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High Intensity Lasers in Periodontics: A Review

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Abstract

Background and Aim: Lasers can serve as a new powerful tool in dentistry. High intensity laser therapy is becoming the treatment of choice compared with conventional periodontal therapy due to accurate incision and soft and hard tissue ablation, hemostasis, reduction of postoperative pain and infection, optimal debridement, and enhanced healing. Although high intensity laser therapy assumes to provide better results compared with conventional treatments, a significant variation exists in the applied laser parameters such as different wavelengths and energy densities of laser. The objective of this study was to collect preliminary information about the type and parameters of surgical lasers and how to use them technically based on the available literature on this topic.

Materials and Methods: After initial screening of 152 potentially relevant articles identified through an electronic search, 44 articles were selected based on the eligibility criteria by three independent reviewers. The inclusion criteria included studies on the outcomes of periodontal high intensity laser therapy in humans published in English between 2013 and 2021 in journals indexed in PubMed Central, Science Direct, Wiley Online Library, Springer or Google Scholar.

Results: The results showed that diode, Nd:YAG, Er:YAG, Er;Cr: YSGG and CO_2 lasers had the highest efficacy for frenectomy, gingivectomy, and osteotomy with specific wavelength, power density, frequency, and pulse mode. Various lasers have been suggested for the abovementioned purposes, and the method of choice depends on the efficacy and availability of laser.

Conclusion: This study confirmed higher efficacy of different laser types compared with conventional treatments.

Key Words: Labial Frenum; Periodontics; Gingivectomy; Osteotomy; Laser Therapy

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Introduction

Laser is an innovative tool in modern dentistry. The term is an acronym for “light amplification by stimulated emission of radiation”. The theoretical foundations for laser were established by Albert Einstein in 1917. The first working laser which was termed ruby laser was operated by Theodor Maiman in 1960 [1]. In 1965, it was reported that the ruby laser could vaporize enamel and cause thermal damage in the pulp tissue; thus, its application was overshadowed [2]. The first

CO_2 laser was invented by Kumar Patel in 1964 [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 the United States, the use of lasers for oral soft tissue was first approved by the United States Food and Drug Administration in 1990, and its use for the hard tissue gained approval in 1996 [5].

In dentistry, lasers are used for bio-stimulation and surgery. Bio-stimulation procedures such as healing enhancement are done by low level lasers which operate at 500 mW power. In contrast, surgical lasers, also called high intensity lasers, such as CO_2, 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 because 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 [6-9].

The first laser invented for use on both hard and soft tissues was the CO_2 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. CO_2 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 CO_2 laser is a thousand times lower than that of diode laser, which results in a thin thermal damage zone following incision [10-12].

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 CO_2 laser. Hard tissue procedures show an excellent healing response. The new CO_2 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 intra-oral soft and hard tissue surgical procedures, laser therapy is an optimal alternative to conventional treatments [12-14].

Different features of lasers allow their customized use based on the type of treatment. The objective of this study was to collect preliminary information about the type and parameters of surgical lasers and how to use them technically based on the available literature on this topic.

Materials and Methods

Search Strategy:

A limited literature search was conducted in

PubMed Central, Science Direct, Wiley Online Library, Springer, and Google Scholar until March 2021. The search strategy included the use of the following combination of key words: High-intensity laser in dentistry, laser-assisted AND gingivectomy OR crown lengthening OR frenectomy OR osteotomy, high intensity lasers (Nd:YAG, Er:YAG, Er,Cr:YSGG, Diode, CO_2) AND gingivectomy OR crown lengthening OR frenectomy OR osteotomy. Hand searching was also performed.

Study Selection:

Inclusion criteria: Three reviewers screened citations and selected the studies. In the first step of screening, the titles and abstracts were reviewed, and potentially relevant articles were selected. Relevant English articles published between 2013 and 2021 were included. Case series, case reports, clinical trials and systematic reviews were included. Only human studies were selected.

Exclusion criteria: Articles published before 2013 in a language other than English or studies evaluating other types of lasers or animal studies and those with no reference to laser parameters were excluded. A total of 152 articles were identified in the literature search. Following screening of the titles and abstracts and applying other exclusion criteria, 91 articles were excluded. Finally, 44 articles were selected for the final review.

