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Review Paper: A Literature Review of Laser Assisted Periodontal Therapy Efficacy and Safety

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ABSTRACT

This study aims to compare previous studies using lasers to evaluate the efficacy and safety of laser therapy adjacent to traditional methods. PubMed and Cochrane search engines were used to identify previous studies of laser assisted periodontal therapy. 29 articles were selected after applying specific keywords, additional filters, inclusion and exclusion criteria between the years 2018 and 2024 out of 107,255 articles. The results have indicated the efficacy of Nd:YAG, diode and CO2 laser for frenectomy.A single study using Er:YAG showed a decrease in operation and bleeding time. Er:YAG, Er, Cr:YSGG and diode have shown an efficacy for second-stage surgery of submerged implants. 2780 nm Er,Cr:YSGG used for crown lengthening surgery have shown a stable height increase after surgery unlike the conventional group. Nd;YAG showed a significant difference while Er,Cr:YSGG haven't in gingivectomy and osteotomy. Significant improved healing was shown using a ER:YAG and 660,940 and 980 nm diode for regenerative surgical therapy. Laser techniques using a 2940 nm Er:YAG and 980 nm Diode laser were efficient for gingival depigmentation. 1064 nm Nd:YAG showed a significant difference while 810 nm diode, PDT and Er:YAG laser haven't in comparison with the traditional method in reduction of bacteria. Studies reported a significant reduction in the average dental pain range using 808, 940, 980 nm diode and 2780 nm Er,Cr:YSGG laser. laser assisted treatments in variety of peridontal therapies was efficient and safe considering the wavelength and type of laser for each therapy.

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1. Introduction

The word laser is an abbreviation for Light Amplification by stimulated Emission of Radiation. As photonic therapy lasers have been used in periodontics since the 1980s, with the first reports of use in periodontal surgery (1,2).

The lasers used in periodontics are divided into two groups: high-power lasers and low-power lasers. High-power lasers (HPL) can be used in soft or bone periodontal surgery and for sulcular debridement of periodontal pocket and root decontamination or as a scaling and root planing (SRP) technique (3).

Nd:YAG laser was introduced by Geusic et al, in 1964 (4). However, its application was abandoned due to its adverse effects on dental hard tissue until 1990 when the pulse mode was introduced. In dentistry, lasers are used for biostimulation and surgery. Bio-stimulation procedures such as healing enhancement are done by low level lasers which run at 500 mW power. In contrast, surgical lasers, also called high intensity lasers, such as CO2, Nd:YAG, Er:YAG, Er,Cr:YSGG, and diode lasers operate at powers beyond 500 mW. Diode laser plays a significant role in dental procedures. Laser wavelengths in the range of 810 to 1064 nm are well absorbed by pigmented tissues, such as hemoglobin, melanin, and collagen. This type of laser incises the soft tissue in contact mode by a hot charred glass tip, and not by the laser beam beca use the wavelengths in the range of 810-1100 nm are poorly absorbed by the soft tissue. This type of laser is an excellent soft tissue surgical laser, and surgery can be performed safely as these wavelengths are poorly absorbed by the hard tissue. Similarly, Nd:YAG lasers use the same chromophores as the diode lasers to cut and ablate the soft tissue. The available dental wavelength is 1064 nm which provides sufficient depth to seal the damaged blood and lymphatic vessels and nerve endings, and leads to good hemostasis and minimal postoperative pain. However, some laser wavelengths such as the Er:YAG lasers cannot seal the damaged blood vessels effectively during tissue ablation due to their optical absorption being much lower than that of blood vessels (5-8).

The first laser invented for use on both hard and soft tissues was the CO2 laser. It is still the most appropriate surgical laser for the soft tissue since both accurate incision and hemostasis are achieved at the same time. This laser at a wavelength of 10600 nm is readily available on the market only for soft tissue surgery. Another type of this laser with 9300 nm wavelength is also being used due to its ability for use on both soft and hard tissues. CO2 laser at a wavelength of 10600 nm is absorbed by water, causing non-specific tissue damage. It may be used in focused mode for tissue incision or in defocused mode for tissue vaporization while sealing blood vessels of 0.5 mm in diameter, which results in effective hemostasis. The penetration depth of CO2 laser is a thousand times lower than that of diode laser, which results in a thin thermal damage zone following incision (9-11). The erbium lasers with the wavelength range of 2780-2940 are capable of both hard and soft tissue ablation, but their coagulating ability is poor due to an optical absorption much lower than that of blood vessels compared with CO2 laser. Hard tissue procedures show an excellent healing response. The new CO2 laser with a wavelength of 9300 nm is the newest alternative to erbium lasers for both soft and hard tissue surgical procedures. High intensity lasers have numerous applications in periodontics, as for gingivectomy, osteotomy, and frenectomy. Use of surgical lasers provides an effective tool to increase efficiency, site specificity, and patient comfort during and after treatment compared with conventional procedures. For many intraoral soft and hard tissue surgical procedures, laser therapy is an optimal alternative to conventional treatments (11-13).

