The benefits of such additional therapies, however, remains unclear.

The use of diode lasers has been described as one adjunctive aide in the treatment of peri-implant mucositis.[21] Dental diode lasers have wavelengths that extend from visible to near infrared, with a range from 800 to 980 nm. An optical flexible fiber of 200 to 600 μm is used to deliver a laser beam to the target area with either continuous or pulsed emission. The high absorption in melanin and hemoglobin allow diode lasers to coagulate, cut, bleach, and disinfect with minimal damage to hard tissues and better postoperative healing.[22] The advantages of diode laser in allowing precise cuts, controlling hemostasis, and minimising postoperative pain or swelling have been demonstrated in a variety of soft tissue surgeries.[23-25] In the treatment of peri-implant diseases, diode lasers could offer additional clinical benefits in terms of inactivating pigmented Gram-negative anaerobic bacterial rods[26] and disinfecting rough and irregular implant surfaces that are difficult to reach via conventional mechanical debridement. In addition, diode lasers may decontaminate implant surfaces with minimal damage to implants.[27]

Several narrative and systematic reviews have evaluated the effects of different types of lasers in the treatment of peri-implantitis.[28-31] However, the evidence is still emerging, and the potential impacts of the adjunctive use of diode lasers in the management of peri-implant mucositis have not been fully assessed. The objective of this systematic review and meta-analyses, therefore, was to assess the outcomes of management of peri-implant mucositis using diode lasers in terms of changes in periodontal parameters based on the available evidence from randomised controlled trials (RCTs).

Materials and methods

This systematic review was prepared referring to the Cochrane guidelines[32] and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement.[33] The systematic review was registered in PROSPERO (International Prospective Register of Systematic Reviews) under reference number of CRD42022306877. A well-defined question of participant, intervention, comparison, outcome and study design (PICOS)[32,34] was formulated:

Participant: Adults aged 18 years and older who require management of peri-implant mucositis.

Intervention: Diode laser (810 nm and 980 nm) and mechanical debridement.

Comparison: Mechanical debridement alone.

Outcomes: Changes in PPD, bleeding on probing, plaque score, and mucosal recession.

Study design: RCT.

Types of studies

Inclusion criteria

RCTs comparing combined use of diode lasers and mechanical debridement to mechanical debridement alone were included. The included studies should provide information on clinical parameters including PPDs, bleeding on probing, plaque score, or mucosal recession. Language restrictions were not imposed.

Exclusion criteria: Insufficient data.

Type of participants

Participants aged 18 years old or older and requiring management of peri-implant mucositis.

Types of interventions

Comparing combined use of diode lasers (810 nm and 980 nm) and mechanical debridement to mechanical debridement alone in the treatment of peri-implant mucositis.

Outcome measures

Primary outcomes: Changes in PPDs.

Secondary outcomes: Changes in bleeding on probing, changes in plaque score, changes in mucosal recession.

Search strategy

An extensive search protocol was followed according to specific guidelines.[32,35] A literature search was conducted on 6

Table 1 – Databases and search terms.

Databases	Keywords
Published studies	
PubMed (1965-November 11, 2021)	(non-surgical treatment OR nonsurgical treatment OR diode laser) AND (peri-implant mucositis OR periimplant mucositis OR peri-implant disease* OR periimplant disease*)
EMBASE via Ovid (1947-November 11, 2021)	(non-surgical adj treatment).mp. OR (nonsurgical adj treatment).mp. OR (diode adj laser).mp. AND (peri-implant adj mucositis).mp OR (periimplant adj mucositis).mp. OR (peri-implant adj disease$).mp. OR (periimplant adj disease$).mp.
Cochrane Central Register of Controlled Trials (CENTRAL) via Ovid (November 11, 2021)	(peri-implant adj mucositis).mp OR (periimplant adj mucositis).mp. OR (peri-implant adj disease$).mp. OR (periimplant adj disease$).mp. AND (non-surgical adj treatment).mp. OR (non-surgical adj treatment).mp. OR (diode adj laser).mp.
Unpublished studies	
MetaRegister of controlled trials OpenGrey (www.opengrey.eu) ClinicalTrials.gov (November 11, 2021)	(peri-implant mucositis OR periimplant mucositis OR peri-implant diseases OR periimplant diseases) AND (non-surgical treatment OR nonsurgical treatment OR diode laser)

electronic databases up to November 11, 2021: MEDLINE, Embase, The Cochrane Central Register of Controlled Trials (CENTRAL), MetaRegister, ClinicalTrials.gov, and the System for Information on Grey Literature in Europe (http://www.opengrey.eu) (Table 1). Two authors (MA and IF) performed the search independently and in duplicate. Manual search were performed on the last 5 years of relevant dental journals (*International Journal of Oral and Maxillofacial Implants, Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, Lasers in Medical Science, Implant Dentistry, International Dental Journal*, and *Journal of Periodontology*) and bibliographies of all involved articles.

Selection of studies

Two reviewers (MA and IF) independently screened the titles and abstracts of the retrieved reference publications. After excluding irrelevant and duplicate papers, the full text was obtained from articles qualifying at the abstract level. Disagreements were settled by discussion between the 2 reviewers or referring to a third reviewer (NA). The reasons for exclusion were reported.

Data collection

Two reviewers (MA and IF) independently retrieved the following information from the finally selected articles through a data extraction sheet: (1) study features: authors' names, title, contact address, study location, year of publication, language of publication, study design (eg, parallel group or split mouth), published or unpublished data, source of study funding, allocation concealment, method of randomisation, and blinding (participants, investigators, outcome examiners); (2) participants: demographic features, number of participants in test and control groups, inclusion and exclusion criteria, number of withdrawals, and reasons for dropouts; (3) interventions: number of participants where treatment of peri-implant mucositis was performed using mechanical debridement and diode laser; (4) comparison: number of participants for whom treatment of peri-implant mucositis was performed using mechanical debridement alone; (5) outcomes: changes in PPDs, bleeding on probing, plaque score, and peri-implant mucosal recession; and (6) length of the observation period. Reviewers resolved any disagreements by discussion or referring to a third opinion (NA). If any additional information was required, the authors of the included trials were approached.

