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Review Article

Efficacy of Dental Lasers as an Adjunct in Non-Surgical Periodontal Treatment: A Systematic Analysis

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ABSTRACT

Dental lasers are applied in numerous periodontal treatments, encompassing both surgical procedures on soft and hard tissues and non-surgical interventions such as microbial reduction, removal of surface deposits, and photobiomodulation. The objective of this review was to analyze the existing scientific evidence to determine whether lasers provide a beneficial effect when used as an adjunct during initial non-surgical periodontal therapy. A comprehensive PubMed search was conducted focusing on randomized clinical trials involving human subjects, in which dental lasers were utilized as an adjunct to initial periodontal therapy between January 2010 and April 2020. The initial search retrieved 1,294 potentially relevant studies. After applying inclusion and exclusion criteria, 20 articles met the eligibility requirements for this review. The selected publications investigated initial therapy outcomes in patients diagnosed with chronic periodontitis. Following periodontal charting, conventional scaling and root planing were performed using manual or ultrasonic instruments, after which the test group(s) received additional laser treatment. The adjunctive laser group generally exhibited varying levels of clinical improvement compared to the control group treated solely with traditional methods. This systematic review revealed that approximately 70% of the analyzed trials demonstrated significant enhancement in specific clinical parameters, while no improvement was noted in others. The remaining 30% of studies showed no statistically significant differences between groups. When appropriate laser parameters are applied, lasers can serve as a supportive adjunct in initial non-surgical periodontal therapy.

Keywords: Adjunctive, Dentistry, Laser, Periodontal, Periodontitis, Randomized clinical trials

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Introduction

Chronic periodontitis remains a prevalent oral health concern among adults [1]. Multiple contributing factors—such as genetics, medical conditions, and lifestyle—can intensify disease progression, and ongoing research continues to identify additional risk elements [2].

This condition represents a multifactorial and primarily chronic inflammatory disorder, where microbial accumulation near gingival tissues produces toxins that trigger tissue destruction and lead to loss of bone and periodontal support. If untreated, it may result in tooth mobility, migration, and eventual tooth loss [3]. Periodontitis develops gradually as a biofilm-associated infection of both soft and hard periodontal tissues. The major cause is the persistence of bacterial biofilm on tooth or gingival surfaces, which induces gingival inflammation. As the microbial load increases, pathogens can infiltrate the connective tissue, causing apical migration of the epithelial attachment and subsequent alveolar bone resorption and tooth loss.

Initial periodontal therapy—commonly referred to as Phase 1 therapy—focuses on eliminating biofilm and mineralized deposits (calculus) and is followed by periodic re-evaluation. If infection persists, surgical treatment (Phase 2 therapy) is required [4]. The standard non-surgical approach, known as periodontal debridement [5], often results in measurable improvements, including reduced probing depths and diminished inflammation, and remains the cornerstone of periodontal treatment [6]. However, debridement frequently fails to completely remove deposits due to limited accessibility in certain periodontal sites [7], and some reports have noted that sonic-powered devices may have minimal impact on bacterial reduction [8].

To enhance outcomes, systemic or locally administered antimicrobial agents have been used as adjuncts, though they present both advantages and drawbacks [9]. Laser systems specifically engineered for dental applications have been available for roughly three decades [10], leading to the development of various parameters and techniques for periodontal therapy [11]. For this review, laser devices refer to instruments designed for debridement of the pocket's soft tissue wall, excluding those used solely for photoactivated disinfection or photobiomodulation.

Although numerous investigations have reported supplementary benefits of laser use, others have found no additional advantage. Therefore, this review critically assessed randomized clinical trials published between January 2010 and April 2020 that employed lasers as adjuncts to periodontal debridement. The central research question addressed whether incorporating laser therapy during initial non-surgical treatment of chronic periodontitis yields superior outcomes compared to conventional therapy alone after a 6-month follow-up.

Materials and Methods

Search strategy

Between 15 and 25 April 2020, an electronic literature search was conducted to identify publications examining the use of lasers as adjunctive tools in non-surgical periodontal therapy. The databases PubMed and the Cochrane Library were searched using the following combinations of MeSH terms and keywords: (Laser OR diode OR Nd:YAG OR Er:YAG OR Er,Cr:YSGG OR CO_2) AND (periodontitis OR periodontal) NOT (aPDT OR photodynamic OR PAD OR PDT OR photobiomodulation OR low level OR peri-implantitis OR endodontic OR orthodontic).

To refine the results, filters were applied to include only English-language clinical trials in humans published within the past decade. This reduced the initial 1,294 records to 61 studies.

Four reviewers independently examined titles and abstracts in accordance with predetermined inclusion and exclusion standards. Any discrepancies during this process were resolved through mutual discussion until full agreement was reached.

Inclusion criteria

- Randomized controlled clinical studies;
- Minimum of 10 participants per study group;
- Diagnosis of chronic periodontitis;
- Laser application in the experimental group;
- Test groups received laser treatment in addition to standard therapy, while control groups underwent conventional therapy alone;
- Observation period of at least 6 months.

Exclusion criteria

- Pilot studies, case reports, or case series;
- Absence of a control group;
- Laser used as the only treatment modality;
- Surgical procedures included;
- Follow-up shorter than 6 months;
- Fewer than 10 subjects per group;
- Application of aPDT or other adjunctive interventions.