2. Materials and Methods

A limited literature search was conducted in PubMed Central, Science Direct, Wiley Online Library, Springer, and Google Scholar from 2018 until 2023. The search strategy included the use of the following combination of key words: High intensity lasers in dentistry OR low intensity lasers in dentistry AND laser-assisted AND periodontal therapy AND high intensity lasers (Nd:YAG, Er:YAG, Er,Cr:YSGG, Diode, CO2) OR low intensity lasers (PDT,PBM) AND gingivectomy OR crown lengthening OR frenectomy OR osteotomy OR SRP OR pain reduction OR bacteria reduction OR regenerative procedure OR implant second-stage surgery. Hand searching was also performed. A total of **107,255** articles were identified in the literature search. Following screening of the titles and abstracts and applying other exclusion criteria, finally, 29 articles were selected for the final review.

Study Selection: Inclusion criteria: i having a periodontal involvationii Only open access articles [full] iii Studies were done on humans iv Articles mention details of lasers usedv Published since 2018Exclusion criteria:

i Articles are written in languages other than English ii Case reports, case series, cross sectioniii Studies involving cell/tissue cultures and not a whole organism iv Incomplete data v Full text not available

3. Results & Discussion

*Results for laser-assisted **frenectomy**:*Laser-assisted frenectomy in many cases minimize pain and discomfort

generally in comparison with conventional periodontal frenectomy. A total of 6 articles in this respect were reviewed (31-34 and 41-42).

A published article used 1064 nm Nd:YAG laser for laser-assisted frenectomy compared with the conventional scalpel technique (42). The results showed less transoperative and postoperative bleeding, less need for suturing and fewer functional complications in terms of chewing and speech and a reduction in surgical time. Amongst the six studies that used 980 nm diode laser for frenectomy (31-33), two studies compared laser surgery with the conventional technique (32,33). One study reported a significant increase in terms of keratinized gingiva width, attached gingiva width, and attached gingiva thickness but there was no significant difference between the laser surgery and the conventional group (33). They also reported minimal discomfort and functional complications in the laser-treated group. All three studies reported normal healing, minimal or no postoperative complications in terms of pain, swelling, and bleeding, and significantly better healing outcomes (31-33). One study compared 980 nm diode laser with 10600 nm CO2 laser for frenectomy (31). The CO2 laser caused faster healing, minimal gingival recession, and less bleeding compared with diode laser. A significant improvement in clinical attachment loss and a significant decrease in periodontal pocket were observed after using 980 nm diode laser, but there was no significant change regarding clinical attachment loss in the CO2 laser group. Both methods effectively decreased pain, but diode laser alleviated pain more quickly. Another study compared 810 nm diode laser with conventional surgery and found no healing complications, no recurrence, and similar probing depth in both groups, but plaque index and gingival index were significantly lower in the laser-treated group (34). A single study compared 2940 nm Er:YAG laser with conventional surgery and found no significant difference in scar tissue formation. The operation time and bleeding time were significantly lower in the laser group. Directly after surgery, the wound was significantly larger in the laser-treated group, but no difference was found after 5 days (41).

Result for laser-assisted ***second-stage surgery of submerged implants****:*Implants when placed in the oral cavity can follow one-stage or two-stage protocol.(43) In one-stage protocol, implants are placed along with healing abutment, known as the "submerged" or "delayed" approach. The two-stage implant placement was the original Brånemark et al. procedure and was advocated by this pioneer as a way of promoting stress-free integration of implants within the mandible (44). In a second surgical procedure, the implant is exposed, its cover screw removed, and the implant is then fitted with an abutment and the prosthetic phase of treatment will be completed (28). The three studies reviewed in this respect have shown a significant difference using a laser versus the conventional technique (25,28,29). The study using a Er:YAG laser has indicated higher PD reduction in laser group than the control group, however there were no significant found in CAL or bone gain (25). Another study reviewed was comparing a 940 nm diode with a Er, Ch: YSGG laser and a conventional method. Operation duration under Er, Cr:YSGG were much faster than the diode laser, however the results were not statistically significant. The operation time under two lasers were faster than the conventional scalpel group. The time taken for healing was faster in the Er, Cr:YSGG laser group than the diode laser and the scalpel group. VAS scale at day 0 was higher in the conventional group than the two laser groups (28). and the other study was using a 808 nm diode (29). The surgical time was shorter in the Laser group and bleeding was present only in the Control Group at the end of surgery.

