Review

Effectiveness of Laser Application for Periodontal Surgical Therapy: Systematic Review and Meta-Analysis

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Background: Evidence has shown some improved clinical outcomes and morbidity reduction with the use of lasers for non-surgical periodontal therapy due to ablation, vaporization, hemostasis, and field sterilization. The purpose of this systematic review is to evaluate and compare studies involving lasers as monotherapy or adjunctive to surgical periodontal treatment.

Methods: Electronic and manual searches were conducted by two independent reviewers in several databases for articles written in English up to December 2014. Articles were included in this review if they reported outcomes of surgical periodontal therapy with and without the use of lasers. The primary outcome was probing depth (PD), and secondary outcomes were measured changes in clinical factors such as clinical attachment level (CAL) and gingival recession (GR). For the comparative studies included, the pooled weighted mean difference (WMD) and 95% confidence interval (CI) of each variable were calculated using random-effects meta-analysis.

Results: Eight and nine articles were included in the quantitative and qualitative analyses, respectively. Although low-to-moderate risk of bias was detected, high heterogeneity among studies was found. In flap surgery with or without laser treatment, there was no statistically significant difference in primary outcome. Similarly, in guided tissue regeneration (GTR)/enamel matrix derivative (EMD) with and without laser treatment, the WMD of PD was negligible; however, the GTR/EMD group showed better outcomes ($P = 0.005$) than the laser group. Regarding the secondary outcomes, in the flap surgery group, the WMD of CAL gain was 1.34 mm, and the WMD of GR was –0.24 mm; no significant difference was detected between groups. In GTR/EMD with and without laser treatment, the WMD of CAL gain was 0.10 mm and the WMD of recession was –0.18 mm; again, no significant difference was detected between groups.

Conclusions: The available evidence is insufficient to support the effectiveness of dental lasers as an adjunct to resective or regenerative surgical periodontal therapy. However, precautions must be exercised when interpreting the results of this study because of the small sample size and high heterogeneity among studies. *J Periodontol 2015;86:1352-1363.*

KEY WORDS

Evidence-based dentistry; lasers; meta-analysis; periodontal diseases; periodontitis; review.

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Periodontal disease, an inflammatory disease caused by opportunistic bacteria residing in the oral cavity, causes periodontal breakdown.[1] Nowadays, periodontal therapy involves not only arresting the disease process, but also regenerating the tissues lost during the disease process.[1-5] Intervention should be addressed with available treatment modalities. Non-surgical therapy (i.e., scaling and root planing [SRP])[6] remains an essential part of periodontal therapy. In SRP, diseased root surface debridement with different hand and ultrasonic instrumentation is performed to facilitate periodontal reattachment. Additionally, other non-surgical and surgical techniques such as subgingival curettage, gingivectomy, modified Widman flap, and apically positioned flap have been studied in an attempt to reduce probing depth (PD) and increase clinical attachment level (CAL).[7-12] Other treatment options aiming to regenerate tissues include guided tissue regeneration (GTR) or the application of growth factors, which have demonstrated varying degrees of success and predictability.[1-5] Regardless of the treatment modality, surgical periodontal therapy is often associated with pain and discomfort.

In the last decade, the use of lasers (*l*ight *a*mplification by *s*timulated *e*mission of *r*adiation) has occupied part of the dialogue within periodontology and oral surgery because of several proposed advantages.[6,13,14] In the arena of periodontology, laser use as an adjunct to non-surgical therapy was demonstrated to enhance periodontal healing;[15] however, it is still a matter of debate.[16] Advantages over conventional periodontal flap surgeries include ablation, vaporization, hemostasis, pocket sterilization, and morbidity reduction.[17,18] Lasers are also advantageous in many aspects for periodontal treatment such as effective root surface debridement.[17,18] Lasers used in this arena include 1) CO_2; 2) neodymium:yttrium-aluminum-garnet (Nd:YAG); 3) erbium:yttrium-aluminum-garnet (Er:YAG); and 4) diode lasers. The Er:YAG laser (ERL) has been reported to be the most promising for periodontal treatment. Its ability to ablate dental calculus effectively without overheating adjacent tissue has been demonstrated.[17-20] Some studies have even pointed out significant CAL gain in conjunction with non-surgical periodontal treatment.[19-21] Laser systems such as CO_2, diode, and Nd:YAG have been used for oral soft tissue procedures (gingivectomy or frenectomy).[22,23] CO_2 lasers have been successfully used as an adjunctive tool to de-epithelialize the mucoperiosteal flap during traditional flap surgery.[24] Laser treatment, alone or in combination with mechanical treatment (SRP), has produced positive clinical outcomes with respect to CAL gain, decreased PD, and decreased bleeding on probing (BOP).[20,25,26] Similar findings were shown using ERL in the medium term for single-rooted teeth with chronic periodontitis (CP), and outcomes achieved could be maintained over a 5-year period.[27] The pulsed Nd:YAG laser has been incorporated into protocols that attempt to regenerate lost alveolar bone, cementum, periodontal ligament (PDL), and connective tissue attachment around natural teeth.[28-30] A similar protocol is also used on compromised implant sites in an attempt to regenerate supporting bone.[31,32]

Although some evidence[15] has shown the benefits of using lasers for non-surgical periodontal therapy with regard to clinical outcomes, its effectiveness for surgical therapy remains unclear. Hence, the purpose of this systematic review is to evaluate and compare various lasers as monotherapy or adjunctive to surgical periodontal therapy.