After the selection process, 20 studies met all eligibility requirements. The study selection procedure followed the PRISMA statement [12], and the full inclusion pathway is illustrated in **Figure 1**.

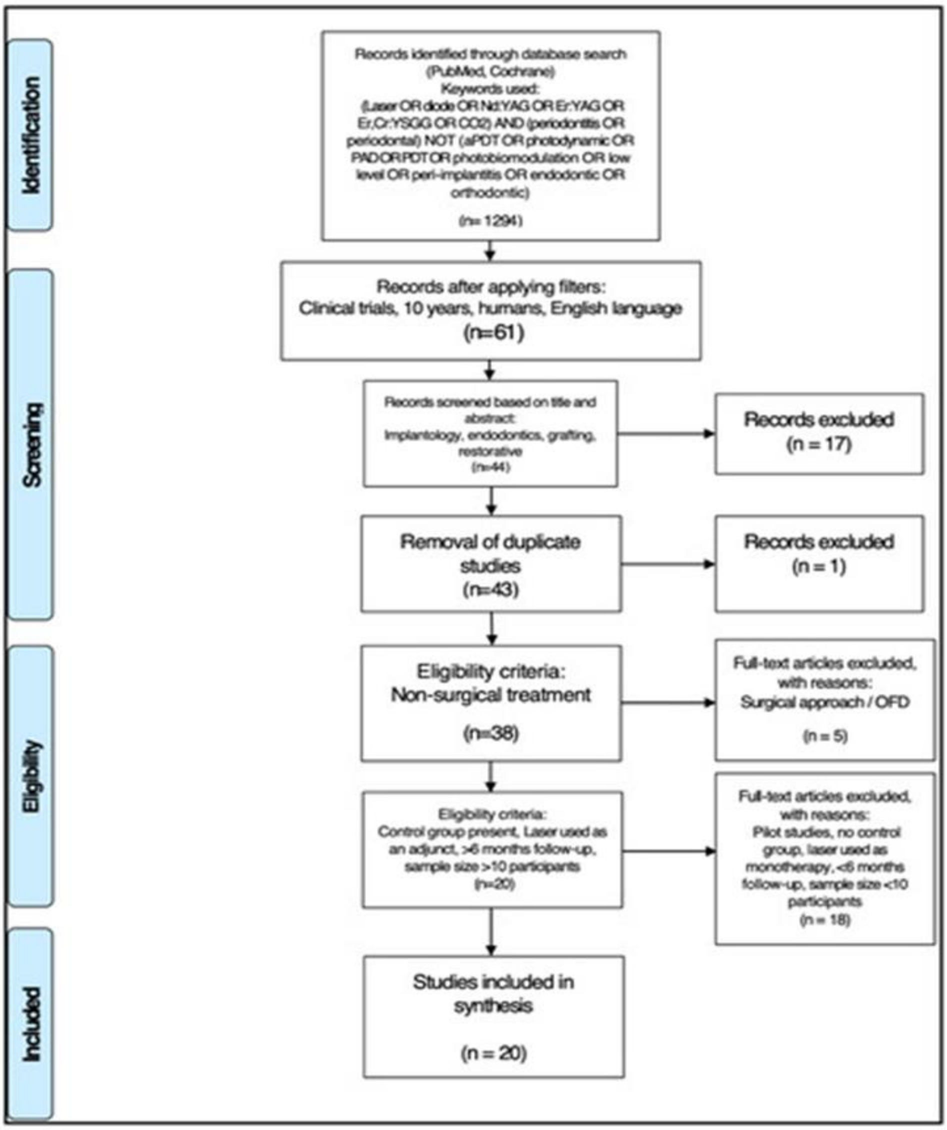

Figure 1. PRISMA diagram showing the article selection process and inclusion stages.

Data extraction

Once consensus on the included articles was achieved, data were independently extracted by the same four reviewers. The following information was retrieved from each study:

- Citation details (lead author and publication year);
- Type of trial, sample number, and pocket depth;
- Test and control group descriptions;
- Evaluated clinical parameters;
- Laser settings and number of treatment sessions;
- Duration of follow-up;
- Final treatment outcomes.

Quality assessment

Following extraction, all studies underwent a bias risk assessment using a modified Cochrane Risk of Bias Tool [13], adapted for this particular review. Each study was evaluated according to the following points, with "yes" or "no" responses assigned for every parameter:

- Was randomization adequately performed?
- Was the sample size calculation included and met?
- Were baseline conditions comparable between groups?
- Was blinding used?
- Were laser parameters clearly reported and calculations accurate?
- Was a power meter utilized?
- Were statistical or numerical results presented?
- Was outcome data complete?
- Did all participants finish the follow-up period?

- Were conclusions appropriately based on the collected data?

The overall bias level was classified based on the number of affirmative responses:

- High risk: 0–4 "yes" responses
- Moderate risk: 5–7 "yes" responses
- Low risk: 8–10 "yes" responses

Results and Discussion

Primary outcome

The main purpose of this review was to analyze and compare the clinical effectiveness of adding laser therapy to conventional non-surgical periodontal treatment protocols.

Data presentation

A summary of the reviewed studies is compiled in **Table 1**.

Table 1. Summary of identified studies including the main author and citation, type of study, total sample number, pocket depth, test/control group setup, evaluated parameters, laser protocol, session count, follow-up duration, and clinical outcome.