Result for ***crown lengthening surgery****:*Interdisciplinary dentistry comes to play and specialists coordinate to salvage the teeth through a crown lengthening procedure to expose sufficient tooth structure to facilitate proper restoration as well as enhance esthetic appearance (5). Two studies were reviewed both using a 2780 nm Er,Cr:YSGG laser (15,19). The gingival margin of the laser group remained at stable height increase after surgery, while the gingival margin of traditional group showed both recession and rebounding (15). There was a significant difference of the VAS scores, with the patients in the laser group displaying significantly lower VAS scores for discomfort compared with the scalpel. On comparing the healing scores there was no statistical difference seen (19).

Results regarding laser-assisted ***gingivectomy*** *and* ***osteotomy****:* Laser-assisted gingivectomy is promoted for both esthetic and restorative purposes. Of the retrieved articles, a study used Nd;YAG laser for gingivectomy which showed a significant decrease in the total operative time, pain duration, pain intensity and and healing time in the laser group in comparison with routine surgery group (17). no significant differences were among laser surgery group and other surgical groups in GI, PLI, PD. a study that used Er,Cr:YSGG laser for treatment of intrabony defects reported that The following primary and secondary outcome variables were noninferior with the following margins: CAL, PD and REC (20).

Table 1. Characteristics of the reviewed studies

Objective	Year	Materials an Methods	Laser	Result	Treatment
Antibacterial Effects of Photodynamic and Diode Laser Therapies as Adjunctive Treatments in Periodontitis (14)	2023	Group A: Laser Group B: PDT 12 patients at the age of 30-60.	**Diode** • 810 nm • 1 w • rotational movement • 300 µm **PDT** photosan system (DK-2800; CMS Dental, Copenhagen, Denmark) and the light sensitive high-viscosity material of toluidine blue	Adjunctive treatment with laser and PDT can reduce periopathogenic bacteria rates being less remarkable in the early weeks (2 weeks), while it became more profound in the final weeks of the study (6 weeks). Evaluation of the effects of treatments on clinical parameters indicated that the clinical signs improved, especially for the BOP parameter, in which the changes were more significant in the final weeks of the study (6 weeks)	Nonsurgical (reduction of periodontopathogenic bacteria)
Flapless Er,Cr:YSGG laser versus traditional flap in crown lengthening procedure (15)	2021	Group A: Laser Group B: control 25 patients at the age of 22-69.	**Er,Cr:YSGG** • 2780 nm	The results demonstrated a significant increase in clinical crown length instantly after surgery in both groups. After a three-month follow-up, the gingival margin of the laser group remained at stable height with 0.17 +- 0.31 mm increase after surgery, while the gingival margin of traditional group showed both recession and rebounding by -0.13 +- 0.63 mm average.	Surgical (crown lengthening surgery)
Evaluation of Electrosurgery and Diode Laser in Gingival Depigmentation (16)	2022	Group I: electrosurgery Group II: diode laser 40 patients.	**Diode**	No significant difference was noted between the two groups for pain assessment at 7 days. Both electrosurgery and laser group showed significant differences between intraoperative time period to 24 hours and 24 hours to 7 days.	Surgical (Removal of melanin pigmentation)
Efcacy of three surgical methods for gingivectomy of permanent anterior teeth with delayed tooth eruption in children (17)	2022	Group A: laser surgery Group B: electrosurgery Group c: routine surgery 63 patients at the age of 7-13.	Group A received a laser ablation of hypertrophic gingiva (Device: LightWalker, brand: Fotona, model: M021-5AF/1, Nd: pulse width: SP; Pulse frequency: 50 Hz; Average output power: 4.5 W) to expose the impacted crown. Laser hemostasis (Nd: pulse width: VLP; pulse frequency: 20 Hz; average	There was a signifcant diference in total operative time, pain duration, pain intensity, and healing time between laser surgery group (group A) and routine surgery group (group C) There were not signifcant diferences among laser surgery group (group A), electrosurgery group (group B), and routine surgery group (group C) in GI, PLI, PD of eruptive permanent teeth after six months of treatment.	Surgical (gingivectomy)

