The efficacy of the diode laser at 800–980 nm as an aid to non-surgical therapy in periodontitis treatment: a review of literature

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The aim of this literature review is to assess the effectiveness of diode laser at a wavelength of 800-980 nm in addition to non-surgical periodontal therapy in periodontitis treatment. The authors performed an electronic research on Pubmed inserting as keywords: (laser OR laser therapy OR diode laser) and (periodontitis OR periodontal disease). The field has been narrowed to select only Randomized controlled clinical trials (RCT) performed from 2010 to 2020. The result of this research was 84 articles, of which eight were included in the review because they respect the inclusion criteria. The clinical, immunological, and microbiological parameters studied in the various clinical random trials were analysed. It has been shown that four out of eight studies have achieved greater benefits, in terms of clinical parameters, with the use of diode laser compared to Scaling and Root Planing. However, the greater increase in clinical parameters in diode laser-treated patients compared to the control group was mainly detected in the short term rather than in the long term. In terms of microbiological parameters, no improvement was detected after six months. Only one study reported six-month improvements in immunological parameters in patients treated with DL compared to the Scaling and Root Planing only group. In conclusion, considering the limitations of this review of literature, there is no evidence that the diode laser at 800-980 nm in addition to non-surgical periodontal therapy is more effective than SRP alone in the long term.

The purpose of the following narrative review of the literature is based on the hypothesis that diode laser at 800-980 nm in addition to non-surgical periodontal therapy in periodontitis treatment could be more effective than non-chemical therapy alone. Therefore, the hypothesis is exactly that the diode laser could be an effective aid to scaling and root planning in the treatment of the periodontitis. In literature, laser's employment is a very discussed theme because of the difference between the results of the studies, these differences are due to the several lasers and wavelength type. Therefore, in this review have been included only studies regarding the diode laser at 800-980 nm, to ensure the homogeneity of the results. Periodontitis is a chronic multifactorial disease that affects the supporting tissues of the tooth. Periodontal tissues are constantly exposed to various bacteria that can alter many local cellular functions (1).

Periodontitis occurs when untreated gingivitis progresses to the loss of the gingiva, bone and ligament, which creates the deep periodontal

Key words: diode laser; periodontitis; non-surgical therapy; scaling and root planing

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0393-974X (2020)

'pockets' that are a hallmark of the disease and can eventually lead to tooth loss. It has been widely demonstrated that the bacteria forming the dental biofilm are the main causative factor of the periodontal disease (2). In fact, the tissues respond to the bacterial attack by implementing an inflammatory process that protects the structures from the bacterial biofilm; the consequence, however, is that a part of the tissues is destroyed during this process (3). The extent and severity of the damage as an evidence of this project may vary from individual to individual. This variation in disease expression is the result of the interaction of host genetics and environmental and microbial factors (4).

In addition to limiting damage to the local level with non-surgical therapy, it could be hypothesized with further studies whether laser in its biomodulative action can stimulate the numerous populations of mesenchymal stem cells isolated from oral tissues (DPSCs, SHEDs, PDLSCs, DFSCs, SCAPs, hPCy-MSCs) to maintain proliferation and multipotency capacities (5). In fact, the scientific community is focusing on the ability of these cells to regenerate tissues through the production of MSC secretomes or with an immunomodulatory activity towards cells of the first immune response (6-7).

A key role in inflammatory response is also played by cytokines, specifically by two families of growth factors-such as transforming growth factor-Bl (TGF-PI) and vascular endothelial growth factor (VEGF) a. In fact, some results obtained suggests, that these two factors play a key role in regulating the immune response which is directly related to the evolution of periodontal disease (8). The therapy is mainly based on the mechanical plaque removal by Scaling and Root Planing (SRP) which in fact are considered a gold standard in periodontal therapy (9). It has also been shown how periodontal therapy affects the improvement of disorganized endothelial vascular structure associated with periodontitis, this because the gingival microcirculation undergoes a change as a result of inflammation progression (10).