Results

Results regarding laser-assisted gingivectomy and osteotomy:

Laser-assisted gingivectomy is promoted for both esthetic and restorative purposes. Of the retrieved articles, 13 studies used high intensity lasers for gingivectomy. Five of them [6-14] used 940 nm diode laser for gingivectomy, four articles reported uneventful healing, lower level of pain and discomfort, lower bleeding, minimal need for suturing and analgesics, and stability of soft tissue margins [6,7,15,16]. One study discussed the possibility of thermal damage to pulp tissue by 940 nm diode laser and reported that the increase in pulpal temperature was below the critical threshold in laser irradiation for 10, 20, and 40 seconds [17-20]. Of two studies that used 810 nm diode laser [12,19], one study reported no significant difference between laser-assisted gingivectomy and conventional gingivectomy but compared with non-surgical treatment group, there was a significant decrease in periodontal pocket depth after 6 months in the laser group. Unlike the non-surgically treated group, relapse was observed after 3 months [12]. Another case series reported no serious bleeding and low level of pain in 940 nm diode laser group [19]. Another case series used a dual-wavelength (810 + 980 nm) diode laser and reported minimal discomfort, excellent healing, and good esthetic outcome [18]. Two other studies used 808 nm and 975 nm diode lasers and reported healing with minimal discomfort and minimal recurrence after 1 year of follow-up [15,16]. A comparative study used a 980 nm diode laser and electrocautery and reported no significant difference regarding the mean duration of procedure, bleeding, healing, pain, or self-limitation of disease. Charring occurred in both groups, but was more likely in the laser group [13].

One study used Nd:YAG (for low-level laser therapy) and Er:YAG lasers for an autofluorescence-guided surgical approach and reported excellent outcomes such as complete mucosal healing and becoming symptom-free due to the highly accurate and minimally invasive procedure [11].

Two studies used Er,Cr:YSGG laser and reported shorter operative time, accelerated healing, no bleeding or pain, and high level of post-operative comfort [19]. Another study used Er:YAG laser for crown lengthening with osteotomy and reported acceptable results [21]. Two studies compared Er:YAG laser and bur for mandibular third molar extraction [9,10]. One of them reported significantly lower pain, swelling, and trismus in the laser group [9]. In contrast, the other one reported no significant difference regarding pain, bleeding, swelling, healing or complications [10]. Time spent on laser-assisted osteotomy was double compared with cutting bone with bur. Another study compared three different methods including Er:YAG laser, piezosurgery, and rotary systems for osteotomy in mandibular bone for third molar extraction [8]. There were no significant differences among the groups in terms of pain, trismus, swelling, or postoperative recovery but pain persisted longer in the rotary group. The longest operation time belonged to the laser group while the shortest time was recorded in the rotary group. They concluded that piezosurgery and Er:YAG laser were both good alternatives to rotary instrument systems for third molar extraction, but the two systems did not have obvious superiority over the rotary system in the early postoperative recovery period [8]. (Table 1)

Results for laser-assisted frenectomy:

Laser-assisted frenectomy is considered for many dental patients to minimize pain and discomfort generally associated with conventional periodontal frenectomy. A total of 21 articles in this respect were reviewed [22-43]. Four published articles used 1064 nm Nd:YAG laser for laser-assisted frenectomy compared with the conventional scalpel technique [22-26]. 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. In contrast to three of these studies [23-25], a comparative study [22] reported no statistically significant difference regarding pain between laser surgery and conventional surgery.

Amongst the six studies that used 980 nm diode laser for frenectomy [25,36, 39-42], three studies compared laser surgery with the conventional technique [25,36,40]. Two studies 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 [25,36]. They also reported minimal discomfort and functional complications in the laser-treated group. All six studies reported normal healing, minimal or no postoperative complications in terms of pain, swelling, and bleeding, and significantly better healing outcomes [25,36, 39-42].

One study compared 980 nm diode laser with 10600 nm CO_2 laser for frenectomy [41]. The CO_2 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 CO_2 laser group. Both methods effectively decreased pain, but diode laser alleviated pain more quickly.