MATERIALS AND METHODS

Focused Question and Process

The focused question for this review is, what is the effectiveness of laser adjunctive therapy in periodontal surgical treatment as measured by clinical parameters?

The patient, intervention, comparative, outcome (PICO)[33] process factors are as follows: P: dentate patients with periodontal disease (chronic or aggressive, moderate or severe), with or without bleeding, with or without exudate, with or without furcation involvement, and with or without gingival recession (GR); I: surgical periodontal treatment using a laser (CO_2, Nd:YAG, Er:YAG, or diode) approved by the Food and Drug Administration for use in surgical (resective or regenerative) or non-surgical periodontal treatment with or without manual debridement; C: surgical resective or regenerative treatment using approaches other than laser, alone or with laser therapy; and O: benefits or lack thereof in PD reduction, CAL gain, radiographic bone (RB) gain, and decrease in GR, BOP, and exudate.

Eligibility Criteria

Articles were included in this systematic review if they met the following inclusion criteria: prospective or retrospective, randomized or not, cohort or case series involving human patients in which outcomes of surgical periodontal therapy using lasers were compared with other surgical approaches. Several factors such as study design, number of patients included at the last follow-up assessment, number of defect sites, smoking or other systemic conditions that might alter the outcome, and type of procedure (including whether bone grafting material or barrier membrane was used) were extracted from the selected studies and analyzed. To address the aim of this study comprehensively, parameters such as PD, CAL, BOP, RB change, suppuration, and GR were further reported (Table 1).[21,24,25,33-39] These were subgrouped by initial and final values and change in percent or millimeters, depending on the parameter

Table 1.

RCT Studies Included in the Qualitative Assessment for Flap Surgery Versus Laser and Regenerative Surgery Versus Laser

Treatment and Reference	Group		Patients (n)	Age (years)	Number of Defects		Type of Defect	Laser		Surgery Type		Follow-Up (months)
	Test	Control			Test	Control		Type	Wavelength	Test	Control	
OFD and laser												
Sculean et al. 2004[22]	Flap + laser	Flap	23	ND	12	11	Deep IBD (PD >6 mm)	Er:YAG	160 mJ/pulse, 10 pulses/second	OFD	OFD	6
Gaspirc and Skaleric 2007[27]	Flap + laser	MWF	25	46.3 ± 9.2	73	73	Advanced CP (PD >6 mm)	Er:YAG	600 milliseconds, 180 mJ/pulse at 20 Hz	MWF	MWF	60
Retzepi et al. 2007[41]	Laser doppler flowmetry in PPF	MWF	10	35 to 65	10	10	CP (PD ≥5 mm)	Laser doppler flowmetry		PPF	MWF	2
Crespi et al. 2011[42]	CAF + laser	MWF	25	45	100	100	≥5 mm PD	CO_2	10.6 µm	CAF + laser	MWF	180
Gokhale et al. 2012[37]	Flap + laser	Flap	30	30 to 50	30	30	≥5 mm PD	CO_2	980 nm, laser dose, 50 J/cm^2/second	OFD	OFD	3
GTR and laser												
Schwarz et al. 2003[26]	Laser + EMD CAF	EMD and CAF alone	22	ND	11	11	IBD	Er:YAG	160 mJ/pulse, 10 Hz	OFD + EDTA + EMD	OFD + EDTA + EMD	6
Ozcelik et al. 2008[38]	EMD + laser	EMD alone	22	31 to 49	22	22	IBD (PD ≥6 mm)	Diode	588 and 4 J/cm	OFD + EMD	OFD + EMD	12
Dilsiz et al. 2010[39]	EMD + laser	EMD alone	21	33 to 46	21	21	IBD (PD ≥6 mm)	Nd:YAG	1 W, 10 Hz, 100 mJ, 1,064 nm	OFD + EMP	OFD + EMP	12
Doğan et al. 2014[40]	GTR + laser	GTR alone	13	26 to 49	13	13	PD ≥5 mm	Nd:YAG	1,064 nm, 100 mW, 100 mJ	GTR	GTR	6

OFD = open flap debridement; RCT = randomized controlled trial; ND = not defined; IBD = infrabony defect; MWF = modified Widman flap; PPF = papilla preservation flap; CAF = coronally advanced flap; EMD = enamel matrix derivative.
None of the study participants smoked or had other systemic conditions.