Study Reference	Study Design / Participant Count / Pocket Depth Criteria	Intervention/Comparison Groups	Objectives/Measurements	Laser Specifications / Treatment Sessions	Monitoring Periods	Results Including PD Reduction and CAL Gain with Statistical Significance
Ciurescu *et al*., 2019 [14]	Parallel-group RCT, 38 participants, Chronic periodontitis, 1 pocket per quadrant ≥5 mm	Intervention (19): 940 nm Diode, Er,Cr:YSGG + ultrasonic scaling; Comparison (19): Ultrasonic + manual scaling	Pocket depth (PD), bleeding on probing (BOP), clinical attachment level (CAL), PCR microbial analysis	(i) Diode, 940 nm: 1.5 W (day 0) to 2 W (day 7), 300 μm non-initiated tip, oscillatory retraction, 30 s (single-rooted) to 60 s (multi-rooted), 3 sessions (days 0, 7, 60); (ii) Er,Cr:YSGG 2780 nm: 1.5 W average power, 30 Hz, 50 μs pulse, 45 mJ/pulse, 500 μm radial tip, 10 s/mm (single-rooted) to 15 s/mm (multi-rooted), 2 sessions (days 7, 60)	2 and 6 months	Intervention group significantly improved PD, CAL, BOP, and microbial counts (Pg, Td, Tf, Pi, Pm, Fn, En) vs. comparison. At 6 months: PD reduction 1.19 mm, CAL gain 0.98 mm, both $p < 0.001$.
Zhou *et al*., 2019 [15]	Randomized, single-blind trial, 25 participants, Split-mouth, chronic periodontitis, one pocket per quadrant ≥4 mm with BOP	Intervention: SRP + Er:YAG (one quadrant); Comparison: SRP (one quadrant)	PD, CAL, bleeding index (BI), plaque index (PI) at baseline, 3, and 6 months	Er:YAG 2940 nm, Hard tissue: 100 mJ, 15 Hz, chisel tip, slow coronal-to-apical paths; Soft tissue: 50 mJ, 30 Hz, 800 μm conical tip	3 and 6 months	Er:YAG + SRP showed significant improvements in PD and CAL vs. comparison at 3 and 6 months, though differences were minor (PD reduction 0.11 mm, CAL gain 0.2 mm at 6 months, both $p < 0.03$).
Celik *et al*., 2019 [16]	Parallel-group RCT, 38 participants, 4 teeth per quadrant with ≥4 pockets, PD ≥5 mm	Intervention (19): SRP + Er:YAG; Comparison (19): SRP	PD, CAL, PI, BOP, PCR microbial assessment	Er:YAG 2940 nm, 150 mJ, 10 Hz, water-irrigated 600 μm tip, coronal-to-apical at 15–20°	3 and 6 months	Intervention group significantly enhanced CAL and PD vs. comparison. At 6 months: PD reduction 0.3–0.8 mm, CAL gain

						0.5–0.8 mm, p < 0.05. No significant microbial differences (Pg, Tf, Td).
Abduljabbar *et al*., 2017 [17]	Split-mouth RCT, 28 male participants, PD ≥4 mm	Intervention: SRP + Nd:YAG; Comparison: SRP	PI, BOP, PD, GCF IL-1β, and TNF-α levels	Nd:YAG 1064 nm, 4 W average power, 80 mJ/pulse, 50 Hz, 350 µs pulse, 240 W peak power, 1430 W/cm² irradiance, 60–120 s/tooth, total energy 240–480 J	3 and 6 months	Intervention group significantly improved PI, BOP, PD, and GCF IL-1β and TNF-α vs. SRP alone. At 6 months: PD reduction 1.0 mm, p < 0.01.
Magaz *et al*., 2016 [18]	Split-mouth RCT, 30 participants, PD ≥4 mm with BOP	Intervention: SRP + Er,Cr:YSGG; Comparison: SRP	PI, BOP, PD, gingival recession (GR), CAL	Er,Cr:YSGG 2780 nm, 1.0 W average power, 50 mJ, 20 Hz, 10% air/15% water, 60 s/tooth, 5–15°, 600 µm tip	6 weeks and 6 months	No notable differences between intervention and comparison groups.
Dereci *et al*., 2016 [19]	Parallel-group RCT, 60 participants, 2 teeth with PD ≥5 mm and halitosis	Intervention: SRP + Er,Cr:YSGG; Comparison: SRP	PI, PD, CAL, BOP, volatile sulfur compounds (VSC) for halitosis	Er,Cr:YSGG 2780 nm, 1.5 W average power, 30 Hz, 11% air/20% water, 140 µs pulse, 600 µm radial tip, 10° apical-to-coronal, 3 sessions (days 0, 2, 7)	1, 3, and 6 months	Intervention group significantly reduced BOP and halitosis (VSC) vs. comparison.
Sanz-Sánchez *et al*., 2015 [20]	Parallel-group RCT, 37 participants, ≥4 teeth per quadrant, one with PD ≥4.5 mm and BOP, chronic periodontitis	Intervention (17): Ultrasonic SRP + Er:YAG; Comparison (20): Ultrasonic SRP	PD, recession (REC), CAL, BOP	Er:YAG 2940 nm, 160 mJ, 10 Hz, sapphire tip	3, 6, and 12 months	Intervention group had significantly fewer PD ≥4.5 mm (p = 0.004). No significant differences in mean PD reduction (0.16 mm) or CAL gain (0.13 mm, p = 0.08) at 12 months.
Üstün *et al*., 2014 [21]	Split-mouth RCT, 19 participants, PD 4–7 mm (incisors/canines in two quadrants)	Intervention: SRP + 810 nm diode; Comparison: SRP	PI, gingival index (GI), CAL, PD, GCF IL-1β (flow cytometry)	Diode 810 nm, 2.5 W, 50% duty cycle, 1.5 W average power, 320 µm fiber, slightly initiated tip, apical-to-coronal sweeping, 20 s/site, 4 sites, 1 session (day 0)	1, 3, and 6 months	Intervention group significantly improved PD, GI, and GCF IL-1β at 1, 3, and 6 months (p < 0.05). At 6 months: PD reduction 0.24 mm, CAL gain 0.45 mm, both p < 0.05.
Saglam *et al*., 2014 [22]	Parallel-group RCT, 30 participants, 2	Intervention: SRP + 940 nm diode;	PI, GI, BOP, PD, CAL, GCF assay (IL-1β, IL-6,	Diode 940 nm, 1.5 W average power, 20 ms on/off, 10 s/buccal, 10 s/lingual, 15 J/cm², 300 µm	1, 3, and 6 months	Intervention group significantly improved PD,