A study used 810 nm diode laser and reported no postoperative bleeding and minimal need for analgesics in children [33]. 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]. Another study used 808 nm diode laser compared with conventional treatment and reported a significant decrease in pain score and discomfort and maximum satisfaction in the laser group [27]. Two other studies used 880 nm diode laser in addition to 606 nm low- level laser for photo-biomodification and revealed excellent results and minimal postoperative discomfort [37,38]. A comparative study used 940 nm diode laser and Er,Cr:YSGG laser and reported no significant difference between the groups but wound surface area was smaller in Er,Cr:YSGG laser group after one week [31]. Other studies used 2940 nm Er:YAG and 2780 nm Er,Cr:YSGG laser for frenectomy [28,30, 35]. Good postoperative healing, no recurrence, and pain were reported. 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 [29]. (Table 2)

Table 1. Characteristics of the reviewed studies regarding laser-assisted gingivectomy and osteotomy

Objective	Materials and Methods	Laser	Result
Comparing laser and scalpel for soft tissue crown lengthening [6]	Group A: diode laser (n=11) Group B: conventional scalpel (n=11) Age: 20-40 years	Diode laser •940 nm •0.8 to 1.5 W	- Significantly lower VAS pain scores for the laser group (3rd and 7th day) - No significant difference between the two groups on the 10th day
Laser-assisted lip repositioning with smile elevator muscle containment and crown lengthening for gummy smile [7]	A 25-year-old woman/ Crown lengthening by gingivectomy	940 nm diode laser Parameters: 0.8 W/1 W in continuous mode	1) Mild pain and tension in the first week 2) Minor scarring 3) No postoperative swelling extraorally 4) Postoperative probing depth, clinical attachment loss, and gingival display were 2, 2, and 3 mm, respectively, and were maintained at the 6 and 12-month follow-ups.
Postoperative evaluation of Er:YAG laser, piezosurgery, and rotary systems used for osteotomy in mandibular third-molar extractions [8]	Group A: 12 females, 8 males (rotary) Group B: 14 females, 7 males (piezosurgery) Group C: 8 females, 8 males (Er:YAG) Age:18- 39 years	Er:YAG parameters: •250 mJ • 20 Hz • 5 W	1) No statistically significant differences in pain scores between the treatment groups at 12 h, 24 h, 48 h, or 7 days. 2) Pain in the piezosurgery group decreased significantly throughout the postoperative period. 3) No significant decrease in pain in the Er:YAG laser group between 24 h and 48 h. 4) No significant pain decrease in the rotary group between 12 h and 24 h. 5) The average change in perceived pain at 24 h compared with 12 h in the rotary instrument group was significantly lower than for those treated with laser or with piezosurgery. 6) No significant difference in maximum mouth opening among the three groups. 7) Trismus decreased on day 2 compared with day 0, but increased significantly on day 7 compared with day 2 in all groups. 8) No statistically significant differences in swelling between groups on day 2 and day 7 9) Significantly longer operation time for the laser treatment group than the piezosurgery and rotary instrument groups.
Erbium yttrium–aluminum–garnet laser versus traditional bur in the extraction of impacted mandibular third molars: Analysis of intra- and postoperative differences [9]	Seventy-six extractions were randomly classified into 2 groups (G1) Er:YAG laser: 35 patients (G2) traditional bur: 41 patients	Er:YAG laser •300 mJ •30 Hz •Fluence of 60 J/cm^2	1) Regarding pain, visual analog scale and numerical rating scale scores were lower in G1 than in G2. 2) Statistically significant differences at days 0, 1, and 3 with visual analog scale and at days 0, 1, 3, and 7 with numerical rating scale. 3) Statistically lower facial swelling and trismus in G1 than in G2 at day 2 4) Statistically lower trismus in G1 than in G2 at days 2 and 7