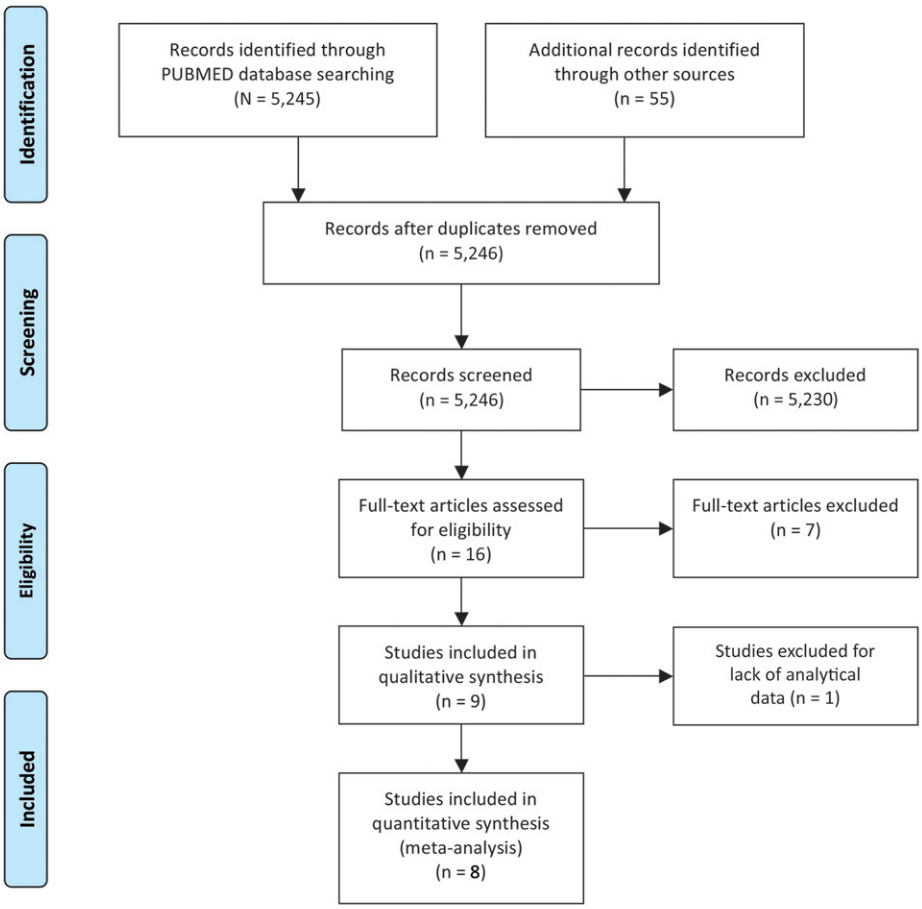

Figure 1.
PRISMA flowchart for the screening process.

being studied. Excluded from the review were: 1) case reports or case series with <10 patients; 2) systematic reviews; 3) preclinical animal studies; 4) human trials studying the use of laser for non-surgical (i.e., SRP) therapy; and 5) human trials with missing information.

Screening Process

Electronic and manual searches were conducted by two independent reviewers (SB and AM) in four databases (MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, and Cochrane Oral Health Group Trials Register databases) for articles written in English up to December 2014. For the PubMed library, combinations of controlled terms (MeSH and EMTREE) and key words were used whenever possible. The search terms used in title and abstract were as follows: (bone loss, periodontal[MeSH Terms] OR debridement, periodontal[MeSH Terms] OR debridement, periodontal epithelial[MeSH Terms] OR periodontal atrophy[MeSH Terms]) OR adult periodontitis[MeSH Terms] AND (periodontal[Other Term] OR periodontal flap[Other Term]) AND (carbon dioxide lasers[MeSH Terms] OR erbium YAG laser[MeSH Terms] OR ablation, laser tissue[MeSH Terms] OR Doppler laser flowmetry[MeSH Terms] OR diode laser[MeSH Terms] OR lasers, neodymium doped yttrium aluminum garnet[MeSH Terms]) AND English language[filter] AND clinical trial[filter] AND humans[filter]. For the Embase and Cochrane Libraries, the terms were restricted to the aim of the study. The key terms applied for the Embase Library were as follows: laser AND periodontal AND surgery OR periodontal AND disease OR periodontal AND treatment AND clinical trials AND humans. For the Cochrane Library, laser periodontal surgery was applied in Title, Abstract, and Keywords in Trials. Additionally, to ensure a thorough screening process, a manual search was performed of periodontics-related journals, including *Journal of Dental Research*, *Journal of Clinical Periodontology*, *Journal of Periodontology*, and *The International Journal of Periodontics & Restorative Dentistry* from January 2014 to December 2014. References of included articles were screened to check all available articles.

Two reviewers (AM and G-HL) designed and assessed the proposal for the project to make sure the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was followed to minimize risk of bias in the screening process and provide a high level of evidence. PRISMA consists of a 27-item checklist and a four-phase flow diagram.[34]

Qualitative Assessment

Criteria used to evaluate the quality of the selected randomized controlled trials (RCTs) were modified from the randomized clinical trial checklist of the Cochrane Center and the Consolidated Standards of Reporting Trials (CONSORT) statement,[35] which provides guidelines for the following parameters: 1) sequence generation; 2) allocation concealment method; 3) masking of the examiner; 4) address of incomplete outcome data; 5) free of selective outcome reporting; and 6) patient accounting at the end of the study. The degree of bias was categorized as low risk if all the criteria were met, moderate risk if one criterion was missing, and high