			output power: 4.00 W) was used to control bleeding		
Comparative evaluation of the efficacy of diode laser as an adjunct to modified Widman flap surgery for the treatment of chronic periodontitis: A randomized split-mouth clinical trial (18)	2021	Group 1: MWF surgery Group 2: MWF surgery with adjunctive diode laser de-epithelization and biostimulation 20 patients at the age of 25-45.	**Diode** • 980 nm, 400-micron diameter and disposable fiber-optic tip at 1.5 W in contact mode at 45° angle to the inner aspect of the flap was used to remove the remaining epithelium	MWF surgery along with diode laser led to a significant improvement in Group 2 compared to Group 1 in clinical parameters such as PPD, relative clinical attachment level, VAS score as well as microbial parameter CFU/ml after 3 months.	Surgical (flap de-epithelialization in regenerative procedure)
Comparison of Flap Techniques for Crown Lengthening Procedures Using an All Tissue Laser (Waterlase Iplus®) and Conventional Surgical Flaps: A Cross Sectional Study (19)	2022	Group A: Laser assisted crown lengthening with osseous reduction using WATERLASE IPLUS® Group B: Apically displaced flap with osseous reduction 21 patients at the age of 19-45.	The all tissue laser (**WATERLASE IPLUS®**) composed of an erbium, chromium: yttrium-scandium-galliumgarnet (Er;Cr:YSGG) laser	Intergroup comparison of the VAS scores for discomfort observed at baseline after the procedure and 7th day of the study suggested that there was a significant difference of the VAS scores, with the patients in the laser group displaying significantly lower VAS scores for discomfort compared with the scalpel. On comparing the healing scores using Landry's simplified healing index there was no statistical difference seen.	Surgical (crown lengh (crown lengthening surgery)
A comparison of Er,Cr:YSGG laser to minimally invasive surgical technique in the treatment of intrabony defects: Twelve-month results of a multicenter, randomized, controlled study (20)	2023	Clinical measurements were recorded at baseline, 4 to 6 weeks following SRP, and 6 and 12 months following surgical therapy. Radiographic results were compared to baseline at 6 and 12 months following surgical therapy. 53 patients at the age of 19-73.	**Er,Cr:YSGG** laser	The following primary and secondary outcome variables were noninferior with the following margins: CAL with a non-inferiority margin of 0.7 mm, PD with a non-inferiority margin of 0.7 mm, and REC with a non-inferiority margin of 0.4 mm. Standardized radiographs suggest similar bone fill of 1.14 ± 1.73 mm for MIST and 1.12 ± 1.52 mm for ERL.	Surgical (osteotomy and osteoplasty)
Effect of Diode Laser-assisted Flap Surgery on Postoperative Healing and Clinical Parameters: A Randomized Controlled Clinical Trial (21)	2018	Test group: Flap surgery with adjunctive diode laser irradiation Control group: conventional access flap surgery 23 patients at the age of 25-60.	**Diode**	. There is no significant difference between the groups however, patients experienced more pain in test sites compared to control sites. Intragroup comparisons showed a statistically significant reduction of all clinical parameters from baseline to 6 months without any significant difference between the groups.	Surgical (flap de-epithelialization in regenerative procedure)
Clinical Evaluation of Diode Laser-Assisted	2021	Test site: MWF + activeDL Control site:	**Diode** • 810 nm, 400-micron diameter	All bacteria were significantly decreased at follow-up times compared with preoperative	Surgical and nonsurgical

Surgical Periodontal Therapy: A Randomized Split-Mouth Clinical Trial and Bacteriological Study (22)		MFW alone 18 patients.	and disposable fiber-optic tip at 1W in continuous wave mode (power density 796 w/cm2)	amounts in both therapy sites. All clinical parameters significantly improved after MWF surgery at follow-up times compared with preoperative values in intragroup comparisons, but a significant difference was not detected in the intergroup comparison.	
The Clinical and Microbiological Effects of LANAP Compared To Scaling and Root Planing Alone in the Management of Periodontal Conditions (23)	2023	Group 1: SRP as monotherapy Group 2: LANAP (the application Of the Nd:YAG laser in the periodontal pockets, scaling and root planing, followed by a Second application of the Nd:YAG laser) 14 patients at the age of 36-67.	**Nd:YAG** laser 1064 nm (Lightwalker AT-S, Fotona® Ljubljana, Slovenia	Both nonsurgical periodontal therapies were proven effective in Patients with chronic periodontal disease; however, LANAP was associated with a greater reduction In pocket depth and improved clinical outcomes, associated with a significant decrease in the amount Of Porphyromonas gingivalis. The clinical results included a decrease in periodontal pocket depth, Bleeding on probing, and dental plaque, with LANAP having better overall outcomes than SRP alone	Nonsurgical (reduction of periodontopathogenic bacteria)
Efficacy of Er:YAG laser on periodontitis as an adjunctive non-surgical treatment: a split-mouth randomized controlled study (24)	2019	test quadrants: Er:YAG laser (ERL) plus SRP control quadrants: SRP only 27 patients at the age of 35-70.	**Er:YAG** laser (ERL) 100mJ/pulse;15 Hz to hard tissue and 50 mJ/pulse; 30 Hz to soft tissue	The PD and CAL means in the ERL+SRP group were significantly lower than those in the SRP group at 3-month follow-up. There were no significant differences in BI and PLI between two groups.	Nonsurgical (reduction of periodontopathogenic bacteria)
Laser-assisted regenerative surgical therapy for Peri-implantitis: A randomized controlled clinical trial (25)	2020	control group : surgical Regenerative therapy, involving mechanical debridement And GBR. test group: adjunctive Laser irradiation in addition to mechanical debridement Prior to bone grafting. Control group patient also received A shame application of the laser on a wet gauze intraorally For masking purposes. 24 patients.	**Er:YAG** laser AdvErL EVO, J. MORITA MFG. CORP, Kyoto, Japan. (Laser tips: PS600T, PSM600T, and R600T)	Both groups showed significant reductions in PD, GI, and CAL gain Overtime. The test group demonstrated significantly higher PD reductions at the Site level compared to the control group (There were no statistical differences found in CAL gain , GI reduction , radiographic linear bone gain or proportional defect size reductionThere was a positive Trend for test patients on PD reduction and CAL gain found in narrow infrabony Defects. Major membrane exposure negatively impaired the overall treatmentOutcome of CAL gain and PD reduction in the test group	Surgical (second-stage surgery of submerged implants)
Effect of a 980 nm diode laser on post	2021	control group: final irrigation was performed	**Diode** • 980 nm	The average pain level in the control group 24 h after the	Nonsurgical (reduction of