	teeth/quadrant, PD ≥5 mm	Comparison: SRP	IL-8, MMP-1, MMP-8, TIMP-1)	tip, apical-to-coronal sweeping, 1 session (day 0)		GI, BOP, MMP-8 (1 month), BOP, TIMP-1 (3 months), PI, GI, TIMP-1 (6 months). At 6 months: PD reduction 1.0 mm, CAL gain 0.2 mm, both $p < 0.05$.
Dilsiz *et al.*, 2013 [23]	Split-mouth RCT, 24 participants, ≥4 non-adjacent teeth with PD ≥5 mm, BOP, bone loss, chronic periodontitis	Intervention: SRP + KTP; Comparison: SRP	PI, GI, BOP, PD, CAL	KTP 532 nm, 0.8 W, 50 ms on/off, 30 s, 200 µm, 11.7 J/cm², horizontal/coronal sweeping, 1 session (day 0)	6 months	SRP + KTP significantly improved PD and CAL vs. comparison. At 6 months: PD reduction 2.08 mm, CAL gain 2.42 mm, both $p < 0.001$.
Euzebio Alves *et al.*, 2013 [24]	Split-mouth RCT, 36 participants, one pair of contralateral single-rooted teeth, PD >5 mm, chronic periodontitis	Intervention: SRP + 808 nm diode; Comparison: SRP	CAL, PD, PI, BOP, microbial analysis (CFU: Pg, Pi, Aa)	Diode 808 nm, 400 µm fiber, 1.5 W continuous wave, 1193.7 W/cm², coronal sweeping, 20 s/pocket, 2 sessions (days 0, 7)	6 weeks and 6 months	No notable differences between groups.
Zingale *et al.*, 2012 [25]	Split-mouth RCT, 25 participants, ≥5 pockets with PD 5–9 mm	Intervention: Laser + SRP, Laser + SRP + laser sealing; Comparison: SRP, papillae reflection + SRP + flap closure, no treatment	PD, BOP, CAL	Diode 810 nm, 0.8 W continuous wave, 400 µm initiated fiber, 30–45 s/tooth (same for curettage/sealing)	3 and 6 months	No notable differences between treatment groups.
Slot *et al.*, 2012 [26]	Split-mouth RCT, 30 participants, ≥2 sites/quadrant, PD ≥5 mm, attachment loss ≥2 mm, BOP, bone loss, moderate-to-severe periodontitis	Intervention: SRP + Nd:YAG; Comparison: SRP	Post-op pain, bleeding, swelling, PD, REC, BOP	Nd:YAG (parameters from Slot 2011), 1-day post-op evaluation, 6 months	1 day and 6 months	Intervention group reported worse pain, bleeding, swelling. No notable differences in PD, REC, BOP.
Giannopoulou *et al.*, 2012 [27]	Split-mouth, three-arm parallel RCT, 32 participants, PD ≥5 mm, CAL loss ≥2 mm, BOP per quadrant	Intervention: SRP + 810 nm diode; Comparison: SRP	PD, BOP, REC, GCF levels (22 biomarkers, cytokines, acute-phase proteins)	Diode 810 nm, 1 W, 60 s/tooth	2 weeks, 2, and 6 months	No notable differences. Intervention group had 25% remaining pockets >4 mm vs. 9% in comparison ($p = 0.034$).