Quality assessment of included studies

The same 2 reviewers (MA and IF) independently performed quality assessment and the quality of RCTs was assessed by Cochrane Risk of Bias (RoB).[32] The RoB tool for RCTs comprises 7 categories (allocation concealment, sequence generation, blinding of outcome assessment, blinding of participants and investigators, selective outcome reporting, incomplete data outcome, and potential sources of bias). The first part of RoB tool delineates each category, whilst the second part grades studies into those having (1) low risk of bias if all the criteria were met, (2) unclear risk of bias if one or more criteria were partially met, or (3) high risk of bias if one or more criteria were not met.

Data synthesis

The meta-analysis was performed in a statistical software programme (Review Manager [RevMan] software, version 5.4, The Nordic Cochrane Center, The Cochrane Collaboration). For continuous data, such as changes in PPDs, the estimate of relative effect was presented to display the mean difference (MD) or standardised mean difference (SMD) and 95% confidence intervals (CIs). For dichotomous data, the effect sizes were expressed as risk ratio (RR) estimates and 95% CIs. A random-effects model was used to pool the results from more than one study, as heterogeneity between studies was expected. The generic inverse variance option in the statistical software programme was used to combine parallel-group and split-mouth trials.

The publication bias was not evaluated when fewer than 10 studies were included.[32] The heterogeneity between the pooled data was analysed through the Cochran test and I^2 statistic.[32] An I^2 value >50 indicated a substantial heterogeneity. The unit of analysis was the dental implant rather than the participant.

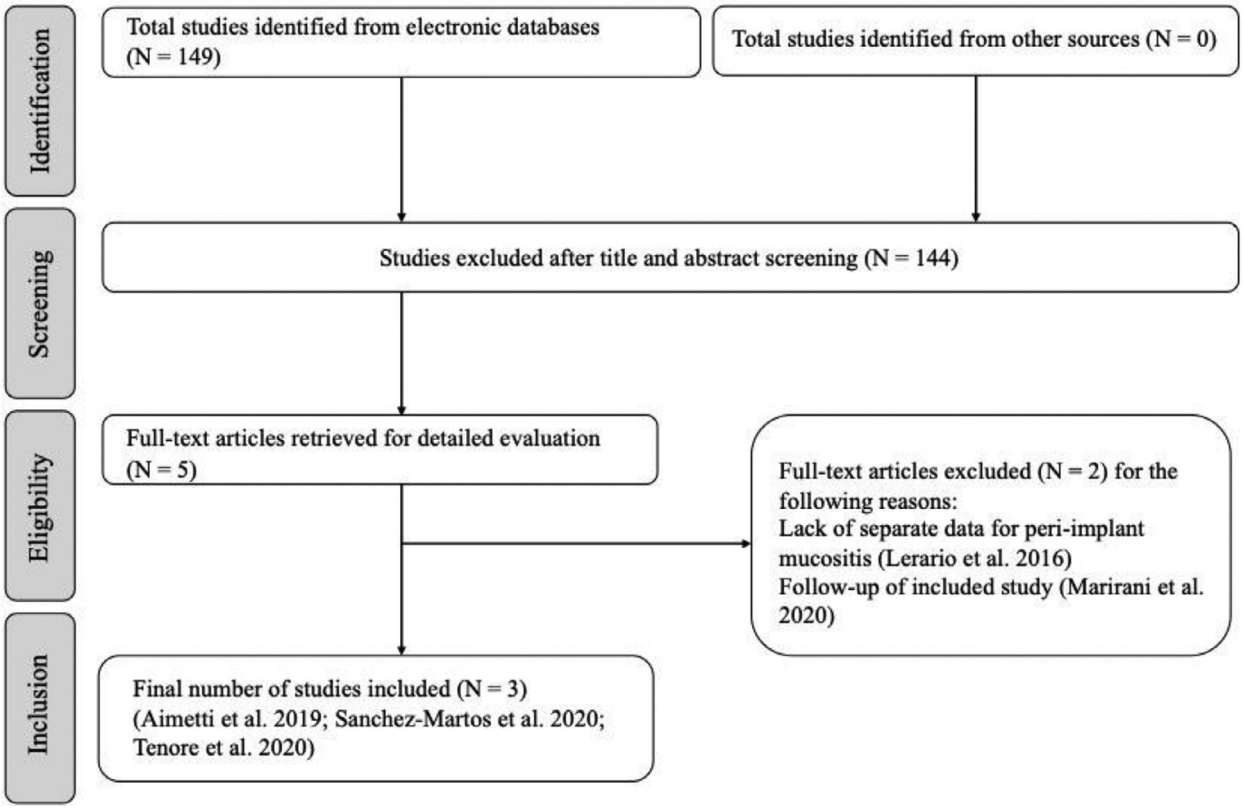

Fig. 1 – Flowchart of the search process.

Results

Study settings

In total, 149 trials were collected from the databases (Figure 1). The 2 review authors (MA and IF) examined the abstracts and titles and found 5 studies that were eligible for full-text review.[36-40] Two studies[37,38] were subsequently excluded and, as a result, 3 studies[36,39,40] were included (Table 2). Of the 3 included studies, 2 were conducted in the Italy[36,40] and one in Spain.[39] All the included RCTs were parallel-group and self-funded studies that took place in a university setting.

Baseline features of participants

Inclusion criteria.