operative pain after endodontic treatment in teeth with apical periodontitis: a randomized clinical trial (26)		using 5 ml of 2.5% sodium hypochlorite (NaOCI), followed by 5 ml of 17% and ethylenediaminetetraacetic acid (EDTA) and 5 ml of distilled water laser group: the root canals were irradiated using a 980-nm diode laser after the final irrigation at both visits 60 patients at the age of 18-65.		first visit was significantly higher than that in the laser group. The average pain level 24 h and 48 h after the second visit was significantly higher in the control group. The levels of PP 24 h after the first visit were higher than those after the second visit only in the control group. After the first visit, analgesic use in the control group was significantly higher after 8 h (40%) and 24 h (23%) as compared with that in the laser group.	postoperative pain)
Comparative evaluation of postoperative pain and tissue response in patients undergoing conventional flap surgeries with or without 940 nm diode laser exposure - A randomized clinical study (27)	2022	Group A and C: Kirkland flap surgery with laser and modified Widman flap (MWF) with laser Group B and D: Kirkland flap surgery and MWF surgery 10 patients at the age of 25-55.	Group A: an arsenide, indium, and gallium **diode** laser Epic X- BIOLASE California, USA possessing a wavelength of 940 ± 10 nm and a power of 1.5 watt involved in a continuous non-contact mode for 30 s Group C: an indium, gallium, and arsenide DL (Epic X Biolase) with a wavelength of 940 ± 10 nm and a power of 1.5 watt was irradiated involved in a continuous non-contact mode for 30 s	Statistically significant difference was attained with postoperative discomfort in laser-assisted groups on 1st and 3rd day postoperatively. There was no significant difference in the proportion of subjects with gingival inflammation. A statistically significant reduction in mean PPD at 6 months postoperatively was seen among all study groups but the inter-group difference was not statistically significant. SBI score reduced significantly from baseline to 6 months follow-up among all four groups. However, we did not find the inter-group difference to be statistically non-significant.	Surgical (reduction of postoperative pain)
Comparison of clinical efficacy of diode laser and erbium, chromium: Yttrium, scandium, gallium, and garnet for implant stage 2 recovery procedure – A randomized control clinical study (28)	2021	Group 1 patients (n = 10): had implant recovery using diode laser Group 2 (n = 10): implant recovery with Er, Cr:YSGG Group 3 (n = 10): conventional scalpel method 30 patients at the age of 25-45.	**Diode** • 940 nm surgical E4 400 µm tip, 2.5 W power, average power: 1.25 W, pulse length CP2: 1.00 ms, pulse interval: 1.00 ms, duty cycle 50½, pulsative mode **Er, Ch: YSGG** 300 mJ, 18 Hz, water cooling at 40%, energy density per pulse: 38.21 J/cm2, tip size: 1.0 mm × 17 mm, distance: 2 mm, tip angle set at 70°, no anesthesia	Results were considered to be statistically significant. Operation duration under Er, Cr:YSGG were much faster than the diode laser, however the results were not statistically significant. The operation time under Er, Ch: YSGG and laser were faster than the conventional scalpel group. The time taken for healing was faster in the Er, Cr:YSGG laser group than the diode laser and the scalpel group. VAS scale at day 0 was higher in the conventional group than the two laser groups.	Surgical (second-stage surgery of submerged implants)
High-power diode	2020	Control group (n = 7):	**diode** (Thera Lase	The surgical time was shorter	Surgical (second-