Eltas *et al*., 2012 (smokers) [28]	Split-mouth, 4-armed RCT, 52 participants, 2 teeth/quadrant, PD 4–6 mm, bone loss, chronic periodontitis	Intervention: SRP + Nd:YAG (smokers/non-smokers); Comparison: SRP (smokers/non-smokers)	PI, CAL, PD, GI, GCF volume	Nd:YAG 1064 nm, 1 W average power, 100 mJ, 10 Hz, apical-coronal sweeping, 120 s/tooth	1 and 6 months	Non-smoker intervention group significantly improved PD (0.5 mm reduction), GI, GCF vs. all groups at 6 months ($p < 0.05$). No differences in smoker group.
Eltas *et al*., 2012 [29]	Split-mouth RCT, 20 participants, 40 teeth, PD 4–6 mm, CAL loss ≥2 mm	Intervention: SRP + Nd:YAG; Comparison: SRP	PI, GI, PD, CAL, GCF IL-1β, MMP-8 levels	Nd:YAG 1064 nm, 1 W average power, 100 mJ, 10 Hz, 200 µm fiber, apical-coronal sweeping, 120 s/tooth	3 and 9 months	Intervention group significantly improved PD, CAL, GI, GCF at 9 months. PD reduction 0.91 mm, CAL gain 1.17 mm, both $p < 0.001$. No differences in IL-1β, MMP-8.
Qadri *et al*., 2011 [30]	Split-mouth RCT, 22 participants, ≥6 pockets of 4–8 mm on each mandibular side	Intervention: SRP + Nd:YAG; Comparison: SRP	PI, GI, PD, marginal bone loss (digital bitewing radiographs), GCF volume	Nd:YAG 1064 nm, 4 W average power, 80 mJ/pulse, 50 Hz, 350 µs pulse, 20–30° angulation, 60–120 s/tooth	Median 20 months (12–39 months)	Intervention group significantly improved PI, GI, PD, marginal bone loss, GCF volume. PD reduction 1.61 mm at 20 months, $p < 0.001$.
Kelbauskiene *et al*., 2011 [31]	Split-mouth RCT, 30 participants, PD 4–6 mm on single-rooted teeth, ≥2 quadrants, chronic periodontitis	Intervention: SRP + Er,Cr:YSGG (509 sites); Comparison: SRP (579 sites)	PI, BOP, PD, REC, CAL	Er,Cr:YSGG 2780 nm, 1 W average power, 20 Hz, 600 µm tip, 10% water/air, 5–15° coronal-to-apical, root surface conditioning, 3 sessions (days 0, 7, 14)	2, 3, 6, and 12 months	Intervention group significantly improved BOP, PD, CAL ($p < 0.001$). No differences in PI, REC.
Rotundo *et al*., 2010 [32]	Split-mouth, 4-armed RCT, 27 participants, ≥2 teeth/quadrant, PD 4–9 mm with BOP	Intervention: SRP + Er:YAG, Er:YAG alone; Comparison: SRP, supragingival debridement	PD, BOP, PI, REC, CAL, VAS pain	Er:YAG 2940 nm, 150 mJ, 10 Hz, 500 µm tip, water, coronal-to-apical 20°	6 months	No notable differences in CAL. No p-values reported for other parameters except VAS and CAL.
Lopes *et al*., 2010 [33]	Split-mouth, 4-armed RCT, 19 participants, 4 non-adjacent sites, PD 5–9 mm with BOP	Intervention: SRP + Er:YAG; Comparison: SRP, no treatment	PD, GR, CAL, PI, GI, BOP, GCF microbial analysis (PCR:	Er:YAG 2940 nm, 100 mJ, 10 Hz, 1.0 W average power, 12.9 J/cm², 1.1 × 0.5 mm tip, 30 s/site, apico-coronal 30°, 180–240 s/patient	1, 3, 6, and 12 months	SRP + laser significantly reduced bacteria at 6 and 12 months ($p < 0.05$). No notable

	Aa, Pg, Pi, Tf, Pn)	differences in PD, CAL, GI, BOP.

Abbreviations: RCT – Randomized Clinical Trial; CPD – Chronic Periodontal Disease; SRP – Scaling and Root Planing; Pt – Patient; US – Ultrasonic Scaling (used for SRP); HI – Hand Instruments (used for SRP); aPDT – Antimicrobial Photodynamic Therapy; PD/PPD – Periodontal Pocket Depth; CAL – Clinical Attachment Loss; PI – Plaque Index; REC – Gingival Recession; BOP – Bleeding on Probing; GI – Gingival Index; GCF – Gingival Crevicular Fluid; CFU – Colony Forming Units; PCR – Polymerase Chain Reaction; VSC – Volatile Sulphur Compounds; mJ – Millijoule; Hz – Hertz; W – Watt; AvP – Average Power; PP – Peak Power; CW – Continuous Wave.

Quality evaluation overview

An assessment of potential bias for all included studies is summarized in **Table 2**.

Table 2. This table presents "yes" or "no" responses for each bias parameter across all selected manuscripts. These parameters are specified in Section 2.3, and total scores are shown in the final column. Overall, 11 out of 20 studies (55%) demonstrated a low risk of bias, with the following scores:

Study Reference	**Randomized Design**	**Sample Size Calculated and Met**	**Comparable Baseline Conditions**	**Blinded Study**	**Laser Parameters Detailed and Accurate**	**Power Meter Utilized**	**Statistical Results Provided**	**No Missing Outcome Data**	**All Participants Completed Follow-Up**	**Data Interpretation Accurate**	**Total Quality Score/10**
Ciurescu *et al*., 2019 [14]	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	8
Zhou, X *et al*., 2019 [15]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Celik *et al*., 2019 [16]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Abduljabbar *et al*., 2017 [17]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	9
Magaz *et al*., 2016 [18]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Dereci *et al*., 2016 [19]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	7
Sanz-Sánchez *et al*., 2015 [20]	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	No	6
Üstün *et al*., 2014 [21]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8
Saglam *et al*., 2014 [22]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	9
Dilsiz *et al*., 2013 [23]	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	8
Euzebio Alves *et al*., 2013 [24]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Zingale *et al*., 2012 [25]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	7
Slot *et al*., 2012 [26]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	7
Giannopoulou *et al*., 2012 [27]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	7
Eltas *et al*., 2012 (Smokers) [28]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	7
Eltas S *et al*., 2012 [29]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	7
Qadri *et al*., 2011 [30]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	7
Kelbauskiene *et al*., 2011 [31]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Rotundo *et al*., 2010 [32]	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	6
Lopes *et al*., 2010 [33]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8

- 10/10: one study [24]
- 9/10: three studies [17, 21, 22]
- 8/10: seven studies [14–16, 18, 23, 31, 33]

Conversely, 9 out of 20 (45%) were considered to have a moderate risk of bias, distributed as follows:

- 7/10: seven studies [19, 25–30]
- 6/10: two studies [20, 32]

Aside from sufficient reporting of the laser protocol, the most frequent deficiencies were linked to (a) missing details on power meter use and (b) lack of sample size estimation or justification.

Data evaluation

For the main outcome, 3 of 20 studies (15%) [14, 17, 30] reported positive results for all tested parameters. Another 11 studies (55%) [15, 16, 19–23, 28, 29, 31, 33] showed improvements in some parameters, with no significant differences in others.

No notable difference between experimental and control groups was found in 4 studies (20%) [18, 24, 25, 32].

Two studies (10%) [26, 27] showed poorer results in certain parameters while others remained unchanged.

With respect to the laser parameters used, 14 out of 20 studies (70%) [15, 16, 18–20, 25–33] lacked complete reporting. The missing details were as follows:

- Tip or spot size: 5 of 14
- Frequency: 2 of 14
- Fluence or irradiance (missing or miscalculated): 5 of 14• Pulse duration: 9 of 14
- Irradiation time: 8 of 14

Only power and energy per pulse were consistently reported or derivable in all cases.

Context

This review aimed to systematically evaluate randomized clinical trials published from 2010 to 2020 that investigated laser therapy as an adjunct to periodontal debridement. In this context, "adjunctive" refers to laser application performed alongside scaling and root planing (SRP) via ultrasonic or manual instruments. Although other supportive treatments exist—such as antimicrobial photodynamic therapy [34] and local/systemic antimicrobials [35]—these were not addressed here.

The concept of "non-surgical therapy" encompasses approaches designed to eliminate plaque, calculus, and pathogenic biofilms to reduce inflammation driving periodontal and peri-implant diseases [36]. Historically, some non-surgical procedures (e.g., gingival curettage, extensive cementum removal) were comparable to surgical interventions, but their use has gradually declined [37]. Surgical periodontal therapy, by contrast, involves flap reflection, tissue excision, suturing, and dressing application [38]. In modern practice, non-surgical modalities are preferred for chronic periodontitis, while surgery often focuses on regenerative procedures involving grafts for soft tissue and bone reconstruction [39].

Laser use in periodontal treatment can target three main goals: (1) removal of infected pocket epithelium, (2) bactericidal action within periodontal pockets, and (3) calculus removal and root detoxification. When properly integrated into therapy, lasers across multiple wavelengths have been utilized for epithelial debridement [40–47]. Moreover, through localized photothermal effects, laser irradiation can effectively address bacterial infection in periodontal tissues [48, 49].

The studies reviewed encompassed a wide range of laser wavelengths—532, 808, 810, 940, 1064, 2780, and 2940 nm. No qualifying publications were identified for CO_2 lasers (9300–10,600 nm).

Table 1 compiles the data extracted from each included article. Criteria such as randomization, sample adequacy, blinding, and statistical analysis were generally met. Some studies employed additional treatment modalities, such as antimicrobial photodynamic therapy in Dilsiz *et al*. [23] and Giannopoulou *et al*. [27], and laser monotherapy in Lopes *et al*. [33]; however, these arms were excluded from the present evaluation as they did not align with the inclusion parameters.

Further aspects of these findings are explored in the subsequent discussion.

Baseline group distribution

Four investigations displayed a noticeable gender imbalance within their participant samples. Sanz-Sanchez *et al*. [20] included 12 men and 28 women, Dilsiz *et al*. had 10 men and 14 women, Euzebio-Alves *et al*. [24] reported 13 men and 23 women, while Giannopoulou *et al*. described 23 men and 9 women.

Although the initial clinical indicators appeared comparable among studies, these four were marked as having an elevated baseline bias risk due to unequal group composition.

Laser characteristics

All reviewed articles provided some description of laser parameters, which were subsequently analyzed in greater detail below.

Power output

The way power was documented varied widely and often lacked consistency. Some papers omitted essential details or used ambiguous notation. For example, Ciurescu *et al*. [14] and Giannopoulou *et al*. described diode laser power without specifying pulse behavior, suggesting the use of continuous wave mode where peak and mean power would coincide. Ciurescu *et al*. further used two different power levels across diode sessions without offering justification.

For free-running pulsed systems, Zhou *et al*. [15], Celik *et al*. [16], Sanz-Sanchez *et al*. [20], and Rotundo *et al*. [32] failed to indicate any numeric power values, leaving such calculations to readers.