Another parameter to consider, although it does not yet have much scientific evidence, is the reduction of mobility as evidence of scaling and root planing. However, it is important to note that non-surgical periodontal instrumentation has some limitations that are the long-term maintainability of the deeper periodontal pockets and the risk of recurrence, and the success of this therapy depends very much on the operator's dexterity (11).

SRP can be accomplished by non-surgical or surgical approach. However, it has been seen how SRP, being an invasive therapy, can cause wounds inside the tissue of the periodontal ligament, being this already compromised, and as the healing depends a lot on the individual cellular response (12). In addition, often there is a tendency to prescribe antibiotics, like tetracycline, nitroimidazoles, fluoroquionolones and macrolides, to patients as an additional therapy for the complete eradication of the pathogenic periodontal bacteria present within the pockets, this methodology however increases the bacterial resistance (13) and therefore, more and more experts have started to look towards new therapies that can further improve periodontal therapy and minimize side effects. The use of diode laser seems to be an excellent addition to non-surgical periodontal therapy because the specific wavelength of the laser affects the bacteria especially gram-negative anaerobic ones, first responsible for periodontitis (14). It has also been demonstrated that laser has properties that can stimulate cell proliferation, reducing inflammation and increasing the production of fibroblasts and consequently the improvement of periodontal tissue (15) and that diode laser can be selectively absorbed by tissues and blood and is widely used in soft tissues, especially in areas where there is an inflammatory process (16); although for the time being no faster resolution of gingival edema has been noted following tissue biostimulation by diode laser (17).

In the consensus report of the sixth European workshop on periodontology, there was no suitable demonstration that could ascertain the lasers' clinical effectiveness applied in SRP (18). But in 2018 it was highlighted by the American academy of periodontology best evidence consensus meeting (AAP BEC) that the confined well-crafted studies applying lasers in periodontal treatment demonstrated moderately greater improvements compared with conventional SRP (19). From the

systematic review of 2016 performed by T. Qadri et al. it was found that in sites with 5 mm deep pockets the therapy with SRP plus LD (800-980 nm) is more effective than the SRP alone (16). In contrast, in the systematic review of D. E Slot et al. no benefits in terms of Clinical Attachment Level (CAL) and Probing Pocket Depth (PPD) were observed between sites treated with DL (808-980 nm) + SRP and those treated with SRP only, however a greater reduction of the BS is evidenced in the group dealt the diode laser (20). Finally, in a meta-analysis carried out by F. Sgolastra et al. no statistically significant reduction of clinical parameters in sites treated with DL+SRP has been highlighted compared to sites treated with SRP only (21). In the study carried out by H. Gou et al. the effectiveness of the addition of laser therapy in the regulation of periodontal tissue vessels was also evaluated, however, in this study the laser did not provide any additional benefit compared to non-surgical periodontal therapy alone (10). As the previous revisions cited implies, there is a persistent debate regarding the efficacy of dental lasers in the treatment of periodontitis or periodontal maintenance therapy. So, the goal of this literature review is to evaluate the effectiveness of the diode laser at 800-980 nm in addition to scaling and root planning.

MATERIALS AND METHODS

Search strategy and selection criteria

Three of the authors performed an electronic research on Pubmed inserting as keywords: (laser OR laser therapy OR diode laser) and (periodontitis OR periodontal disease). The field has been narrowed to select only Randomized controlled clinical trials (RCT). All studies analyzed are not older than ten years. The search was limited to human subjects and studies that adhered to other eligibility criteria. Only studies using diode laser at 800-980 nm on patients diagnosed with periodontitis were selected. In Table I, the inclusion and exclusion criteria have been included.

Titles and abstracts of studies that accomplish the inclusion criteria were examined and valued. Data were obtained from the included studies according to the following parameters: author/country, study design (RCTs), subjects (sample size; mean and age range in years), inclusion of confounders, periodontitis diagnostic criteria, study groups, study outcome, and follow-ups. Moreover, methodological quality and the features of laser were evaluated.