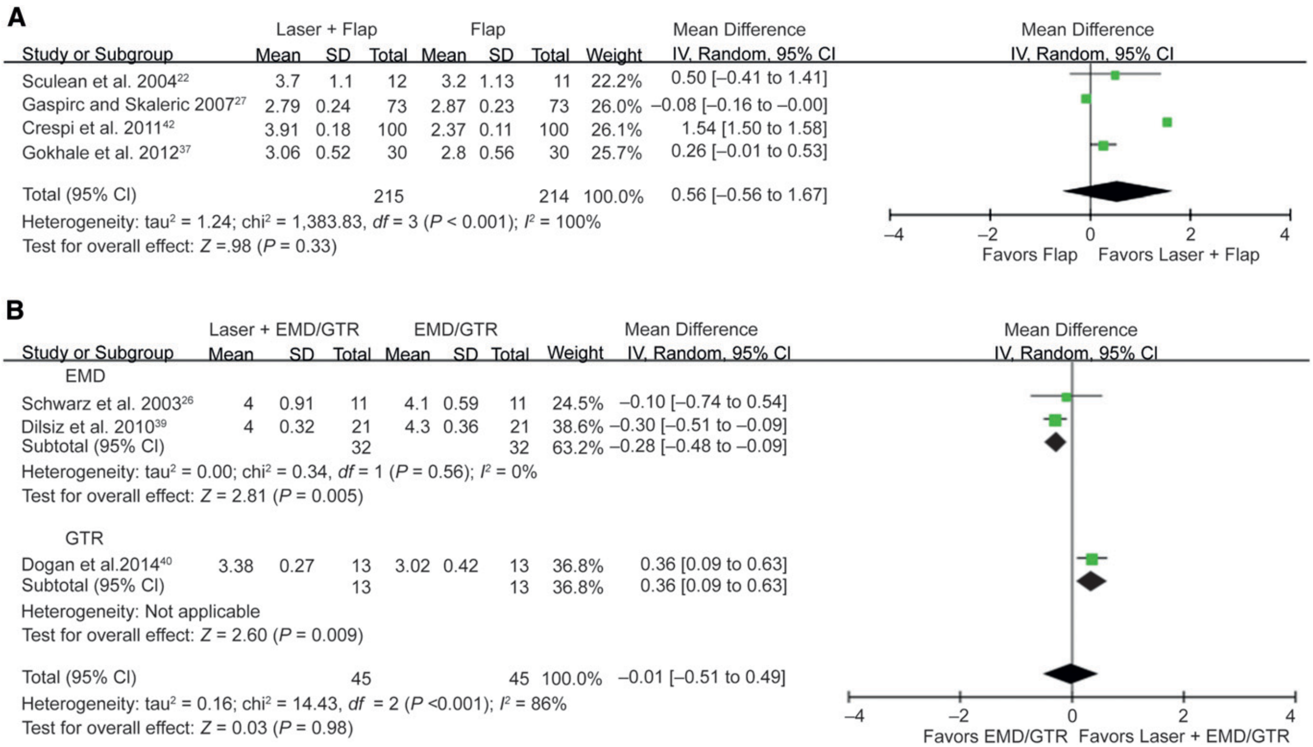

Figure 2.
A) *Meta-analysis for comparison of PD among selected studies in flap surgery with and without laser treatment. The overall WMD was 0.56 mm (95% CI = −0.56 to 1.67 mm, P = 0.33).* ***B)*** *Meta-analysis for comparison of PD among selected studies in GTR/EMD with and without laser treatment. The overall WMD was −0.01 mm (95% CI = −0.51 to 0.49 mm, P = 0.98). IV = independent variable.*

risk if ≥2 criteria were missing.[36] Two independent reviewers (SB and AM) evaluated all the included articles.

Statistical Analyses

The primary outcome was PD reduction, and the secondary outcomes were CAL gain and GR reduction. BOP, suppuration, and RB change could not be meta-analyzed because of the high heterogeneity in studies reporting them.

Because of the variance in study designs and laser types, the analysis was divided into two subgroups: 1) flap surgery with and without laser treatment; and 2) GTR/enamel matrix derivative (EMD) with and without laser treatment. For the comparative studies included, the pooled weighted mean difference (WMD) and 95% confidence interval (CI) of each variable were calculated with random-effects meta-analysis by a computer program.[†] Forest plots were produced to graphically represent WMD and 95% CI in primary and secondary outcomes for the studies, using number of defect sites investigated as the analysis unit. In addition, heterogeneity among studies was assessed with the χ^2 test, with a P value <0.05 representing significant heterogeneity. Funnel plots were also generated to report potential publication bias.

RESULTS

Study Selection

An initial screening yielded a total of 5,446 articles, of which 16 potentially relevant[13,20,22,26-28,37-46] articles were selected after an evaluation of titles and abstracts. The full texts of these articles were obtained and thoroughly evaluated. Nine articles[22,26,27,37-42] fulfilled the inclusion criteria and are included in the systematic review. Because of the lack of analytical data, one of these studies was excluded;[41] thus, only eight articles[22,26,27,37-40,42] are included in the quantitative analysis (Fig. 1). Details of all included studies were summarized in Table 1. Briefly, for open-flap debridement (OFD), 103 individuals were included, and for GTR/OFD + EMD, 78 individuals were included. Reasons for exclusion are displayed in supplementary Table 1 in online *Journal of Periodontology*.

Study Quality

All the studies included in the qualitative and quantitative analyses were RCTs. The RCT checklist of the Cochrane Center and the CONSORT statement were used to score studies' quality (see supplementary Table 2 in online *Journal of Periodontology*). Low

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Table 2.

Quantitative Assessment for Flap or Regenerative Surgery versus Laser: PD and CAL