1. Aged >18 years[39] or 20 to 80 years[40]
2. Healthy periodontium[36,39] or history of treated periodontitis without residual PPD of ≥5 mm[36]
3. Full mouth plaque score of ≤20%[36]
4. Full mouth bleeding score of ≤20%[36]
5. Presence of at least one implant site with bleeding on probing and PPD of ≥4 mm[36,39] and ≤ 6 mm[40]
6. Absence of radiographic marginal bone loss beyond the initial bone remodeling[36,39]
7. Absence of occlusal overload[36]
8. Lack of any detected cement remnants[36]
9. At least 6 months of functional loading prior to enrollment in the study[36]
10. Nonsmokers or light smokers (<10 cigarettes/d)[36]

Exclusion criteria:

1. Systemic conditions and/or medications that may affect the treatment outcomes[36,39,40]
2. Use of antibiotics within 6 months prior to initial assessment[39]
3. Long-term use of anti-inflammatory drugs[39]
4. History of head and neck radiotherapy[39]
5. Pregnancy or lactation[36]
6. Presence of peri-implantitis[36,40]
7. Previous nonsurgical peri-implant treatment within 6 months or surgical peri-implant treatment within 12 months prior to initial assessment[39]
8. Presence of cement-retained or multiple implant-supported prostheses[39]
9. Smoking[40]

Case definitions

Two studies[36,39] defined peri-implant mucositis as the presence of PPD of ≥4 mm with bleeding and/or suppuration on probing and absence of any radiographic peri-implant bone loss beyond marginal bone level changes resulting from initial bone remodeling, marginal bone loss of ≤1 mm as compared with baseline radiographs, or marginal bone loss of <2 mm in the absence of previous examination.[41,42] In

Table 2 – Characteristics of the included studies.

	Aimetti et al. 2019	Sanchez-Martos et al. 2020	Tenore et al. 2020
Study design	RCT (parallel group)	RCT (parallel group)	RCT (parallel group)
Location	University of Turin, Turin, Italy	European University of Valencia, Valencia, Spain	University of Rome, Rome, Italy
Number evaluated (participants/implants)	220/220	68/68	23/23
DL	110/110	34/34	11/11
MD	110/110	34/34	12/12
Age (y)	57.5 ± 10.1 (range, 32-78)	57.0 ± 11.39	56.1 (range, 20-80)
Smokers, n (%)			
DL	14 (12.73)	2 (5.88)	0 (0)
MD	20 (18.18)	6 (17.65)	0 (0)
History of periodontitis, n (%)			
DL	54 (49)	NR	NR
MD	45 (41)	NR	NR
Implant surface characteristics, n (%)			
Minimally rough (machined) < 1.0 μm			
DL	NR	0	NR
MD	NR	0	NR
Moderately rough 1.0-1.9 μm			
DL	NR	34	NR
MD	NR	34	NR
Rough ≥ 2.0 μm			
DL	NR	0	NR
MD	NR	0	NR
Implant time in function (y)			
DL	6.8 ± 3.6	3.1 ± 1.5	NR
MD	7.4 ± 4.4	3.1 ± 1.5	NR
Implant location			
Incisors, n (%)			
DL	8	NR	NR
MD	12	NR	NR
Canines, n (%)			
DL	6	NR	NR
MD	9	NR	NR
Premolars, n (%)			
DL	52	NR	NR
MD	42	NR	NR
Molars, n (%)			
DL	44	NR	NR
MD	47	NR	NR
Mechanical debridement	Ultrasonic and manual instruments (titanium-coated curettes or carbon fiber curettes)	Ultrasonic and manual instruments (plastic curettes)	Ultrasonic and manual instruments (titanium-coated or carbon fiber curettes)
Laser settings	980 nm 2.5 watts 10 KHz pw, 30 s	810 nm* 1 watt in pulsed mode 30 s	980 nm† 1 watt in pulsed mode 60 s
Methods of assessment	Periodontal probe	Periodontal probe‡	Periodontal probe§
Changes in PPD implant (mm) at 3 months			
DL	−0.6 ± 0.8	−0.21 ± 0.06	−1.06 ± 0.11
MD	−0.4 ± 0.7	−0.14 ± 0.08	−0.26 ± 0.15
Changes in number of implant sites with BoP at 3 months			
DL	NR‖	−0.91 ± 0.80	−3.45 ± 0.20
MD	NR‖	−0.61 ± 0.13	−2.00 ± 0.22
Changes in number of implant sites with plaque at 3 months			
DL	NR‖	−0.34 ± 0.11	NR
MD	NR‖	−0.17 ± 0.09	NR
Mucosal recessions of 1-3 mm at 3 months, n (%)			
DL	6 (5.45)	NR	NR
MD	9 (8.18)	NR	NR
Follow-up period (months)	3	3	3

RCT, randomised controlled trial; DL, diode laser; MD, mechanical debridement; PPD, probing pocket depth; BoP, bleeding on probing; NR, not reported.

* Fox® diode laser, A.R.C. Laser GmbH, Nurnberg, Germany.
† Raffaello®, Dental Medical Technologies, Lissone, Italy.
‡ North Carolina Probe, Hu-Friedy, Leinmen, Germany.
§ Goldman-Fox William, Asa Dental S.P.A., Italy.
‖ Not reported in terms of number of sites.

addition, one study[40] required the presence of PPD of ≤6 mm with bleeding and/or suppuration on probing for the diagnosis of peri-implant mucositis.

Characteristics of the interventions

The combined mechanical debridement and diode laser group included the use of 980-nm diode laser at 2.5 watts,[36] 980-nm diode laser at 1.0 watt,[40] or 810-nm diode laser at 1.0 watt[39] in pulsed mode. A 300-μm optical fiber was inserted parallel to the long axis of the implant and moved in apico-coronal and mesio-distal directions for 30[36,39] or 60 seconds.[40] Each diode laser application was preceded and followed by pocket irrigation with 3% hydrogen peroxide solution for 10 seconds.[36] Another study[39] used 0.12% chlorhexidine and 0.05% cetylpyridinium chloride for pocket irrigation, whilst the remaining one[40] applied 1% chlorhexidine gel in the peri-implant pockets. Mechanical debridement was then carried out using ultrasonic and manual instruments such as titanium coated Gracey,[36,40] carbon fiber,[36,40] or plastic curettes.[39] Both diode laser application and mechanical debridement were repeated 3 times in one study.[36]

In the mechanical debridement group, only instrumentation with ultrasonic and manual curettes were used,[36,39,40] with an operating time ranging between 7 and 10 minutes.[36] In both groups, prosthetic suprastructures were removed in one study[39] prior to mechanical debridement. At 1- and 3-month recalls, participants received reinforcement in oral home care[36,39,40] and professional implant cleaning with rubber cups and polishing paste.[36]

Features of outcome measures.