Risk of bias

A limit of this literature review is that the electronic search was performed using only the PubMed search

Table I. *Inclusion and exclusion criteria.*

INCLUSION CRITERIA	EXCLUSION CRITERIA
In vivo studies	In vitro studies
Randomized controlled clinical trials (RCT)	Non-randomized controlled clinical trials (NRS); Review articles
Studies involving human subject	Animal studies
Patients diagnosed with periodontitis	Studies with patients diagnosed with peri-implant mucositis or peri-implantitis
800-980 nm diode laser	Diode laser > 800 nm
	Studies with patients suffering from systemic disease (like diabetes)

engine. The data that can constitute a risk of bias are the parameters regarding the energy fluence, the power output, the power density and the optical fiber used during the laser session that vary a lot between the various studies included. In addition, some studies performed different numbers of laser sessions and the duration of irradiation per tooth varies depending on the study. Due to the variation of all these parameters, it was not possible to perform a meta-analysis and therefore a statistical analysis of the data

RESULTS

Study selection

Based on titles and abstracts search, initially 84 studies were identified. Later, after examining the abstract, 52 studies were removed as the topic was not inherent in the objective of this review. There were 32 articles available in full text, of which 16 were excluded because they did not meet the inclusion criteria: 5 studies included in the sample patients with systemic diseases, 5 studies included in the sample patients with diagnosis of peri-implants mucositis or peri-implantitis and 7 studies used diode laser at wavelengths less than 800. The final selection included 8 articles. Fig. 1 shows the flow diagram of study selection process and results of the literature search according to PRISMA guidelines (22).

Characteristics of included studies

All studies are RCT (23-30). Five of these split mouth Random clinical trials (24-27, 30). Trials originated from Turkey (23, 25, 28), Brazil (27), Italy (24), Greece (26) and Serbia (29). In all studies the number of participants is between 19-31 with an average age ranging from 34.9-48.5 years. The presence of confounders, such as