laser for second-stage implant surgery: a randomized pilot clinical trial (29)		conventional scalpel technique Laser group (n = 8): HPL-assisted technique 15 patients at the age of 18 or older.	Surgery™, DMC Ltda, Brazil) • 808 nm wavelength (continuous wave mode, optical fiber 400 µm, output power 1.5 W)	in the Laser Group than in the Control Group, with a statistically significant difference. Bleeding was present only in the Control Group at the end of surgery and on the seventh day, with a statistically significant difference between groups by Fisher's Exact test No patient complained of pain immediately after surgery, as well as on the fifteenth day. Furthermore, no statistically significant difference was obtained between groups on the seventh day by the Mann-Whitney test. With regards to peri-implant mucosa status, all cases had healthy peri-implant mucosa both immediately after surgery and on the fifteenth day; however, only one patient of the Control Group presented mucositis on the seventh day, data without statistically significant difference between groups by Fisher's Exact test. Likewise, 2 patients of Control group and 1 of Laser Group reported pain medication use only on the first day after surgery, data without statistically significant difference by Fisher's Exact test.	stage surgery of submerged implants)
Effectiveness of Low-Level Laser Therapy during Tooth Movement: A Randomized Clinical Trial (30)	2019	Diode laser and control group 41 patients at the age of mean 13.4± 2.1 years, range 10.2-18.4 years .	high-power **diode** laser (Thera Lase Surgery™, DMC Ltda, Brazil) • 808 nm wavelength (continuous wave mode, optical fiber 400 µm, output power 1.5 W) Diode laser operating at 980 nm (Wiser Laser Doctor Smile, Lambda, Brendola, Italy) with a wavelength of 810 nm (1 W of output power, a continuous wave of 66.7 J/cm2) and 0.6 mm optic with fiber.	The test side (diode laser) showed a significant reduction in the average range of dental pain due to orthodontic traction after first laser treatment application. At a further 6-month follow-up check, none of the patients enrolled presented any clinical periodontal damage, such as signs of gingivitis or initial signs of root resorption.	Nonsurgical (reduction of postoperative pain)
Diode versus CO2 laser therapy in the treatment of high labial	2020	Diode group and CO2 group 26 patients at the age of 7-12.	High power **Diode** Parameters: •980 nm •2.5 W	- Both lasers showed a good performance but diode laser had better results in wound healing, gingival recession,	Surgical (frenulectomy)

frenulum attachment (31)			•Continuous mode •1.000 Hz **CO2** laser Parameters: • 10600 nm •4.5 W • Super pulse wave • 80 Hz	periodontal parameters and pain - CO2 laser group showed fewer bleeding cases on average compared with the diode laser treatment.	
Diode laser versus conventional technique for Frenectomy (32)	2019	20 patients at the age of 18-45.	High power **Diode** Parameters: • 980 nm •1.5 W • contact mode	1) Significantly better healing in the diode laser group. 2) Less pain and discomfort 3) Better healing of the test side at 1 and 7-day recall visits. 4) Bleeding and redness immediately after surgery were less in the test side than the control side	Surgical (frenulectomy)
Patients perceptions and clinical efficacy of labial frenectomies using diode laser versus conventional Techniques (33)	2018	Diode group and conventional group 36 patients at the age of 14-51.	**Diode** laser Parameters: • 980 nm • 2.8 W • Continuous mode	1)100% of those in the scalpel group required local anesthesia; however, only 40% in the laser group required anesthesia. 2) No bleeding and no need for suturing in the laser group. 3) Significantly lower swelling and redness in the fifth day in the laser group. 4) Statistically significant gains in the keratinized gingiva width, attached gingiva width, and attached gingiva thickness after surgery in both groups; however, there was no significant difference between the study groups. 5) The diode laser group had lower visual analog scale discomfort and functional complication scores compared with scalpel surgery	Surgical (frenulectomy)
Clinical efficacy of conventional and diode laser-assisted frenectomy in patients with different abnormal frenulum insertions (34)	2020	Conventional group (n=36) Diode laser group (n=34) 70 records were included 70 patients at the age of 35.24 ± 11.69 years.	**Diode** laser Parameters: • 810 nm • 2.5 W, 20 Hz • Short pulse duration (140 µs)	1) No complications associated with postoperative healing in either group. 2) The frenulum attachment to the mucogingival junction declined significantly in both groups without any difference between them. 3) No recurrence in any patient at 6 weeks. 4) PI and GI were significantly higher in the conventional group, whereas PD was similar at 6 weeks	Surgical (frenulectomy)
The evaluation of healing effect of low-level laser treatment following Gingivectomy (35)	2020	A :test group consist of ten patients after gingivectomy a diode laser was applied to the wound area B :The control group (ten patients) did not receive laser 20 patients at the age of 22-45.	**Diode** • 660 nm	Both groups showed similar results immediately post-surgery. At day 3 p.s., a better improvement was observed in wound healing for laser than control group. Significant improved healing for laser than control group was detected	Surgical (gingivectomy)