Primary outcome measures: Changes in PPDs as measured by periodontal probe.[36,39,40]

Secondary outcome measures: Changes in bleeding on probing as measured by periodontal probe[39,40]; changes in plaque score as measured by periodontal probe[39]; and changes in mucosal recession as measured by periodontal probe.[36]

Risk of bias

Methods of randomisation and allocation concealment were adequately described in all studies and hence were all found to be at low risk of bias for those categories.[36,39,40] One study[36] reported on blinding the outcome assessors and was rated to be at low risk of bias, whilst the remaining 2 studies did not mask the data assessors and were judged to be at high risk of bias.[39,40] For reporting and attrition biases, all the trials[36,39,40] were judged as low-risk (Figure 2, Table 3).

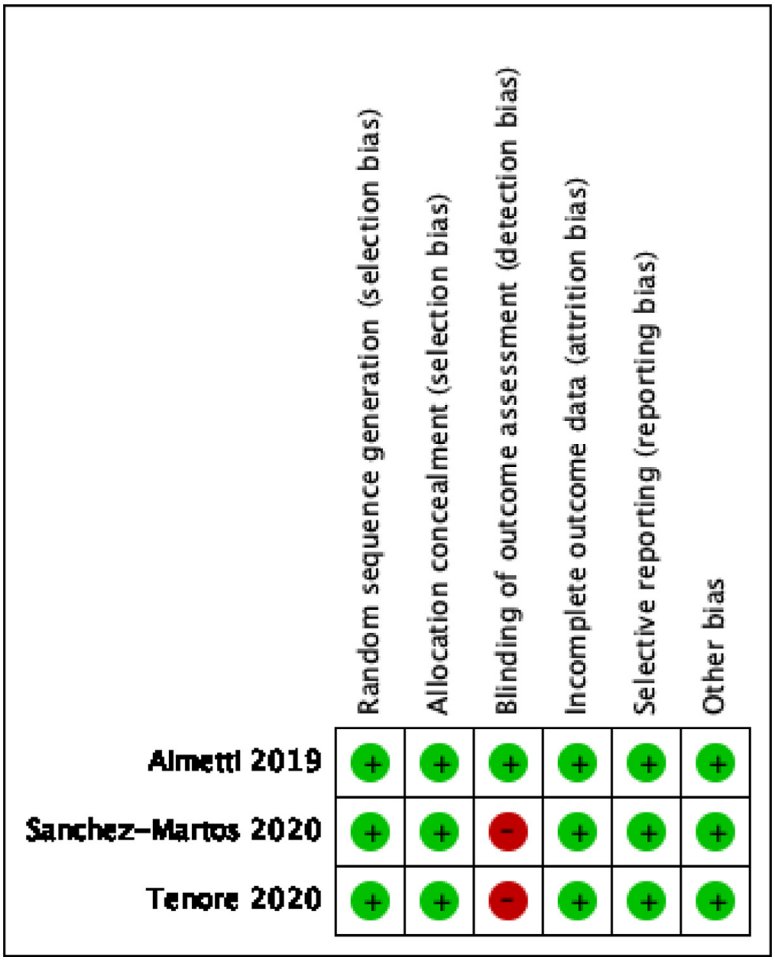

Fig. 2 – Assessment of risk of bias of the included trial.

Table 3 – Assessment of risk of bias of the included studies.

	Aimetti et al. 2019	Sanchez-Martos et al. 2020	Tenore et al. 2020
Random sequence generation (selection bias)	Low risk *Reported in the article "A balanced randomly permuted block was used to prepare the randomization table"*	Low risk *Reported in the article "using a randomized system based on stratified blocks"*	Low risk *Reported in the article "patients were randomly allocated from a computer-generated list of random numbers"*
Allocation concealment (selection bias)	Low risk *Reported in the article "To conceal assignment, forms with the treatment modality were put into identical and opaque envelopes"*	Low risk *Reported in the article "The allocation concealment was carried out through the use of sealed opaque envelopes"*	Low risk *Reported in the article "Allocation concealment was achieved through the provision, by professionals not involved in patient enrolment, of a numbered sequence of opaque and sealed envelopes"*
Blinding of outcome assessment (detection bias)	Low risk *Reported in the article "Two examiners, who were blinded to the group assignment, performed all measurements of clinical assessment"*	High risk *Reported in the article "The interventions assigned to each group were performed by a calibrated and trained examiner not blind to the group assignment"*	High risk *No information in the article*
Incomplete outcome data (attrition bias)	Low risk *All data presented*	Low risk *All data presented*	Low risk *Number and reasons for withdrawals were reported. It does not seem that the lost data had affected the results*
Selective reporting (reporting bias)	Low risk *All outcomes appear to be detected*	Low risk *All outcomes appear to be detected*	Low risk *All outcomes appear to be detected*
Other bias	None detected	None detected	None detected

Sample size calculation

All studies[36,39,40] described the sample size calculation.

Registration of clinical trials

No information was provided on whether any of the 3 studies[36,39,40] was registered prior to the initiation of the study.

Effects of interventions

In total, 311 participants with 311 dental implants diagnosed with peri-implant mucositis were included in the present review. Of these, 155 implants were treated using diode laser and mechanical debridement, whilst the remaining implants were treated with mechanical debridement alone.

Changes in PPD

All included studies[36,39,40] reported on changes of PPDs. With regard to changes in PPDs at 3 months, the difference in PPDs was not statistically significant amongst implants treated with mechanical debridement and diode laser or mechanical debridement alone (MD, −0.36; 95% CI, −0.88 to 0.16; $P = 0.18$; Figure 3). Substantial heterogeneity was detected ($\chi^2 = 163.40$, $df = 2$ [$P < .0001$]; $I^2 = 99\%$).