Reference	Mean PD (mm)						Mean CAL (mm)					
	Initial		Final		Reduction		Initial		Final		Reduction	
	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control
Sculean et al. 2004.[22]	7.8 ± 1.3	7.8 ± 0.8	4.1 ± 1.3	4.6 ± 1.6	3.7	3.2	9.8 ± 2.9	9.2 ± 1.2	7.2 ± 2.5	7.7 ± 1.6	ND	ND
Gaspirc and Skaleric 2007[27]	5.63 ± 0.95	5.78 ± 0.82	2.84 ± 0.43	2.91 ± 0.55	2.79	2.87	6.14 ± 1.80	6.36 ± 2.00	3.97 ± 0.89	4.05 ± 0.89	ND	ND
Retzepi et al. 2007[41]	5.8 ± 0.1	5.7 ± 0.1	3.3 ± 0.1	2.8 ± 0.1	2.5 ± 0.2	2.8 ± 0.2	6.9 ± 0.2	6.7 ± 0.2	5.5 ± 0.2	5.4 ± 0.3	1.5 ± 2.1	1.3 ± 0.3
Crespi et al. 2011[42]	7.91 ± 0.81	7.17 ± 0.33	4.00 ± 0.38	4.80 ± 0.45	ND	ND	8.71 ± 0.34	8.63 ± 0.22	3.61 ± 1.11	8.23 ± 0.63	ND	ND
Gokhale et al. 2012[37]	6.03 ± 1.22	5.80 ± 1.19	2.97 ± 0.72	3.00 ± 0.95	ND	ND	11.07 ± 1.57	11.5 ± 1.97	9.70 ± 1.62	9.80 ± 1.77	ND	ND
Schwarz et al. 2003[26]	8.6 ± 1.2	8.1 ± 0.8	4.6 ± 0.8	4.0 ± 0.5	ND	ND	10.7 ± 1.3	10.4 ± 1.1	7.5 ± 1.4	7.1 ± 1.2	3.2	3.3
Ozcelik et al. 2008[38]	6.6 (5.9 ± 6.8)	6.5 (5.9 ± 6.7)	1.3 (1.2 ± 2.3)	1.7 (1.3 ± 3.3)	ND	ND	7.2 (6.8 ± 7.5)	7.2 (6.5 ± 7.5)	3.1 (2.4 ± 3.7)	3.2 (2.8 ± 4.7)	ND	ND
Dilsiz et al. 2010[39]	7.3 ± 0.6	7.3 ± 0.7	3.3 ± 0.4	3 ± 0.4	ND	ND	9.5 ± 0.7	9.3 ± 0.8	6.9 ± 0.7	6.4 ± 0.5	ND	ND
Doğan et al. 2014[40]	6.01 ± 0.47	5.95 ± 0.43	2.63 ± 0.29	2.93 ± 1.98	3.38 ± 0.27	3.02 ± 0.42	7.35 ± 0.48	7.43 ± 0.60	4.46 ± 0.57	5.18 ± 0.46	2.91 ± 0.43	2.26 ± 0.34

ND = not defined.

(55.5% of studies) to moderate (44.5% of studies) estimated potential risk of bias was found from the studies included in the qualitative appraisal.

Results of the Primary Outcome (PD)

In flap surgery with and without laser treatment, the WMD of PD was 0.56 mm (95% CI = –0.56 to 1.67 mm, *P* = 0.33) (Fig. 2A). No significant difference was detected among groups. A high degree of heterogeneity (*P* <0.001 for χ^2 test) was noted.

In GTR/EMD with and without laser treatment, the WMD of PD was –0.01 mm (95% CI = –0.51 to 0.49 mm, *P* = 0.98) (Fig. 2B). No significant difference was detected between groups. A high degree of heterogeneity (*P* <0.001 for χ^2 test) was noted. Interestingly, in the EMD subgroup, the meta-analysis showed a significantly favorable outcome toward the EMD/GTR-only group (*P* = 0.005), with a low degree of heterogeneity between studies (*P* = 0.56 for χ^2 test).

Data for the initial, final, and reduction in mean PD for the included studies are presented in Table 2.

Results of the Secondary Outcome (CAL gain and GR decrease)

In flap surgery with and without laser treatment, the WMD of CAL gain was 1.34 mm (95% CI = –2.02 to 4.70 mm, *P* = 0.44) (Fig. 3A). No significant difference was detected among groups. The *P* value for χ^2 test was <0.001, indicating a high heterogeneity among studies. In GTR/EMD with and without laser treatment, the WMD of CAL gain was 0.10 mm (95% CI = –0.64 to 0.85 mm, *P* = 0.78) (Fig. 3B). No significant difference was detected among groups. The *P* value for χ^2 test was <0.001, indicating a high heterogeneity among studies. However, in the EMD subgroup, the meta-analysis showed a significantly favorable outcome toward EMD/GTR without the use of laser (*P* = 0.03), with a low degree of heterogeneity among studies (*P* value for χ^2 test 0.69). Data for the initial, final, and reduction in mean CAL for the included studies are presented in Table 2.

The WMD of GR was –0.24 mm (95% CI = –0.82 to 0.35 mm, *P* = 0.42) (Fig. 4A). No significant difference was detected among groups. The *P* value for χ^2 test was 0.18, indicating a moderate degree of heterogeneity among studies. Additionally, the WMD of GR was –0.18 mm (95% CI –0.42 to 0.07 mm, *P* = 0.15) in the comparison of EMD/GTR with and without the use of lasers (Fig. 4B). No significant difference was detected. The *P* value for χ^2 test was 0.59, indicating a low degree of heterogeneity among studies. Data for initial, final, and reduction in mean BOP, mean GR, and discomfort are presented in Table 3.

Funnel plots evaluating the publication bias of each parameter are shown in supplementary Figures 1 through 6 in online *Journal of Periodontology*.