Saglam *et al*. [22] and Dilsiz *et al*. provided power readings for gated diode lasers without stating whether these referred to mean or peak power. Slot *et al*. [26] simply referred to another publication for such data. Qadri *et al*. [30] used a pulsed Nd:YAG laser (1064 nm) with automated power regulation via water cooling.

Among the group, the most comprehensive reports came from Ciurescu, Abduljabbar, Ustun, Saglam, Dilsiz, and Euzebio-Alves.

Mean power serves as a key reference for clinicians when evaluating treatment consistency, particularly since most laser units display that setting on their control panels. Parameters for non-surgical laser therapy should always remain below those needed for surgical tissue removal [36].

Pulse duration

Several studies, including Zhou *et al*. [18], Sanz-Sanchez *et al*. [20], Ustun *et al*. [21], Eltas and Orbak [28], Kelbauskiene *et al*. [31], Rotundo *et al*. [32], and Lopes *et al*. [33], omitted details on pulse length. Since pulsed or gated systems allow users to modify the "on-time," which directly influences local heating, the lack of such data limits reproducibility and temperature correlation.

Output verification with power meter

With the exception of Euzebio-Alves *et al*., none of the authors measured real power output from the optical fiber tip. Their study noted roughly a 20% reduction in transmitted energy.

Experimental findings show that fiber transmission losses and variability can occur due to differences in construction and material. Evidence from urological laser fiber evaluations confirmed these discrepancies through direct power meter readings [50]. It is recognized that fiber purity and structure can affect transmission efficiency [51], with reported energy losses ranging from 5% to 20% [52]. Other data indicate that infrared fibers often show higher attenuation rates compared with silica-based fibers [53]. Consequently, reported laser output values in many studies are likely to be inaccurate.

Fiber or tip specifications

Most research specified the diameter of the delivery tip, though some provided incomplete or commercial-based identifiers. Examples include Zhou's "chisel-shaped fiber tip of 17 mm length," Celik *et al*.'s "quartz tip (VARIAN 600/14)," and Dereci *et al*.'s "RFPT 5–14 360° firing tip." Abduljabbar *et al*. [17] and Eltas and Orbak [28] omitted fiber dimensions altogether. Sanz-Sanchez *et al*. employed a "sapphire proprietary tip," and Lopes *et al*. used a "custom tip (1.1 × 0.5 mm)."

Such omissions prevent reliable calculation of the optical power density delivered to tissue surfaces.

Exposure time

Reported irradiation times varied notably between studies.

Four papers described per-pocket exposure durations: Ustun *et al*. (20 s), Dilsiz *et al*. (30 s), Euzebio-Alves *et al*. (20 s), and Lopes *et al*. (30 s).

Nine studies reported per-tooth durations: Ciurescu *et al*. (30–60 s for diode, 10–15 s for Er,Cr:YSGG), Abduljabbar *et al*. (60–120 s), Magaz *et al*. (60 s), Saglam *et al*. (20 s), Zingale *et al*. [25] (30–45 s), Giannopoulou *et al*. (60 s), Eltas and Orbak [28, 29] (120 s), and Qadri *et al*. (60–120 s).

Slot *et al*. stated that treatment lasted "no more than 60 s per site" without further clarification.

Meanwhile, Zhou, Celik, Dereci, Sanz-Sanchez, Kelbauskiene, and Rotundo did not specify any timing data.

The exposure period of laser light plays a decisive role in achieving sufficient thermal effect to decontaminate and remove diseased tissues [36, 54]. The broad time variation across studies could therefore explain differences in treatment outcomes.

Treatment protocols

Across the reviewed studies, conventional SRP procedures were carried out with some methodological variations.

During SRP, Sanz-Sánchez, Dilsiz, and Euzebio Alves (for both the test and control groups), along with Giannopoulou *et al*. (for test sites only), relied exclusively on ultrasonic devices.

Conversely, Abduljabbar, Magaz, Dilsiz, Zingale, and Lopes, together with their co-researchers, used manual tools such as curettes alone.

Several other teams—Ciurescu, Zhou, Celik, Dereci, Ustun, Salgam, Euzebio Alves (for test teeth only), Slot, Qadri, Kelbauskiene, Rotundo, Eltas, and Orbak [28, 29]—combined both hand and ultrasonic approaches.

While these procedural differences may not have major effects and often reflect clinician preference, the tactile precision achieved with manual scaling can be advantageous for calculus detection. Notably, Euzebio Alves's use of hand scaling only in the experimental sites could have influenced the final outcomes.

In several investigations—those of Abduljabbar, Magaz, Sanz-Sánchez, Saglam, Slot, Giannopoulou, Qadri, Kelbauskiene, Lopes, Eltas, and Orbak [28, 29]—SRP and adjunctive laser therapy were executed in a single appointment.

However, Ustun and Zingale applied an 810 nm diode laser, whereas Dilsiz employed a 532 nm KTP device before SRP.

Given the strong absorption of these wavelengths by pigmented tissues [54], caution is warranted since they may interact with dark deposits on the root and generate thermal injury. In contrast, Zhou and Rotundo used erbium-based lasers prior to SRP in the same visit, a system considered safer for calculus removal [36].