Changes in bleeding on probing and plaque score

All studies[36,39,40] reported changes in bleeding on probing at 3 months. The meta-analyses showed no significant difference in bleeding on probing between the combined use of mechanical debridement and diode laser and mechanical debridement alone (MD, −0.71; 95% CI, 1.58–0.16; $P = .11$; Figure 4A). Significant heterogeneity was detected ($\chi^2 = 59.56$, $df = 2$ [$P < .0001$] $I^2 = 97\%$). The changes in plaque score were reported in 2 studies.[36,39] Significant reduction in plaque score was

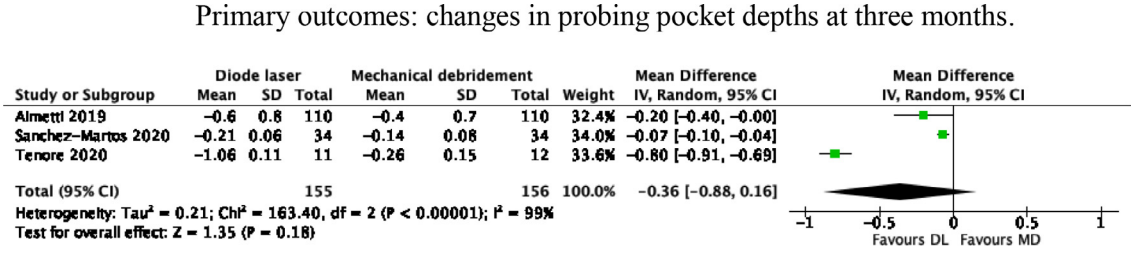

Fig. 3 – Comparison of treatment of peri-implant mucositis: diode laser vs mechanical debridement. Primary outcomes are changes in probing pocket depths at 3 months.

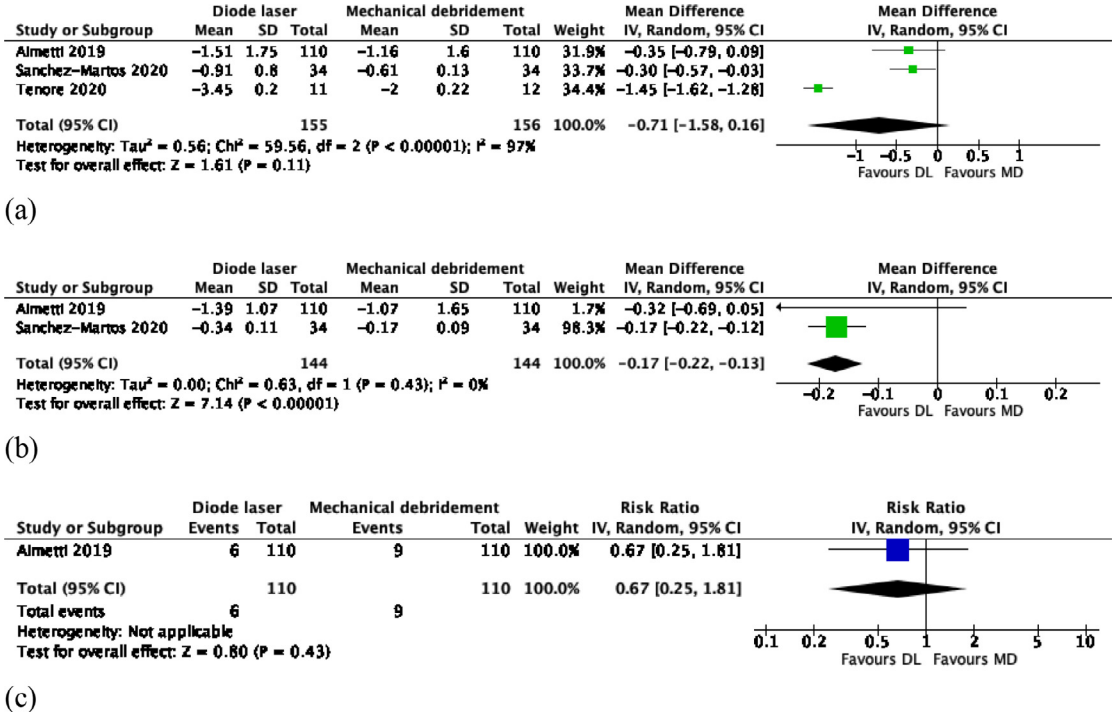

Fig. 4 – Comparison of treatment of peri-implant mucositis: diode laser vs mechanical debridement. Secondary outcomes are (a) changes in bleeding on probing, (b) changes in plaque score, and (c) peri-implant mucosal recession.

observed with use of the diode laser (MD, −0.17; 95% CI, −0.22 to −0.13; $P < .0001$; Figure 4B) without any substantial heterogeneity ($\chi^2 = 0.63$, $df = 1$ [$P = .43$]; $I^2 = 0\%$).

Peri-implant mucosal recession

Mucosal recession was documented in one study.[36] The difference in number of sites with 1- to 3-mm recession was not statistically significant between the 2 groups (RR, 0.67; 95% CI, 0.25–1.81; $P = .43$; Figure 4C).

Discussion

Summary of main results

The present review compared the clinical outcomes of treatment of peri-implant mucositis with either combined mechanical debridement and diode laser or conventional mechanical debridement alone. Diode laser (810 nm or 980 nm) seems to have no significant effect on PPD, bleeding on probing, and peri-implant mucosal recession when compared to conventional mechanical debridement except for plaque score. Although the decrease in plaque score observed in the diode laser group was statistically significant, its clinical relevance could be considered negligible.

Quality of evidence

The present review included only RCTs based on strict selection criteria so that the heterogeneity is reduced and the overall quality is enhanced. However, heterogeneity amongst the included studies was significant. Sources of heterogeneity were related to differences in designs and characteristics of implant surface as well as the use of different instruments (ie, ultrasonic with either titanium-coated Gracey, carbon fiber, or plastic curettes) for mechanically debriding the implant surfaces. Other sources of heterogeneity were the use of different antiseptics (ie, 0.12% chlorhexidine, 0.05% cetylpyridinium chloride, and 1% chlorhexidine gel) for pocket irrigation in the test group and the timing of laser application (30 vs 60 seconds). However, homogeneity across the included studies was observed in terms of case definitions and observation period. Overall, the generalisability of the findings using diode laser as an adjunctive tool for treatment of peri-implant mucositis is week, and it is critical to further assess the effectiveness of diode laser use amongst different implant locations and systems.