Erbium yttrium–aluminum–garnet laser versus traditional bur in the extraction of impacted mandibular third molars: Analysis of intra- and postoperative differences [9]	Seventy-six extractions were randomly classified into 2 groups (G1) Er:YAG laser: 35 patients (G2) traditional bur: 41 patients	Er:YAG laser •300 mJ •30 Hz •Fluence of 60 J/cm^2	1) Regarding pain, visual analog scale and numerical rating scale scores were lower in G1 than in G2. 2) Statistically significant differences at days 0, 1, and 3 with visual analog scale and at days 0, 1, 3, and 7 with numerical rating scale. 3) Statistically lower facial swelling and trismus in G1 than in G2 at day 2 4) Statistically lower trismus in G1 than in G2 at days 2 and 7
Laser vs. bur for bone cutting in impacted mandibular third molar surgery [10]	40 patients with impacted mandibular third molars Group A: Bur Group B: Laser each group: n=20	Er: YAG laser •2.94 μm •7 W •10 Hz •Duration of each pulse: 250 s	1) Lower pain and bleeding in the laser group but not statistically significant. 2) Significantly lower swelling in the laser group 3) Laser group required almost double the time taken for bone cutting with bur. 4)Trismus persisted for a longer time in the laser group. 5) No significant difference in the two groups regarding wound healing and complications
Medication-related osteonecrosis of the jaw: An auto fluorescence-guided surgical approach performed with Er:YAG laser [11] Conventional versus laser gingivectomy in the management of gingival enlargement during orthodontic treatment [12]	Sixty subjects (33 males and 27 females) with a mean age of 14.4 ± 1.9 years with gingival enlargement 1) conventional scalpel gingivectomy (treatment group) 2) laser-assisted gingivectomy (treatment group) 3) non-surgical periodontal treatment (control group)	Diode laser •810 nm •Contact mode •1–1.5 W	1) After 1 month, the treatment groups showed significantly better periodontal parameters 2) No statistically significant differences between the two treatment groups 3) Relapse occurred in the treatment groups at the 3-month observation 4) No significant differences among the three groups in the 6-month observation for any periodontal measurement but in long-term evaluation (6-month versus baseline), a significantly greater reduction in pocket depth was noted in the treatment groups compared with the control group
Comparative evaluation of healing after gingivectomy with electrocautery and laser [13]	17 patients (7 females and 10 males/gingival hyperplasia/14–48 years	Class IV diode laser •980 nm •Contact mode •5 W	1) The mean time taken in the laser group < the electrocautery group but it was not statistically significant. 2) Bleeding in the laser group < electrocautery group but it was not statistically significant. 3) Charring was observed in both sides but more charring in the laser side 4) No significant difference in healing 5) No significant difference in postoperative pain
Effects of laser-assisted cosmetic smile lift gingivectomy on postoperative bleeding and pain in fixed orthodontic patients [14]	30 patients/ 17-29 years / gingivectomy 15 patients in each group	Diode laser •940 nm •0.9 W	1) Significantly higher bleeding in the laser group 2) No postsurgical pain in laser group (visual analog scale score of 5.2 in the conventional group)
High-power diode laser on management of drug-induced gingival overgrowth [15]	Two cases/ gingivectomy and gingivoplasty Case 1: 18-year-old female case 2: 11-year-old male	high-power laser •Diode •808 nm •1.5 W	1) Minimal bleeding and discomfort during surgery 2) No pain or bleeding after the procedure. 3) After 1 year of follow-up, patients presented a minimal increase of gingival volume

Surgical treatment of excessive gingival display using lip repositioning technique and laser gingivectomy as an alternative to orthognathic surgery [16]	27-year-old woman	gingivectomy/high-power diode (975 nm,1.5 W) Frenectomy/high-power diode laser (975 nm, 4 W) Gingivectomy/high-power diode laser (975 nm, 3 W)	- Discomfort or inability to move the lip during the first week but no tension or numbness at 2 weeks, and 3 and 6 months - Improvement of smile esthetics
Can we determine an appropriate timing to avoid thermal pulp hazard during gingivectomy procedure? An in vitro study with diode laser [17]	Ninety human freshly extracted teeth (30 anterior, 30 premolar, and 30 molar teeth)	Diode laser • 940 nm • 1 and 2 W exposure time of 10, 20, 30, 40, 50, and 60 s	1) Anterior and premolar teeth exceeded the threshold values earlier than molar teeth for both 1 and 2 W. 2) At 10 s, temperature rise for all types of teeth was below the critical value of 5.6°C, which would cause pulp damage. 3) Dark deposits on tooth surfaces boosted thermal effect of diode lasers
The integration of a dual wavelength super pulsed diode laser for consistent tissue ablation in the esthetic zone [18]	Case 1: 20-year-old female/Gingivoplasty with diode laser Case 2: A male patient/gingivoplasty Case 3: A female, 54 years/gingivectomy Case 4: A 49-year-old female/gingivoplasty	Diode laser • 810 nm and 980 nm • 2 W, in a super pulsed mode • 50Hz	1)Good esthetic outcome and no pain postoperatively 2)Uneventful healing 3)Efficient cutting and less tissue charring
Er,Cr:YSGG laser-assisted treatment of gummy smile [19]	A 24-year-old female with gummy smile	Er,Cr:YSGG laser was set according to the manufacturer's laser setting	-Reduced operation time without postoperative complications -Increased postoperative comfort level
Evaluation of soft tissue marginal stability achieved after excision with a conventional technique in comparison with laser excision [20]	20 subjects/18-35 years/marginal stability	diode laser •940 nm •2.00 W •1.00 ms pulsed	-More stable soft tissue margins with lasers when compared with scalpel.
The esthetic crown lengthening by Er,Cr:YSGG laser: A case series [19]	Six female and 1 male aged 20 to 60 years. All patients were treated with laser. All cases needed esthetic crown lengthening. In some cases, frenum revision and class V cavity preparation were done by Er,Cr:YSGG laser. In one case, gingivectomy was accomplished by a diode laser.	Diode laser •810 nm •4 W •Chopped mode with pulse duration of 20 ms and interval of 20 ms	-No bleeding and pain for the two lasers
Minimally invasive (flapless) crown lengthening by erbium:YAG laser in aesthetic zone [21]	53-year-old woman 47-year-old woman	Er:YAG in defocalized modality (180 mJ/10 Hz)	Total absence of laser-related thermal injuries in the oral hard and soft tissues Less invasive and faster clinical outcomes in contrast to the conventional surgical technique