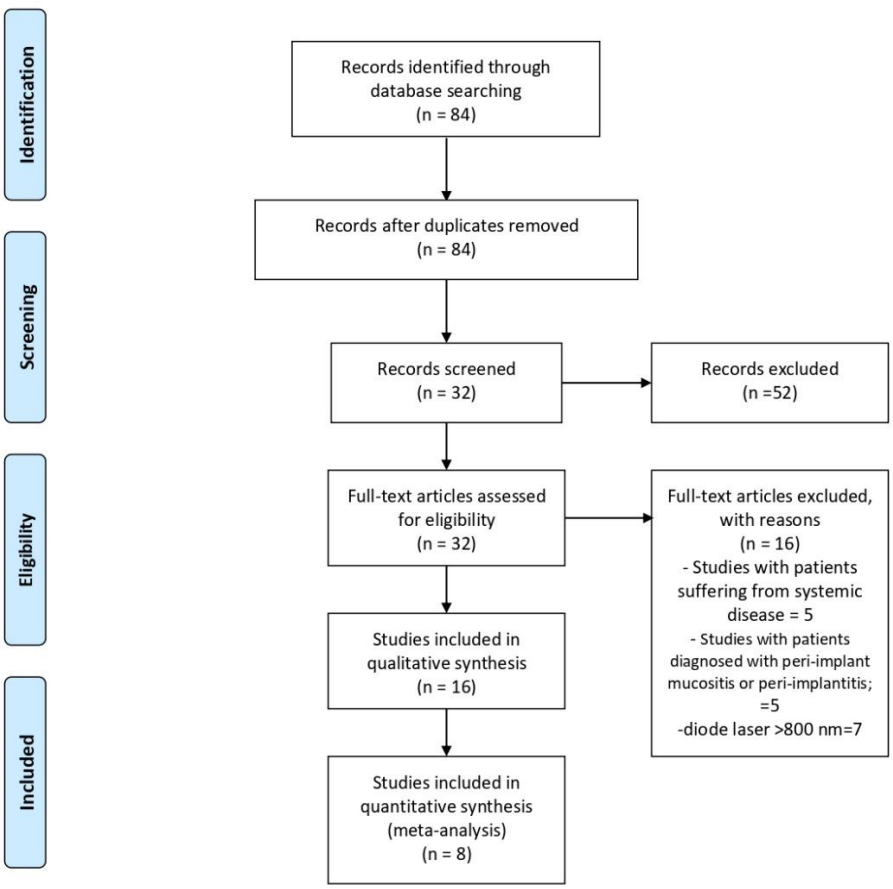

Fig. 1. *Study selection process and results of the literature search (PRISMA flow diagram).*

smokers, were included in two studies (26,28). All of the studies used the combined approach LD+SRP in the test group and SRP alone in the control group. The follow-up period for all of the studies ranged from 4 to 48 weeks. Among the studies analyzed in the review, only one study has performed a follow up of 4 weeks (29) and another of 6 weeks (26), five studies have performed a follow up of 24 weeks (23, 25, 26, 28, 30) while only one of 48 weeks (24). All studies performed the laser session following scaling and root planning except one study (25) which performed the laser session prior to non-surgical periodontal therapy (Table II).

Table II. *General characteristics of the included studies.*

Investigators & Country	Study design	Sample size, mean age in years (range)	cofonders	Periodontitis diagnostic criteria	Study groups		Follow up (week)	study outcome	funding source
					test (n)	control (n)			
M. Saglam et al; Turkey 2014 [23]	RCT	30, 41.48 (32-57)	Excluded	14 teeth with at least two teeth with ≥5 mm probing depth at each quadrant	SRP+DL (15)	SRP (15)	24	Test group showed a significant improvement in clinical periodontitis parameters as compared to control group at follow-up, but immunological outcomes were comparable for both groups at follow up	Not reported
G. Matarese et al; Italy; 2017 [24]	RCT, Split mouth	30, 34.9	Excluded	Radiographic evidence of interproximal bone loss exceeding ≥50% of the root length, a probing depth (PD) >5 mm at more than eight sites per quadrant, >30 years old or <40 years old with a rapid bone loss as shown by radiographs, a minimum of six teeth per quadrant, respectively, and a concentration of more than 104 colony-forming units/mL of Actinobacillus actinomycetemcomitans.	SRP+DL (30)	SRP (30)	48	Clinical outcomes were significantly better for the test group compared to the control group at follow up, but microbiological and immunological outcomes were comparable for both groups at follow up	Reported
K. Ustun et al; Turkey;2014 [25]	RCT, Split mouth	19, 40.23 (22-55)	Excluded	least two incisor or canines at two quadrant with periodontal pockets depth between 4 and 7 mm	SRP+DL (19)	SRP (19)	24	Clinical and immunological outcomes were significantly better for the test group compared to the control group at follow up	Reported
F. Katsikanis et al; Greece; 2019 [26]	RCT, Split mouth	21, 48.2	Light to moderate smokers	3 o more quadrants each containing at least three sites with periodontal pocket depht (PPD) of ≥ 5 mm	SRP+DL (21, 448 sites)	SRP (21, 389 sites)	24	Clinical and immunological outcomes were comparable for both groups at follow up	Not reported
G. De Micheli et al; Brazil,2009 [27]	RCT, Split mouth	27, 48.5	Excluded	Presence of a pair of single rooted controlateral teeth with a clinical probing depth ≥ 5 mm	SRP+DL (27)	SRP (27)	6	Clinical, immunological and microbiological outcomes were comparable for both groups at follow up	Not reported
G. Aykol et al; Turkey;2011 [28]	RCT	36, 42.89 (31-58)	Smokers	Presence of probing depth with PD ≥ 4 mm to PD ≤ 10 mm	SRP+LD (18)	SRP (18)	24	Clinical and immunological outcomes were comparable for both groups at follow up	Reported
MS Petrovic et al; Serbia,2017 [29]	RCT	60, 40	Excluded	Presence of CAL ≥ 3 mm at ≥ 30% of sites	SRP+DL (30)	SRP (30)	4	Clinical and microbiological outcomes were significantly better for the test group compared to the control group at follow up	Not reported
V. T. Euzebio Alves et al; Brazil;2011 [30]	RCT, Split mouth	36, 46.8 (37-64)	Excluded	Minimun probign depth (PD) of 5 mm	SRP+DL (36)	SRP (36)	24	Clinical, immunological and microbiological outcomes were comparable for both groups at follow up	Not reported