The included trials described the method of randomisation and allocation concealment; however, 2 studies[39,40] did not assess the outcomes blindly and were judged to be at high risk for bias. All of the studies were rated at low risk for attrition and reporting bias. The limitations of absence of assessor blinding and heterogeneity across the studies require cautious interpretation of the outcomes of the present systematic review.

Applicability of evidence

The early detection and treatment of peri-implant mucositis may allow resolution of peri-implant inflammation and arrest disease progression to peri-implantitis.[43,44] However,

complete resolution is not always achieved,[17] and therefore using an adjunctive therapy may provide additional benefits to conventional mechanical debridement. The present systematic review showed that conventional mechanical debridement with diode laser was effective in lowering inflammatory signs up to 3-month follow-up. However, the peri-implant tissue response to diode laser did not reach statistical or clinical significance in terms of reduction of PPD and bleeding on probing when compared to mechanical debridement alone.

The use of different diode laser settings amongst the included studies might have influenced the efficacy of diode laser as an implant decontamination tool. The frequency and timing of laser application varied between 1 and 3 applications and 30 to 60 seconds, respectively. It is assumed that a single laser application may not maintain the anti-inflammatory effect.[45] Repeating laser application 3 times in one included study,[36] however, did not yield statistically significant improvements in periodontal parameters in the test group. On the other hand, a recent study has shown that the repeated application of diode laser on titanium implants has eradicated all the microorganisms in more than two-thirds of the sample without changing the quality of the implant surface.[46] In the same context, Mettraux et al[47] showed that repeated diode laser application following mechanical debridement in the management of peri-implantitis lesions resulted in a significant improvement in the periodontal parameters for at least 2 years. Moreover, temperature rise above critical threshold of 10 °C after 18 seconds of application[48,49] could be an associated issue of concern. For example, the application of diode laser for 60 seconds in one study[40] brings about more heat that could have jeopardised the implant and surrounding peri-implant tissues.[50] Therefore, special considerations of thermal damage should be taken into account to minimise the improper irradiation effect.[51] The optic fiber diameter, which influences the power density and amount of energy released during laser application, could have possibly altered the anti-inflammatory effects of the diode laser.[52] Nevertheless, diode laser has been safely used for peri-implant soft tissue modification and uncovering of submerged dental implants without untoward alteration to titanium implant surfaces compared to other types of lasers or settings.[27] Moreover, no adverse effects such as swelling, pain, or discomfort were detected following the adjunctive use of diode laser with mechanical debridement in the treatment of peri-implant diseases.[47]

The antimicrobial effect of diode lasers has also been evaluated in different implant surfaces and materials. The findings suggest that the diode laser can decontaminate several types of implant surfaces such as hydroxyapatite-coated, plasma-sprayed, acid-etched, and sandblasted titanium surfaces. The required power density to generate a sufficient bactericidal effect is determined by surface characteristics.[51] When evaluating the effect of diode lasers on different materials utilised for dental implant constructions such as zirconia and porcelain, the laser operation effectively eliminated bacteria from the surfaces, regardless of the exposure period. Moreover, diode laser irradiation on healing abutments has markedly eliminated the predominant pathogenic bacteria and accelerated wound healing without any harmful effects on the evaluated implant material.[53,54]

It remains unclear whether removal or retention of the prosthetic suprastructure, implant surface characteristics, or implant design have influenced the treatment outcomes reported in this review. Only one study[39] has reported the removal of the implant prosthesis to allow access for peri-implant debridement, and only one study[39] has described the implant system. The small number of included trials, therefore, did not allow an adequate evaluation of the potential benefits of implant prosthesis removal or determine whether the presence of machined or moderately roughened implant surface have any influence on the treatment outcomes.

Agreements and disagreements with other systematic reviews

The findings of using lasers of various wavelengths in treating peri-implant diseases have been reported in several reviews,[28,29,55-59] but the outcomes of using diode lasers in the management of peri-implant mucositis was reported in 2 systematic reviews.[20,60] Both reviews[20,60] included studies that evaluated the adjunctive use of both photodynamic therapy and diode laser of different wavelengths and showed that both adjunctive therapies did not provide additional benefits, in agreement with our findings. However, the present review adopted an extensive search protocol and included only RCTs that met stringent criteria having a test group in which dental implant sites with peri-implant mucositis were treated with mechanical debridement and diode laser (810 nm and 980 nm) and a control group in which sites were treated with mechanical debridement alone. A quantitative analysis of outcomes related to changes in periodontal parameters was also reported. Nevertheless, a number of limitations primarily related to the limited number of trials, the number of withdrawals in one study,[40] and the heterogeneity across the trials included in the present review should be noted. In particular, heterogeneity in terms of implant locations, surface characteristics, types of curettes, and laser settings need to be acknowledged. Moreover, microbiologic, cost-effectiveness, and patient-reported outcomes were not analysed in this review due to lack of or limited information.

Conclusions

In the management of peri-implant mucositis, the combined use of a diode laser and mechanical debridement did not provide any additional clinical advantage over mechanical debridement alone. Long-term, well-designed RCTs are still needed.

Author contributions

Momen A. Atieh: Concept/design, data collection, data analysis/interpretation, drafting article, critical revision of article, approval of article.

Israa Fadhul: Concept/design, data collection, critical revision of article, approval of article.

Maanas Shah: Critical revision of article, approval of article.

Haifa Hannawi: Critical revision of article, approval of article.

Nabeel H.M. Alsabeeha: Critical revision of article, approval of article.

Conflict of interest

None disclosed.