Three investigations restricted their analysis to a limited number of teeth. Euzebio Alves and Eltas & Orbak [29] conducted full-mouth SRP but measured outcomes on a single contralateral pair or one individual tooth per group. Lopes *et al*. restricted each group (SRP versus laser + SRP) to four sites. Although this focused-tooth design provides controlled comparison, its extrapolation is limited in patients with generalized disease.

Some authors extended treatment over multiple sessions. Ciurescu *et al*. reported a sequence involving diode application initially, diode + Er,Cr:YSGG one week later, and a final combination two months after, targeting pockets ≥ 4 mm. Celik *et al*. performed SRP and laser within a 24-hour period. Dereci *et al*. applied laser therapy three times in a 7-day span. Sanz-Sánchez began laser one week following SRP, while Euzebio Alves conducted diode sessions on the following day and again after seven days. Kelbauskiene's protocol comprised an initial SRP + laser session followed by two additional laser visits spaced roughly a week apart. Multiple exposures to laser energy appeared to enhance therapeutic gains, though in most reports results paralleled those of single-session treatments.

Additional clinical measures and contributing variables

Gingival crevicular fluid (GCF) evaluation

Split-mouth sampling of GCF was reported by Abduljabbar, Ustun, Euzebio Alves (for CFU counts), Giannopoulou, Qadri, Lopes, Eltas, and Orbak [28, 29], while Saglam *et al*. used a parallel-group layout. Both are valid, but split-mouth assays may share microbial overlap, possibly affecting precision.

Appropriate participant numbers are essential for reliable statistics [55]; the included GCF studies enrolled between 19 and 52 subjects.

Two studies—Euzebio Alves *et al*. and Eltas & Orbak [29]—restricted analysis to one contralateral tooth pair or one tooth per patient. Considering the variable microbiota of periodontal niches, integrating microbial assays with standard clinical protocols can improve evaluation of treatment effectiveness [56].

Smoking

Smoking remains a major etiological contributor to periodontal breakdown [57]. Eltas and Orbak [28] observed that smokers, whether in control or laser groups, derived no measurable benefit from adjunctive laser application.

Halitosis

In Dereci's work, adjunctive laser intervention markedly diminished halitosis, likely due to reduction of volatile sulphur compound (VSC)–producing bacteria. This is noteworthy, since oral malodor—being prevalent—frequently motivates patients to seek dental treatment [58].

Follow-up period

A minimum follow-up of six months was required to ensure meaningful evaluation, with some trials extending beyond that window. Regular recall is emphasized for individuals at risk of periodontal relapse to prevent progression or recurrent episodes. According to the American Academy of Periodontology, periodontal maintenance (PM) visits should occur less than six months apart, ideally every three months [59].

General remarks

The periodontal pocket is a complex three-dimensional structure with uneven morphology [60]. To achieve an effective interaction between light energy and tissue, a clear and detailed explanation of the laser protocol is essential [61]. While some researchers outlined precise directions and emission points of the laser during application, others failed to include such specifics. Descriptions commonly referenced coronal-to-apical or "sweeping" motions and different angulations of the tip. These details are especially critical when an end-firing optical fiber or tip is used [62, 63].

For instance, Ciurescu detailed that the laser tip was "inserted subgingivally to the depth of the pocket, and irradiation was carried out with gentle sinusoidal retracting movements until all reachable surfaces were contacted." Abduljabbar explained that "the fiber was placed nearly parallel to the tooth surface, moving continuously from mesial to distal on both buccal and lingual sides, maintaining constant motion in close contact with the epithelial lining, parallel to the long axis of the root." In contrast, Giannopoulou merely indicated that "subgingival irradiation was conducted with a diode laser for 60 seconds," without further elaboration. A few authors referred to adherence to the manufacturer's guidelines, though this was not common practice. Consequently, the absence of detailed procedural descriptions hinders accurate study replication and comparison.

Some investigations restricted their focus to single-rooted teeth, whereas others included entire quadrants containing multi-rooted sites. Certain study designs evaluated only one tooth per subject. Because of the anatomical variability of roots, such limitations may restrict the broader applicability of their findings to generalized periodontitis therapy.

Among the reviewed works, only two studies [26, 27] documented negative laser-related outcomes in select parameters compared to SRP alone—specifically increased discomfort, bleeding, swelling on the first day, and a higher percentage of sites with residual pockets >4 mm. These findings, however, reinforce the general safety of lasers as an adjunctive method in non-surgical periodontal treatment.

Table 2's bias assessment indicated that 55% of the studies [14–18, 21–24, 31, 33] had a low risk of bias, while 45% [19, 20, 25–30, 32] demonstrated a moderate level, with the two lowest scores being 6.

Conclusion

Due to the multifactorial nature of periodontal disease and the diversity of therapeutic techniques available for initial management, creating uniform standards and comparisons among studies remains challenging. This systematic review determined that approximately 70% of the analyzed research [14–17, 19–23, 28–31, 33] observed significant improvement in certain clinical outcomes, though other parameters showed no change. The remaining 30% [18, 24–27] found no statistically meaningful differences in any measured indices.

When laser parameters are properly selected, these devices appear to serve a beneficial adjunctive function in initial non-surgical periodontal procedures. Continued publication of long-term, well-controlled randomized clinical trials is recommended to further substantiate these findings and clarify their clinical relevance.

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