Laser parameters

All the studies used diode lasers. The wavelengths of different lasers used in the included studies ranged between 810 and 980 nm. Six studies have not defined the energy fluence (J cm-2) (25-30), while the power output varies from 250 to 2500 mw. Only three studies reported power density (W cm-2) (26, 27, 30), ranging from 1193.7 to 2831 W cm -2. Four studies reported that the duration of irradiation was 20 seconds per tooth (23, 24, 27, 30), one study specified that the duration of irradiation was 10 seconds for incisors and premolars and 20 seconds for molars (28), two studies exposed teeth to laser for 30 seconds (26, 29) and only one study used the laser for 80 seconds per tooth (25). Two studies didn't mention the diameter of the optical fiber used (28, 29), while in the remaining studies three used an optical fiber with a diameter of 300µ (23, 24, 26), one study used an optical fiber with a diameter of 320µ (25) and one study used a diameter of 400µ (27). The total number of laser applications is only once in five studies (23-25, 28, 29), two in two studies (27, 30) and three in one study (26). Only two studies specified that the laser sessions were all performed by the same clinician for all patients (26, 28) (Table III).

Main outcomes of the studies and microbiological findings

Only four studies, among those considered, also examined microbiological parameters (24, 27, 29, 30). One of these examined patients with a single follow-up after one month, resulting in a decrease in all microbiological parameters: a decrease in the prevalence of bacteria after treatment in the DL+SRP group was observed for *Aggregatibacter actinomycetemcomitans* and *P. intermedia* and *P. gengivalis* (29). In the other studies have shown a lower level of *Aggregatibacter actinomycetemcomitans*, *P. gingivalis, T. forsythia, T. denticola* and a lower number of colony-forming units (CFU) in the test group than in the control group, during the follow-up to 6 weeks (24, 27, 30). In contrast, during the 6-month follow-up, no statistically relevant differences were found in the microbiological indices between the two groups (24, 30).

Clinical findings

The only included study that saw patients with a one-year follow-up found an improvement in clinical attachment level (CAL) (3.44 mm±0.28 in group DL+SRP *vs* 4.23 mm±0.21 in group with SRP only), an improvement in probing depth (PD) (2.56 mm±0.44 *vs* 3.36 mm±0.51 respectively) and a decrease of percentage of bleeding on probing (BoP) (26.16±2.4 *vs* 32.26±3.1) largest in the group that received diode laser therapy after one year, while after six months it did not detect any difference between the two groups except in the BoP (22.79±4.2 *vs* 24.67±3.2) (24). Five studies examined patients at a six-month follow-up (23, 25, 27, 28, 30) and only two (23, 25) of these obtained significant differences