				a significant reduction in VAS score was shown for laser compared to the control group	
Evaluation of surgical scalpel versus semiconductor diode laser techniques in the management of gingival melanin hyperpigmentation: A split-mouth randomized clinical comparative study (36)	2020	bilateral physiologic melanin hyperpigmentation of gingiva (dark gums) in the anterior segment The depigmentation procedure was randomly allotted to either of the areas by the flip of a coin 20 patients at the age of 20-35.	**Diode** • 810 nm • 1.5–2.0-watt • continuous wave mode with the flexible fiberoptic delivery system, in a continuous contact mode	The mean of plaque and gingival indices scores were low at 9 months postoperatively compared to baseline. Moreover, there was a statistically significant difference was seen between the treatment groups for both indices Slight (55%)-to-moderate (45%) bleeding observed in quadrant which was operated surgical scraping and none of the surgical sites showed bleeding seen when operated with diode laser.	Surgical (Removal of melanin pigmentation)
Gingival Depigmentation Using Diode 980 nm and Erbium-YAG 2940 nm Lasers: A Split-Mouth Clinical Comparative Study (37)	2021	Facial gingiva of the anterior teeth and premolars of each jaw was divided into two halves. .e right or left side of each jaw quadrant randomly received either diode laser or erbium-YAG laser 15 patients at the age of 28.6 ± 7.8.	**Er:YAG** laser • 2940 nm • emission mode free running pulse, 2 watts, 20 Hz, 1.5 ml/min H20, and the tip in fiber-optic handpiece with 800 microns, noncontact mode, and 1 mm distance from the tissue for 600 seconds **Diode** laser • 980 nm 400µ tip in a fiber-optic handpiece using a power range of 0.80–1.10 watts with angulations of the tip 12.7 degrees 240–600 seconds	Both techniques were efficient for gingival depigmentation. Nevertheless, bleeding during surgery was statistically higher for Er:YAG laser technique as compared to diode laser. Wound healing showed statistically nonsignificant differences between the two lasers, although Er:YAG seems to give better outcomes than the diode.. patients were satisfied with both laser techniques during and after gingival depigmentation. However, the pain score was higher for Er:YAG laser than for diode laser	Surgical (Removal of melanin pigmentation)
Evaluation of Treatment Outcome in Gingival Hyperpigmentation with Scalpel Vis-a-Vis Laser: A Split-Mouth Study (38)	2021	Group A: Right half: upper andlower central incisors to premolars will be treated using diode laser Group B: Left half: upper and lower central incisors to premolars will be treated by Scalpel technique 20 patients at the age of 18-35.	**Diode** • 980 nm	Pain and healing were comparable in both the groups, though intraoperative time consumed and bleeding was significantly lower for laser group. Recurrence also was significantly lower on the laser group	Surgical (Removal of melanin pigmentation)
THE EFFECTS OF LOW LEVEL LASER THERAPY ON HEALING OF GINGIVA AFTER GINGIVECTOMY-AN IN VIVO STUDY (39)	2019	The test group (15 sites) were irradiated with 940nm laser following gingivectomy the control group (15 sites) received placebo 15 patients at the age of 18-45.	**Diode** • 940 nm for 4 minutes at 120mW delivering 4J/cm2, with pulse interval of 50 milliseconds and pulse length of 10	The laser irradiated site healed earlier than the contra lateral side, indicating that laser application accelerates healing in gingivectomy wounds. The sites treated with LLLT showed statistically significant	Surgical (flap de-epithelialization in regenerative procedure)

			milliseconds energy		
Evaluation of pain perception and wound healing after laser-assisted frenectomy in pediatric patient (40)	2021	Diode group: n=11 Er:YAG group: n=11 22 patients at the age of 8-13.	**Diode** •940 nm •1.5 W, 298.5 W/cm² •Continuous wave mode •Contact mode **Er,Cr:YSGG** Parameters for incision: •Free-running pulsed laser •2.75 W, 50 Hz, 600 µs, 55 mJ/pulse, 22 J/cm² Parameters for laser bondage: •0.5 W, 30 Hz, 700 µs •Non-contact mode	1) Er,Cr:YSGG group: significantly better wound healing results 2) No significant difference between 2780 nm Er,Cr:YSGG laser and 940 nm diode laser groups in terms of pain	Surgical (reduction of postoperative pain)
Evaluation of upper labial frenectomy: A randomized, controlled comparative study of conventional scalpel technique and Er:YAG laser technique (41)	2021	Conventional group and Er:YAG group 40 patients at the age of 7-19.	**Er:YAG** Parameters: Parameters for laser bondage: •0.5 W 2940 nm •150 mJ,10 Hz •Pulse duration of 1000 µs •(VLP mode)	1) Significantly longer surgical antibiotics, no recurrence at 1 year time and bleeding in the conventional group. 2) Directly after surgery, the wound area was significantly larger in the laser group 3) No difference between the groups on the 5th day. 4) No difference in scar tissue formation 5) Faster surgical time and less bleeding in the laser group	Surgical (frenectomy)
Frenectomy with conventional scalpel and Nd:YAG laser technique (42)	2019	Group A scalpeltechnique (n=10) Group B: Nd:YAG laser (n=10) 20 patients.	**Nd:YAG** laser Parameters: •1064 nm	Group B: less pain, less bleeding, fewer number of analgesics taken Healing outcome at 3 months showed no significant difference between the two groups	Surgical (frenectomy)