REFERENCES

1. Buser D, Sennerby L, De Bruyn H. Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions. Periodontol 2000;73:7–21 2017.
2. Atieh MA, AlAli F, Alsabeeha NHM. Outcome of supportive peri-implant therapy on the rates of peri-implant diseases and marginal bone loss: a systematic review and meta-analysis. Quintessence Int 2021;52:122–31.
3. Atieh MA, Alsabeeha NH, Faggion Jr CM, Duncan WJ. The frequency of peri-implant diseases: a systematic review and meta-analysis. J Periodontol 2013;84:1586–98.
4. Atieh MA, Pang JK, Lian K, et al. Predicting peri-implant disease: chi-square automatic interaction detection (CHAID) decision tree analysis of risk indicators. J Periodontol 2019;90:834–46.
5. Atieh MA, Shah M, Alsabeeha NH. Etiology of peri-implantitis. Curr Oral Health Rep 2020;7:313–20.
6. Berryman Z, Bridger L, Hussaini HM, Rich AM, Atieh M, Tawse-Smith A. Titanium particles: an emerging risk factor for peri-implant bone loss. Saudi Dent J 2020;32:283–92.
7. Tawse-Smith A, Atieh M, Leichter J, Girvan L, Rich AM. Peri-implant bone loss and its uncommon causes: a case report. Clin Adv Periodontics 2015;5:242–7.
8. Salvi GE, Lang NP. Diagnostic parameters for monitoring peri-implant conditions. Int J Oral Maxillofac Implants 2004;19 (Supp l):116–27.
9. Heitz-Mayfield LJ, Salvi GE, Botticelli D, et al. Anti-infective treatment of peri-implant mucositis: a randomised controlled clinical trial. Clin Oral Implants Res 2011;22:237–41.
10. Porras R, Anderson GB, Caffesse R, Narendran S, Trejo PM. Clinical response to 2 different therapeutic regimens to treat peri-implant mucositis. J Periodontol 2002;73:1118–25.
11. Felo A, Shibly O, Ciancio SG, Lauciello FR, Ho A. Effects of subgingival chlorhexidine irrigation on peri-implant maintenance. Am J Dent 1997;10:107–10.
12. Caton JG, Armitage G, Berglundh T, et al. A new classification scheme for periodontal and peri-implant diseases and conditions - introduction and key changes from the 1999 classification. J Periodontol 2018;89(Suppl 1):S1–8.
13. Berglundh T, Armitage G, Araujo MG, et al. Peri-implant diseases and conditions: consensus report of workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Clin Periodontol 2018;45(Suppl 20):S286–91.
14. Jepsen S, Berglundh T, Genco R, et al. Primary prevention of peri-implantitis: managing peri-implant mucositis. J Clin Periodontol 2015;42(Suppl 16):S152–7.
15. Salvi GE, Zitzmann NU. The effects of anti-infective preventive measures on the occurrence of biologic implant complications and implant loss: a systematic review. Int J Oral Maxillofac Implants 2014;29(Supp l):292–307.
16. Figuero E, Graziani F, Sanz I, Herrera D, Sanz M. Management of peri-implant mucositis and peri-implantitis. Periodontol 2014;66:255–73 2000.
17. Schwarz F, Becker K, Sager M. Efficacy of professionally administered plaque removal with or without adjunctive measures for the treatment of peri-implant mucositis. A systematic review and meta-analysis. J Clin Periodontol 2015;42 (Suppl 16):S202–13.
18. Suarez-Lopez Del Amo F, Yu SH, Wang HL. Non-surgical therapy for peri-implant diseases: a systematic review. J Oral Maxillofac Res 2016;7:e13.
19. Riben-Grundstrom C, Norderyd O, Andre U, Renvert S. Treatment of peri-implant mucositis using a glycine powder air-polishing or ultrasonic device: a randomized clinical trial. J Clin Periodontol 2015;42:462–9.
20. Albaker AM, ArRejaie AS, Alrabiah M, Abduljabbar T. Effect of photodynamic and laser therapy in the treatment of peri-implant mucositis: a systematic review. Photodiagnosis Photodyn Ther 2018;21:147–52.
21. Heitz-Mayfield LJ, Mombelli A. The therapy of peri-implantitis: a systematic review. Int J Oral Maxillofac Implants 2014;29 (Supp l):325–45.
22. Goharkhay K, Moritz A, Wilder-Smith P, et al. Effects on oral soft tissue produced by a diode laser in vitro. Lasers Surg Med 1999;25:401–6.
23. Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: an innovative tool in modern dental practice. Natl J Maxillofac Surg 2012;3:124–32.
24. Hilgers JJ, Tracey SG. Clinical uses of diode lasers in orthodontics. J Clin Orthod 2004;38:266–73.
25. Kamma JJ, Vasdekis VG, Romanos GE. The effect of diode laser (980 nm) treatment on aggressive periodontitis: evaluation of microbial and clinical parameters. Photomed Laser Surg 2009;27:11–9.
26. Chan Y, Lai CH. Bactericidal effects of different laser wavelengths on periodontopathic germs in photodynamic therapy. Lasers Med Sci 2003;18:51–5.
27. Romanos GE, Everts H, Nentwig GH. Effects of diode and Nd: YAG laser irradiation on titanium discs: a scanning electron microscope examination. J Periodontol 2000;71:810–5.
28. Ashnagar S, Nowzari H, Nokhbatolfoghahaei H, et al . Laser treatment of peri-implantitis: a literature review. J Lasers Med Sci 2014;5:153–62.
29. Mattar H, Bahgat M, Ezzat A, Bahaa El-Din B, Keraa K, El Taftazany I. Management of peri-implantitis using a diode laser (810 nm) vs conventional treatment: a systematic review. Lasers Med Sci 2021;36:13–23.
30. Ramanauskaite A, Daugela P, Juodzbalys G. Treatment of peri-implantitis: meta-analysis of findings in a systematic literature review and novel protocol proposal. Quintessence Int 2016;47:379–93.
31. Ting M, Craig J, Balkin BE, Suzuki JB. Peri-implantitis: a comprehensive overview of systematic reviews. J Oral Implantol 2018;44:225–47.
32. Higgins JPT, Thomas J, Chandler J, et al. Cochrane handbook for systematic reviews for interventions version 6.0 [online]. Cochrane Collaboration; 2019.
33. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151:264–9 W264.
34. Richardson WS, Wilson MC, Nishikawa J, Hayward RS. The well-built clinical question: a key to evidence-based decisions. ACP J Club 1995;123:A12–3.
35. Faggion Jr CM, Atieh MA, Park S. Search strategies in systematic reviews in periodontology and implant dentistry. J Clin Periodontol 2013;40:883–8.
36. Aimetti M, Mariani GM, Ferrarotti F, Ercoli E, Liu CC, Romano F. Adjunctive efficacy of diode laser in the treatment of peri-