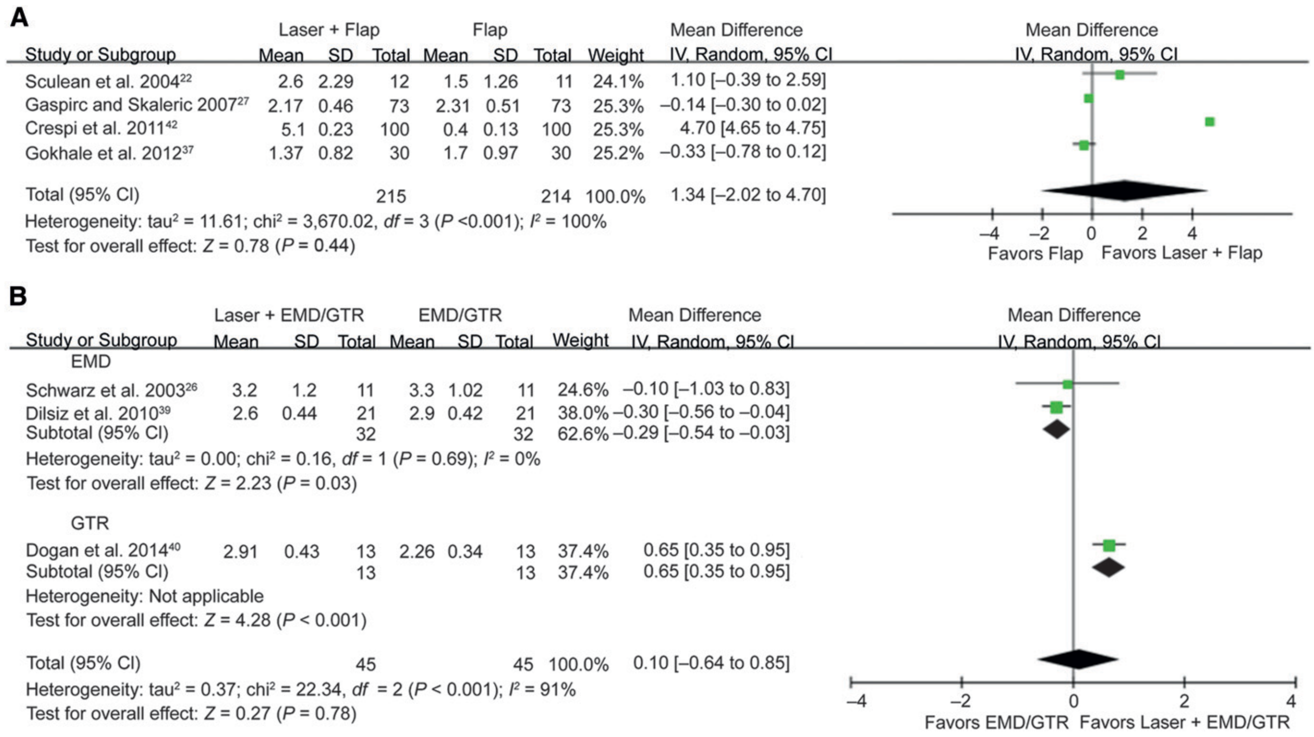

Figure 3.
A) *Meta-analysis for comparison of CAL gain among selected studies in flap surgery with and without laser treatment. The overall WMD was 1.34 mm (95% CI = −2.02 to 4.70 mm,* P *= 0.44).* ***B)*** *Meta-analysis for comparison of CAL gain among selected studies in GTR/EMD with and without laser treatment. The overall WMD was 0.10 mm (95% CI −0.64 to 0.85 mm,* P *= 0.78). IV = independent variable.*

DISCUSSION

The effective applicability of lasers in the treatment of periodontal disease according to their theoretic advantages (i.e., ablation or vaporization, hemostasis, and sterilization effect) compared to conventional therapy is currently a very controversial topic in clinical periodontics. Findings from this study show that for regeneration and PD reduction surgical procedures, adjunctive use of lasers offers no significant clinical advantages in CAL gain and PD reduction compared with conventional approaches. These results must be cautiously interpreted, since limitations exist in regard to sample size and heterogeneity among studies.

Summary of Main Findings

Different types of laser, including CO_2, Nd:YAG, Er:YAG, and diode, have been used for periodontal disease treatment and hard and soft tissue management.[15,16,47] Laser irradiation, at low level, stimulates surrounding tissue cells and results in reduction of inflammation, higher tissue regeneration, better tissue attachment, and even increased lymph flow, as well as less postoperative pain, once the scattered beams penetrate into pockets.[48] Smooth and flat root surfaces with sealed dentinal tubules as well as bacterial elimination can be obtained using CO_2 lasers (in defocused pulsed mode with power of 2W), which in turn enhance fibroblast attachment.[49] A diode laser with wavelength of 810 or 910 to 980 nm is a useful setup for soft tissue management (coagulating and cutting gingiva or oral mucosa, sulcular debridement) and has antibacterial effects.[50] It must be noted that CO_2, Nd:YAG, and diode lasers are not effective in treating or dealing with hard tissue surfaces in terms of calculus removal.[23,49] In contrast, the ERL has the ability to effectively ablate dental calculus without creating thermal damage to adjacent tissue.[19] ERL has a wavelength of 2,940 nm, close to the absorption coefficient of water, making it safe and free of thermal side effects.[23] Moreover, ERL has antimicrobial effects and works to remove lipopolysaccharide from root surfaces.[23] In the present study, it was not the aim to compare the effectiveness of laser subtypes, and no particular one was found to be superior.