*Laser-assisted **regenerative** surgical therapy:* From 5 articles about efficacy of laser in regenerative procedure ,4 studies showed statistically significant results in terms of pain perception and lower VAS score (18,25,35,39). In contrast a study detect that patients experienced more pain in test sites (Flap surgery with adjunctive diode laser irradiation).Significant improved healing for laser was shown (18,25,35,39). but no statistical differences found in CAL gain, GI reduction, radiographic linear bone gain or proportional defect size reduction by using Er:YAG laser (25) and also in a study reported no significant difference between the groups with respect to healing response of tissues (21) but MWF surgery along with diode laser (980nm) led to a significant improvement in clinical parameters such as PPD, relative clinical attachment level as well as microbial parameter CFU/ml after 3 months (18).

*Results for **removal of melanin pigmentation**:* It was reported no significant difference between diode laser assisted group and another (36,16). However one study showed that Recurrence also was significantly lower on the 980 nm diode laser group (38). Also a study reported that Laser techniques using a 2940 nm Er:YAG laser and 980 nm Diode laser were efficient for gingival

depigmentation. Nevertheless, bleeding during surgery was statistically higher for Er:YAG laser technique as compared to diode laser (37).

Results regarding laser-assisted ***non-surgical*** *periodontal therapy:Results for laser-assisted* ***reduction of bacteria***: The determining role in the progression of periodontal disease is played by oral cavity hygiene through the microbial factor, and the other favoring or predisposing factors (45,46). four articles reviewed evaluating the laser-assisted therapy of reduction of bacteria in periodontal diseases. An article comparing a 810 nm diode, PDT and control group of conventional therapy have shown that although therapies have shown a significant PD reduction and CAL in all three groups of laser, PDT and control from the baseline, but there was no significant difference between the treatment groups. The mean value of BOP significantly decreased from baseline in the laser and PDT treatment groups; however, it did not differ significantly in the control group (14). Other article used a 1064 nm Nd:YAG laser (LANAP therapy) and comparing to a SRP therapy alone. Improvements were detected statistically significant in the average revolution of the periodontal pocket depth, the visible plaque index, and bleeding on the probing index in both groups and the effects of the two treatments did not vary statistically (23). The other study used a Er:YAG laser. Within the groups, compared with baseline measurements, both therapies (ERL+SRP or SRP) produced significant reductions in the means of PD, CAL, BI, and PLI. ERL+SRP quadrants had lower PD and CAL means at 3-month follow-up than the control quadrants However, the magnitudes of such differences between the two groups were very small. There were no significant differences in BI and PLI between ERL+SRP quadrants and control quadrants (24). Other study showed a significant decrease in bacteria using a 810 nm diode (22).

results about ***pain reduction*** *by laser assisted procedures*: A RCT study reviewed the effectiveness of 980 nm diode laser on post operative pain after endodontic treatment in teeth with apical periodontitis, reported significant higher average pain level in control group than in the laser group (26). Another study used a high power 808 nm diode laser reported a significant reduction in the average dental pain range, due to the orthodontic traction after the first laser treatment application (30). We observed a statistically significant reduction in the mean VAS score for postoperative pain among the study groups (27). Studies evaluating pain perception by laser-assisted frenectomy in pediatric patients showed no significant difference between 2780 nm Er,Cr:YSGG laser and 940 nm diode laser groups in terms of pain, but both laser wavelengths were safe and efficient for frenectomies in pediatric patients with less pain (40).

• A limited number of articles evaluating laser-assisted gingivectomy and osteotomy since 2018

• The variety of articles evaluating different treatments using variety of lasers with different wavelengths was limited.

4. Conclusion

Although a Significant difference between the laser-assisted periodontal therapy in comparison with the conventional method through the studies reviewed was shown in the most studies reviewed, some of the studies haven't shown statically significant difference from the conventional method and some patients reported a minimal discomfort using lasers. Further research reviewing lasers with different wavelength with a wider range of procedures done is needed for a more reliable conclusion.

Ethical Considerations

Not applicable.

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Authors' Contributions

Shabnam Aghayan: Conceptualization, Methodology, Writing - Review & Editing **Neda Abolhoseini**: Writing - Original Draft, Data Curation, Supervision **Maryam Oloumi**: Resources, Investigation, Visualization.

Conflict of Interests

The authors declare no conflict of interest.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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