Table 2. Characteristics of the reviewed studies regarding laser-assisted frenectomy

Objective	Materials and Methods	Laser	Result
Labial frenectomy with Nd:YAG laser and conventional Surgery [22]	Group 1: conventional surgery (n=22) Group 2: Nd:YAG laser surgery (n =18) Age: 8-51 years	Nd:YAG laser Parameters: •1,064 nm •40 J •40 Hz • 4 W for 10 s •Power density=5 W/cm2 • Energy density=50 J/cm2 • short pulse width	No significant differences in pain or oral functions. Nd:YAG laser frenectomy had lower transoperative bleeding, less need for suturing, and shorter surgical time in comparison with conventional surgery.
Postoperative discomfort after Nd:YAG laser and conventional frenectomy [23]	(1) Nd:YAG laser group, n= 45 (26 females, 19 males) age: 11.58 to 29.75 years 2) Conventional group, n=44 (25 females, 19 males) age: 11.32 to 28.75 years	Nd:YAG laser Parameters: •1064 nm •100 mJ •40 Hz	Visual analog scale score of pain, chewing disability, and speaking discomfort were statistically higher in the conventional group on the operation day and first and third days postoperatively.
Evaluation of patient perceptions after frenectomy operations: A comparison of neodymium-doped yttrium aluminum garnet laser and conventional techniques in the same patients [24]	Forty patients. One side of each patient was treated with laser, whereas the other side was treated with the conventional technique.	Nd:YAG laser Parameters: •free-running pulsed • 1064 nm •100 mJ •40 Hz •4 W •150 ms pulse duration	On the day of operation: statistically significant differences between the laser and conventional treatment groups in terms of all three scores (pain, phonetic, function). On the 1st postoperative day: no significant difference in terms of function while there were statistically significant differences between the groups in terms of pain and phonetic assessments. On days 3, 7, and 10: no significant difference between the two treatments.
Patient perceptions and clinical efficacy of labial frenectomies using diode laser versus conventional techniques [25]	Age: 8-51 years Group 1 (n = 20) received diode laser Group 2 (n = 16) received conventional scalpel	•continuous wave mode, •980 nm	width, attached gingiva thickness, and the clinical parameter scores PI, GI, PD and CAL* 2) Lower visual analog scale pain scores in the laser than conventional technique, except for the second day 3) Lower visual analog scale swelling scores in the laser than scalpel except for the first day 4) Similar visual analog scale redness scores The only difference was found in the fifth day, with the laser group displaying significantly lower swelling and redness scores. 5) Visual analog scale speaking discomfort scores were higher in the conventional group in the first, second and third postoperative days, but these differences were not statistically significant. 6) In the conventional group, the visual analog scale chewing discomfort scores were significantly higher than in the laser group in the first and second days.