Table III. *Laser parameters of the included studies.*

Investigators	type of laser	Wavelenght (nm)	Energy Fluence (J cm $^{-2}$)	Power output (mW)	Power density (W cm $^{-2}$)	Duration of irradiation (sc/Tooth)	Optic fiber diameter (µm)	Number of laser session
M. Saglam et al; Turkey 2014 [23]	Diode laser	940	15	1500	N.A.	20	300	1
G. Matarese et al; Italy; 2017 [24]	Diode laser	810	28,84	1000	N.A.	20	300	1
K. Ustun et al; Turkey;2014 [25]	Diode laser	810	N.A	2500	N.A.	80	320	1
F. Katsikanis et al; Greece; 2019 [26]	Diode Laser	940	N.A.	2000	2831	30	300	3 (Every laser session was performed by the same clinician)
G. De Micheli et al; Brazil,2009 [27]	Diode laser	808	N.A.	1500	1193,7	20	400	2
G. Aykol et al; Turkey;2011 [28]	Diode laser	808	N.A.	250	N.A.	10 (incisors and premolar) 20(molars)	N.A.	1 (Every laser session was performed by the same clinician)
MS Petrovic et al; Serbia,2017 [29]	Diode laser	980	N.A.	200	N.A.	30	N.A.	1
V. T. Euzebio Alves et al; Brazil;2011 [30]	Diode laser	808	N.A.	1500	1193,7	20	400	2

NA: not available.

in CAL and PD between the two groups in favor of the test group. The other studies that examined the patients after six months (26, 28, 30) did not find any improvement in terms of clinical and immunological parameters for follow-up purposes. However, three months later, in the study carried out by F. Katsikanis et al (26), an increase of CAL (5.22 mm±1.17 *vs* 6.61 mm±2.35) and PD (3.42 mm±0.97 *vs* 4.25 mm±1.57) in the Deep pockets (7 mm≤PD≤9 mm) as noted in favor of the diode laser group. No study found differences between the two groups in the plaque index (PI) values at 6 months. A 1-month follow-up study was also included which resulted in an improvement of all clinical parameters, CAL (3.32 mm±0.63 in group DL+SRP *vs* 3.77 mm±0.73 in group SRP only) PI (0.68±0.31 *vs* 1.01±0. 49) and bleeding index (BI) (0.16±0.29 *vs* 0.58±0.66) in patients treated with diode lasers (29) The only included study that followed patients at a maximum of 6 weeks (27) found no difference between the control group and the test group except for CAL. In one study, smokers were also compared with non-smokers and no difference was noted between the two types of patients in terms of clinical parameters (28) In the other study, which also included light or moderate smokers in the results, it was not specified whether a difference was found between smokers and non-smokers (26).

Inflammatory findings

At the level of inflammatory parameters only one study produced better results in the DL+SRP group than the group with SRP only, IL-1β (0.09±0.14 *vs* 0.18±0.18) gingival crevicular fluid (GCF) (13.56±14.85 *vs* 28.07±31.23), after six months (25). In the study carried out by G. Matatrese et al. (24) there was a significant decrease in levels of IL-1β after 15 and 30 days (11.67±5.36 *vs* 9.36±8.12) in the diode group more SRP than in the SRP-only group.

DISCUSSION

This literature review is based on the assumption that the use of diode laser at 800-980 nm in combination with SRP is more effective than SRP alone in the treatment of periodontitis. The wide methodological heterogeneity of the various studies present in the literature makes difficult to interpret the results obtained, that is why this literature review has tried to focus on a certain type of laser at a certain wavelength. The optimal goal of periodontal therapy is to minimize or avoid invasive procedures while achieving a stable and lasting improvement of periodontal health and increasing the quality of life of the patient, avoiding the use of local or systemic antibiotics in a widespread way, in order to prevent the selection of resistant microbial stocks (31).

It was found that SRP are effective in periodontitis treatment however in some cases, where it is difficult to get the instrumentation, this technique may not completely remove the bacteria present in the periodontal pockets (32). It has been seen how non-surgical periodontal therapy becomes less effective when performed inside pockets with a depth of >5 mm (33). In addition, single-root teeth and rear teeth with intact furcation respond better to SRP than multi-root teeth and molars with invasions of bifurcations (34). Therefore, it seems useful to try alternative therapies that can face the limits of periodontal therapy, such as the use of 0.20% Chlorhexidine (CHX) which would seem to help to have good control over clinical indices and in particular the bleeding index (35).