Agreements and Disagreements With Previous Studies

In contrast to these findings, a long-term follow-up study[42] showed that in deep pockets (PD ≥7 mm), a coronally advanced flap combined with CO_2 laser provides greater PD reduction compared with a modified Widman flap procedure. A similar trend was also noted in CAL assessment. It was then concluded

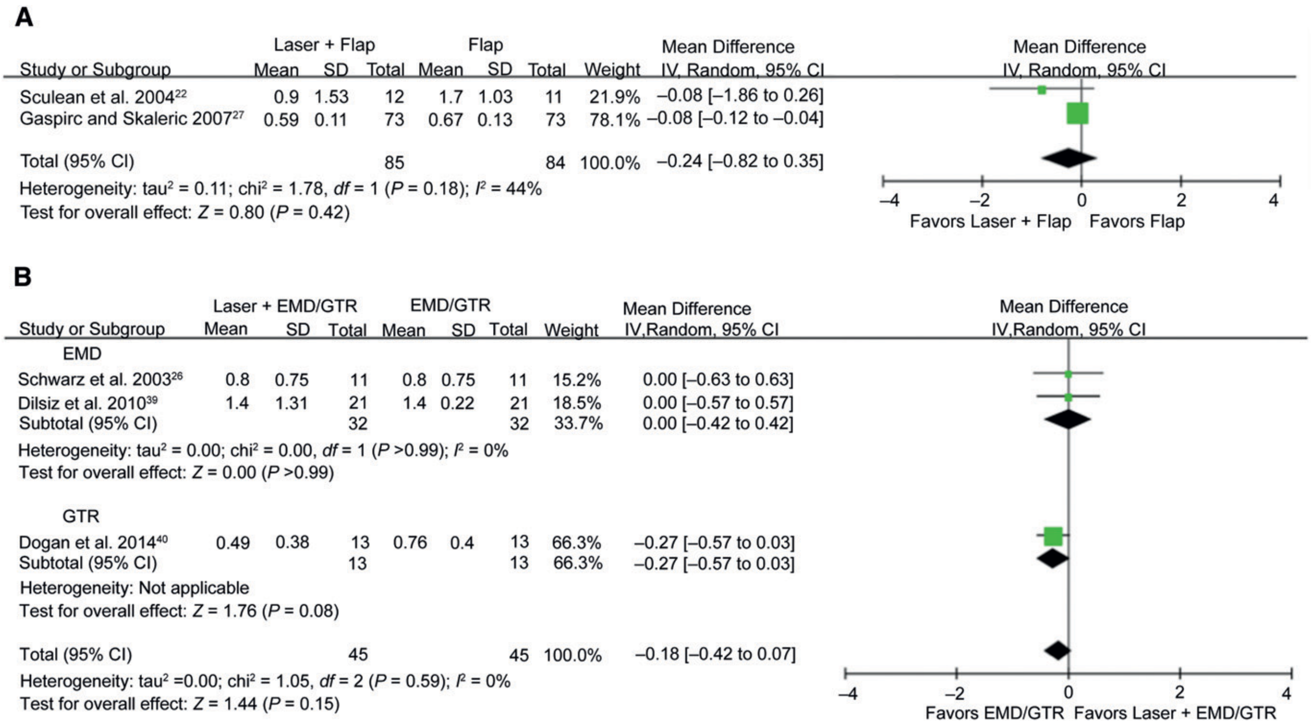

Figure 4.
A) *Meta-analysis for comparison of GR among selected studies in flap surgery with and without laser treatment. The overall WMD was −0.24 mm (95% CI = −0.82 to 0.35 mm, P = 0.42).* ***B)*** *Meta-analysis for comparison of GR among selected studies in GTR/EMD with and without laser treatment. The overall WMD was −0.18 mm (95% CI = −0.42 to 0.07 mm, P = 0.15). IV = independent variable.*

that CO_2 lasers might provide meaningful clinical benefits in the treatment of deep pockets. These findings have been partially attributed to the ability of the CO_2 laser to remove the smear layer and eliminate bacterial cells from diseased root surfaces.[51] Also, myofibroblasts, which are suggested to be responsible for tissue contraction, are less abundant after treatment with CO_2 lasers,[51] which may be another rationale for better CAL gain in the test group. Nonetheless, the findings may be attributed not just to the laser, but also to the study design, in which no similar surgical procedures were evaluated. Moreover, this specific study showed no crater formation or root surface damage resulting from laser therapy. These results were in contrast to previously reported studies.[51-54]

Other studies[26,37,39] are in agreement with the present findings. In a comparative evaluation[37] of the efficiency of the diode laser as an adjunct to mechanical debridement versus conventional mechanical debridement in periodontal open flap surgery, no difference was found between laser-treated and non–laser-treated groups with regard to clinical parameters. However, it was reported[37] that the use of laser treatment adjunctive to open flap debridement provides a beneficial effect by reduction of anaerobic bacterial colonies within the sulci. The antiseptic potential of lasers was explained based on laser energy disrupting the protective mechanism of the organisms.[55] The visual analog scale showed that patients tolerated application of the diode laser; nonetheless, its application did not make a difference in pain perception.[55] Similar findings were reported by another group.[37]

Dental lasers have slight advantages but also some inherent drawbacks that have to be pointed out, including possible damage to bone owing to overheating and ineffectiveness in removing calculus. Hence, intermittent laser application and correct laser settings are key factors to reduce potential damage. Another investigation using ERL for the surgical treatment of chronic periodontal disease[26] found no statistically significant clinical differences compared with resective procedures.