implant mucositis with mechanical therapy: a randomized clinical trial. Clin Oral Implants Res 2019;30:429–38.
37. Lerario F, Roncati M, Gariffo A, et al. Non-surgical periodontal treatment of peri-implant diseases with the adjunctive use of diode laser: preliminary clinical study. Lasers Med Sci 2016;31:1–6.
38. Mariani GM, Ercoli E, Guzzi N, et al. One-year clinical outcomes following non-surgical treatment of peri-implant mucositis with adjunctive diode laser application. Minerva Stomatol 2020;69:269–77.
39. Sanchez-Martos R, Samman A, Bouazza-Juanes K, Diaz-Fernandez JM, Arias-Herrera S. Clinical effect of diode laser on peri-implant tissues during non-surgical peri-implant mucositis therapy: randomized controlled clinical study. J Clin Exp Dent 2020;12:e13–21.
40. Tenore G, Montori A, Mohsen A, Mattarelli G, Palaia G, Romeo U. Evaluation of adjunctive efficacy of diode laser in the treatment of peri-implant mucositis: a randomized clinical trial. Lasers Med Sci 2020;35:1411–7.
41. Sanz M, Chapple IL;. Working Group 4 of the VEWoP. Clinical research on peri-implant diseases: consensus report of Working Group 4. J Clin Periodontol 2012;39(Suppl 12): 202–6.
42. AAP. Peri-implant mucositis and peri-implantitis: a current understanding of their diagnoses and clinical implications. J Periodontol 2013;84:436–43.
43. Pontoriero R, Tonelli MP, Carnevale G, Mombelli A, Nyman SR, Lang NP. Experimentally induced peri-implant mucositis. A clinical study in humans. Clin Oral Implants Res 1994;5:254–9.
44. Salvi GE, Aglietta M, Eick S, Sculean A, Lang NP, Ramseier CA. Reversibility of experimental peri-implant mucositis compared with experimental gingivitis in humans. Clin Oral Implants Res 2012;23:182–90.
45. Ramos UD, Ayub LG, Reino DM, et al. Antimicrobial photodynamic therapy as an alternative to systemic antibiotics: results from a double-blind, randomized, placebo-controlled, clinical study on type 2 diabetics. J Clin Periodontol 2016;43:147–55.
46. Wawrzyk A, Lobacz M, Adamczuk A, Sofinska-Chmiel W, Rahnama M. The efficacy of a diode laser on titanium implants for the reduction of microorganisms that cause periimplantitis. Materials (Basel) 2021;14.
47. Mettraux GR, Sculean A, Burgin WB, Salvi GE. Two-year clinical outcomes following non-surgical mechanical therapy of peri-implantitis with adjunctive diode laser application. Clin Oral Implants Res 2016;27:845–9.
48. Sennhenn-Kirchner S, Klaue S, Wolff N, Mergeryan H, Borg von Zepelin M, Jacobs HG. Decontamination of rough titanium surfaces with diode lasers: microbiological findings on in vivo grown biofilms. Clin Oral Implants Res 2007;18:126–32.
49. Tavares LJ, Pavarina AC, Vergani CE, de Avila ED. The impact of antimicrobial photodynamic therapy on peri-implant disease: what mechanisms are involved in this novel treatment? Photodiagnosis Photodyn Ther 2017;17:236–44.
50. Geminiani A, Caton JG, Romanos GE. Temperature change during non-contact diode laser irradiation of implant surfaces. Lasers Med Sci 2012;27:339–42.
51. Kreisler M, Kohnen W, Marinello C, et al. Antimicrobial efficacy of semiconductor laser irradiation on implant surfaces. Int J Oral Maxillofac Implants 2003;18:706–11.
52. Radvar M, MacFarlane TW, MacKenzie D, Whitters CJ, Payne AP, Kinane DF. An evaluation of the Nd:YAG laser in periodontal pocket therapy. Br Dent J 1996;180:57–62.
53. Wawrzyk A, Lobacz M, Adamczuk A, Sofinska-Chmiel W, Wilczynski S, Rahnama M. The use of a diode laser for removal of microorganisms from the surfaces of zirconia and porcelain applied to superstructure dental implants. Microorganisms 2021;9.
54. Wawrzyk A, Rahnama M, Rybitwa D, Wilczynski S, Machoy M, Lobacz M. Effective microbiological decontamination of dental healing abutments colonised with *Rothia aeria* by a diode laser as a helpful step towards successful implantoprosthetic therapy. Lasers Med Sci 2021;36:875–87.
55. Lin GH, Suarez Lopez Del Amo F, Wang HL. Laser therapy for treatment of peri-implant mucositis and peri-implantitis: an American Academy of Periodontology best evidence review. J Periodontol 2018;89:766–82.
56. Shahmohammadi R, Younespour S, Paknejad M, Chiniforush N, Heidari M. Efficacy of adjunctive antimicrobial photodynamic therapy to mechanical debridement in the treatment of peri-implantitis or peri-implant mucositis in smokers: a systematic review and meta-analysis. Photochem Photobiol 2022;98(1):232–41.
57. Saneja R, Bhattacharjee B, Bhatnagar A, Kumar PGN, Verma A. Efficacy of different lasers of various wavelengths in treatment of peri-implantitis and peri-implant mucositis: A systematic review and meta-analysis. J Indian Prosthodont Soc 2020;20:353–62.
58. Choe R, Balhaddad AA, Fisher JP, Melo MAS, Huang HC. photodynamic therapy for biomodulation and disinfection in implant dentistry: is it feasible and effective? Photochem Photobiol 2021;97:916–29.
59. Pisano M, Sammartino P, Di Vittorio L, et al. Use of diode laser for surgical removal of pyogenic granuloma of the lower lip in a pediatric patient: a case report. Am J Case Rep 2021;22:e929690.
60. Sanchez-Martos R, Samman A, Priami M, Arias-Herrera S. The diode laser as coadyuvant therapy in the non-surgical conventional treatment of peri-implant mucositis: a systematic review and meta-analysis. J Clin Exp Dent 2020;12:e1171–82.