Laser treatment has been proposed in addition to non-surgical periodontal therapy because the laser has shown beneficial effects against pathogenic periodontal bacteria, but the actual effectiveness of the laser in addition to SRP is still unresolved (36). Diode lasers are among the most efficient converters of electric energy into coherent radiation. Diode lasers employ semiconductor crystals as active media, which, after excitation, will emit coherent radiation in the VIS or IR region (typical medical diode lasers range between 630 and 980 nm), which can be easily transmitted via optical wave guides to the patient (37). The advantage of laser in the treatment of inflammatory diseases, such as periodontitis, is its ability to stimulate various biological mechanisms (38). It can be said, based on some studies, that regenerative repair can be greater thanks to laser-assisted stimulation; however, an exact frequency has not yet been established

(39). The advantage of laser in the treatment of inflammatory diseases, such as periodontitis, is its ability to stimulate various biological mechanisms (40). In July 2015, the Journal of the American Dental Association (JADA) published a systematic review with meta-analysis and evidence-based practice guidelines on the treatment of periodontitis by SRP with and without adjunctive therapies. In this systematic review it was seen that the diode laser in addition to the non-surgical periodontal therapy did not bring any more benefits than the SRP alone (41). The results obtained in the meta-analysis of C. Ren (42) may suggest that the addition of the laser to scaling and root planning is more effective in the short term than in the long term. All studies included in this review have shown an improvement in clinical parameters in patients treated with diode laser. In no study patients reported adverse effects such as discomfort, dentin hypersensitivity, burning sensation or pain associated with laser irradiation. Four studies included in this review have achieved better results in the test group than in the control group (23, 24, 25, 29).

An interesting finding in most studies is that there was an improvement in clinical parameters during follow-up before three months in favor of the Diode Laser Group. Therefore, it was noted, analyzing the results of the various studies in terms of clinical parameters, that the laser could bring benefits to the non-surgical periodontal therapy especially in the short term rather than in the long term. In the systematic review performed by S. Mokeen in 2018 (43) from the results obtained, it was observed that the laser could be a valid addition to scaling and root planning. In the meta-analysis performed by L. Jia et al. (44) it was found that diode laser could be the best additional therapy for periodontitis treatment. This result was achieved by looking at the gain of CAL in studies with a follow-up of 3 to 6 months. In contrast to the review by C. M. Cobb (45), which says that current evidence on the use of diode lasers, both as monotherapy and as additional scaling therapy and root planing, shows that it provides minimal benefits. The rational use of laser in the treatment of periodontitis is given by its anti-infective, physical and ablative properties (46). A key role in the etiology and progression of periodontitis is played by the subgingival microbical biofilm (47). Given the important role played by bacterial biofilm, periodontal therapy should aim at preventing immune response and thus reducing these active microbial factors (48). However, the ability of the laser to act against bacteria within periodontal pockets varies greatly depending on the wavelength and power used (49). The in vitro study performed by X. Song et al did not observe any relevant anti-bacterial effect following a diode laser session at 800-980 nm, always taking into account the limitations of this study (50). In the studies included in this literature review no improvement of microbiological parameters was observed after six months of follow-up (24-30) In the short term it was noticed an improvement of all microbiological parameters especially was observed a reduction of the bacteria of the red complex of Socranski during the first weeks of follow-up. This data would seem to indicate, as mentioned above, that the benefits of laser are more in the short term than in the long term. At the level of inflammatory parameters, it is known as IL-1β plays a role in multiple biological activities and regulates several genes expressed during inflammation (51). One of the randomized clinical trials in the literature performed by D. Sezen et al noted a decrease in levels of IL-1β greater in the laser-treated group than in the control group. However, the previous study used a different type of laser than diode laser (52). Speaking instead of the immunological and inflammatory parameters in the review performed by S. V. Kellesarian the results of the various studies considered were too inconsistent with each other with regard to the levels of pro-inflammatory cytokines (53). Analyzing the data obtained from this review of the literature only one study has noticed lower levels of IL-1β and GCF at six months (25) and another study (24) has instead always noticed a decrease in levels of IL-β 30 days later, however, in the latter study it was also seen that, on the contrary, the levels of IL-10 were higher in the diode laser group than in the control group. All other included studies that examined immunological and inflammatory parameters have not found differences between the test group and the