Dental lasers have been applied and investigated for regenerative procedures (i.e., GTR).[38,56] In a short-term study,[56] patients with CP who had intrabony defects and were receiving treatment with GTR in combination with low-level laser therapy demonstrated statistically better improvements in PD reduction, CAL gain, and decreased GR at 6 months versus the group who received GTR alone. Additionally, a significant reduction of the sulcular bleeding index favored the laser-treated group. These findings

Table 3.

Quantitative Assessment for Flap or Regenerative Surgery versus Laser: BOP, Recession, and Discomfort

Reference	Mean BOP (%)						Mean Recession (mm)						Discomfort of Procedure
	Initial		Final		Reduction		Initial		Final		Increase		
	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control	
Sculean et al. 2004.[22]	40	44	15	18	25	26	2.2 ± 1.6	1.5 ± 1.0	3.1 ± 2.0	3.2 ± 1.3	0.9	1.7	ND
Gaspirc and Skaleric 2007[27]	40.2	39.4	15.6	16.7	15.6	22.7	0.61 ± 0.25	0.58 ± 0.30	1.2 ± 0.39	1.25 ± 0.45	ND	ND	ND
Retzepi et al. 2007[41]	ND	ND	ND	ND	ND	ND	1.1 ± 0.1	1.1 ± 0.1	2.2 ± 0.1	2.6 ± 0.1	−1.1 ± 0.1	−1.5 ± 0.2	ND
Crespi et al. 2011[42]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	Similar in both groups
Gokhale et al. 2012[37]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Schwarz et al. 2003[26]	65	57	30	31	35	26	2.1 ± 0.9	2.3 ± 0.9	2.9 ± 1.0	3.1 ± 1.0	−0.8	−0.8	ND
Ozcelik et al. 2008[38]	ND	ND	ND	ND	ND	ND	1.9 (1.1 ± 2.4)	2.3 (1.8 ± 3.0)	2.3 (1.1 ± 2.8)	2.9 (2.4 ± 3.8)	ND	ND	ND
Dilsiz et al. 2010[39]	100	100	9.52	4.76	90.48	95.24	2.2 ± 0.5	2 ± 0.4	3.6 ± 0.5	3.4 ± 0.3	ND	ND	ND
Doğan et al. 2014[40]	ND	ND	ND	ND	ND	ND	1.33 ± 0.42	1.48 ± 0.55	1.82 ± 0.52	2.24 ± 0.43	ND	ND	ND

ND = not defined.

were partially corroborated with the same laser type by other studies carrying out other periodontal regenerative approaches.[38,56] Thus, it seems that low-level laser therapy as an adjunct to GTR may improve short-term clinical outcomes. Some in vitro studies were conducted to evaluate the responsiveness of PDL cells to low-level laser therapy.[57-59] Less collagen breakdown after laser irradiation was described in terms of plasminogen activator plasmin proteolytic system inhibition with the use of lasers.[60] Additionally, sites treated with an 809-nm laser showed higher fibroblast proliferation as well as increased production of basic fibroblast growth factor.[59] This can be mainly attributed to the stimulatory effect of laser therapy on PDL cell regeneration.[59]

Contrary to previous findings[38,40,42] and in agreement with ours, Dilsiz et al.[39] compared the clinical outcomes of enamel matrix proteins (EMP) alone and combined with Nd:YAG laser in the treatment of infrabony defects. They reported that the use of Nd:YAG laser did not have superiority over EDTA as a root conditioning agent.[39] Along these lines, it is important to mention that consensus is lacking that EMP as a biologic agent enhances clinical outcomes compared to GTR procedures using barrier membranes.[61-64] Also noteworthy is that there are still controversies in the literature regarding the effectiveness of root conditioning agents.[65-67] Other studies demonstrated the efficacy of laser application as a root biomodification instrument to achieve better periodontal regenerative outcome by means of new attachment formation.[68-70] Cementum biocompatibility alteration using Nd:YAG laser for more predictable new attachment after periodontium regeneration has also been demonstrated.[70]

Limitations of the Study

Finally, it is important to highlight some evident limitations found in the qualitative assessment of articles using dental lasers as an adjunct to regeneration. For instance, defect morphology can potentially affect the final outcome. Steffensen and Webert showed statistically better results for defects angled <45 degrees. As a matter of fact, wider defects had higher RB loss.[71] Likewise, Cortellini and Tonetti demonstrated that in scenarios of radiographic angulation ≤25 degrees, presence of a deep infrabony defect (≥3 mm), and ≥1 mm of gingival thickness over the site, the most consistent CAL and bone gains were achieved, regardless of the number of bony walls.[72] Many factors contribute to the results of any regenerative procedure, and precautions must be exercised when interpreting the present findings.

Moreover, it is essential to understand the limitations of the present review based on the heterogeneity of the studies included. Certainly, all the included studies were RCTs; nonetheless, as evaluated by the CONSORT statement, 44.5% have moderate risk of bias, mainly on two sections: 1) masking examiner and 2) selective outcome reporting. In such a controversial topic, where conflict of interest might play a major role in the outcome, studies on this matter must be cautiously interpreted to avoid misleading readers.

CONCLUSIONS

Within the limits of this study, this systematic review fails to support the effectiveness of dental lasers as an adjunct to resective or regenerative surgical periodontal therapy, owing to the lack of significant superiority over conventional approaches. Precautions must be exercised when interpreting the results of this study because of the small sample size and high heterogeneity among studies. Therefore, more randomized clinical trials examining different laser types and wavelengths are required to obtain stronger conclusions in this regard.

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