control group (26, 27). It is not yet clear how the laser can act in the modulation of these parameters; we have already discussed an immunomodulatory effect of the laser, but we do not have sufficient data to say that there is definitely a decrease in the level of inflammation in laser-treated patients, so further studies are needed.

As noted by S.G. Grossi (54) smokers have a worse recovery, both in terms of clinical parameters and microbiological parameters, following non-surgical periodontal therapy. In the only study (28) included in the review that also compared smokers' patients to no smokers' patients, no differences in clinical parameters were found in both groups. However, care should be taken to consider the data from this literature review since there are limits. First of all, there are differences regarding the power output and the different optical fiber used in the various studies. In addition, some studies have not reported the energy fluence (25-30) or power density used (22, 24, 25, 28, 29). It is known that fiber diameter influences the overall power density and energy output during laser therapy and can modify the actual amount of energy released during the process, potentially affecting the antimicrobial efficacy of laser therapy (55). Finally, the diode laser therapy can be a good alternative for the current period, to minimize the production of aerosol and droplets especially in patients with chronic viral and autoimmune diseases (HIV, HCV, Sjogren's etc.) (56-60). Although attempts have been made to take studies that used only a certain laser wavelength to minimize the heterogeneity of the various studies, there are many other factors that affect the results. It should be remembered that some studies have also performed more than one session of diode laser therapy (26, 28, 30).

Although this review of the literature included studies that performed a different number of laser sessions, analyzing various results of studies that performed multiple sessions with those that performed only one, it would seem that the number of sessions carried out do not have a particular effect on the outcome of the therapy. Due to the heterogeneity of the various data taken from the analyzed studies and the different laser parameters used it was not possible to perform a meta-analysis and therefore a statistical analysis of the data; For the presence of these variables, it was possible to perform only a review of the literature. It should also be considered that only the PubMed search engine has been used to carry out this review of the literature, and this also implies a limit to be taken into account during the discussion of the results.

Considering the limitations of this review of literature, it would seem that the diode laser at 800-980 nm + SRP is effective in periodontitis treatment only in the short term or in any case bring minimal benefits. However, it should also be remembered that in the literature there are not many studies that show the results after a year or more, most of them follow patients only to a maximum of six months. So, in the future, you'd need more Random clinical trials with more follow-up to see the real long-term effectiveness of the laser.

Talking about diode lasers, there are many variations to consider in order to assess its actual effectiveness, so within the limits of our study no evidence was found that the addition of diode laser at 800-980 nm in non-surgical periodontal therapy may be more effective than long-term SRP alone. The main benefits of using diode lasers were found in the short term, from 4 weeks to 12 weeks, rather than six months of follow-up. This may suggest that diode laser is more effective in the short term rather than in the long term. In the future, more follow-up studies will be needed for patients over six months to assess their actual effectiveness. The results of this literature review should be considered preliminary and further, more robust, well-designed studies with long-term follow up and standardized comparators with laser parameters are warranted.

ACKNOWLEDGEMENTS

Authors' contributions: G. Tetè contributed to conception and design, critically revised the manuscript and gave final approval; L. Ferrante contributed to acquisition, analysis, or interpretation, drafted the manuscript and gave final approval; M. Moretto contributed to acquisition, analysis, or interpretation, drafted the manuscript and gave final

approval; G. Rellandini contributed to acquisition, analysis, or interpretation, drafted the manuscript and gave final approval; E. Polizzi contributed to conception and design, critically revised the manuscript and gave final approval.

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