Frenectomy with conventional scalpel and Nd:YAG laser technique [26]	Group A scalpel technique (n=10) Group B: Nd:YAG laser (n=10)	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.
Evaluation of patient perceptions after labial frenectomy procedure: A comparison of diode laser and scalpel techniques [27]	10 subjects	Diode laser Parameter: •808 nm 1.5-2 W	The laser group displayed significantly lower VAS pain scores.
Laser labial frenectomy: a simplified and predictable technique. Retrospective clinical study [28]	20 frenectomies in children aged 8 to 10 years	Er:YAG Parameters: • 2940 nm • 150 mJ, 2.5-3.0 W,15-20 Hz • Pulse duration of 300 µs for soft tissue vaporization and 100 µs for periosteal incision • "Focused"mode	1) No postoperative pain, bleeding or recurrence after 4 years 2) All reported that the procedures were well tolerated.
Evaluation of upper labial frenectomy: A randomized, controlled comparative study of conventional scalpel technique and Er:YAG laser technique [29]	(Conventional group and Er:YAG group) 40 frenectomies in patients between 7 and 19 years.	Er:YAG Parameters: •2940 nm •150 mJ,10 Hz •Pulse duration of 1000 µs •(VLP mode)	1) Significantly longer surgical 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
Er,Cr:YSGG laser for the treatment of ankyloglossia [30]	A 22-year-old female	Er,Cr:YSGG (2780 nm) Parameters for incision: •Short pulse "H" mode •1.5 W Parameters for laser bondage: •0.5 W	-No scar tissue, no delayed hemorrhage, no need for analgesics and antibiotics, no recurrence at 1 year

Evaluation of pain perception and wound healing after laser-assisted frenectomy in pediatric patients [31]	Diode group: n=11 Er:YAG group: n=11 Patients' age: 8-13 years	Diode laser Parameters: •940 nm •1.5 W, 298.5 W/cm^2 •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/cm^2 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
Clinical study of laser treatment for frenectomy of pediatric patients [32]	21/35 patients aged 15 years or younger 20 boys /15 girls Lingual frenulum (LF): 27 Maxillary frenulum (MF):8 Using CO_2 laser in 21 patients: 15/27 (LF) and 6/8 (MF)	CO_2 laser Parameters: •10600 nm •2-5 W,60 s	1) Reduced the need for anesthesia and suturing 3) No intraoperative problem, hemorrhage or pain after returning home 4) Re-adhesion in 1/15 patients with lingual frenulum and 0 patients with maxillary frenulum. 5) Quick and safe surgery
Reduced need of infiltration anesthesia accompanied with other positive outcomes in diode laser application for frenectomy in children [33]	30 patients aged 7 to 14 years Female :10 Male: 20	Diode laser Parameters: •810 nm •0.8 W •Continuous mode •Contact mode	1) 93.34% of patients with definitely positive and positive behavior 2) 83.3% of children did not take any analgesics, not a single child complained of any pain 3 days after surgery. 3) No postoperative bleeding.
Clinical efficacy of conventional and diode laser-assisted frenectomy in patients with different abnormal frenulum insertions [34]	Conventional group (n=36) Diode laser group (n=34) 70 records were included	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.
Short lingual frenum in infants, children and adolescents. Part 2: Lingual frenum release. Functional surgical approach [35]	30 patients from 8 to 18 years.	Er:YAG Parameters: •2940 nm •120-160 mJ, 15 Hz •Pulse duration: 300 µs to 600 µs	1) No pain during surgery. 2) Short operative time (5 min) 3)Mild to severe pain only during the functional stretching of the tongue in the initial postoperative days. 4) Significant postural improvements in 18 of 30 patients.

Patients perceptions and clinical efficacy of labial frenectomies using diode laser versus conventional techniques [36]	(diode group and conventional group) 36 patients 14 -51 years	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. 4) Significantly lower swelling and redness in the fifth day in the laser group. 5) 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.
High Power Laser and Photobiomodulation in Oral Surgery [37]	Labial frenectomy in a female patient aged 20 years	High power diode laser parameters: •880 nm •2 W • in a continuous mode •energy of 120 J • 20 pps Photo-biomodification was performed with low-level laser • Parameters: •660 nm •3 J •100 mW	1) Better disinfection of the operated area, accurate incision of the tissue, minimal damage to adjacent tissues, hemostatic effect 2) Reduction of operative time 3) Decreased level of pain, fear, anxiety and adverse events post-surgery
Lingual frenectomy with diode high-power laser in an adult patient [38]	Lingual frenectomy in a female patient aged 20 years.	Diode high power laser parameters: •A continuous wavelength of 880 nm •2 W •energy level 120 J •20 pps Photo-biomodification was performed with low-level laser parameters: •660 nm •3 J •100 mW •30 s on each point	Reduction of edema, postoperative pain and postoperative healing.
Diode Laser Frenectomy [39]	Labial frenectomy in a female patient aged 20 years.	Diode laser parameters: •980 nm •1.37 W Contact mode	-No intraoperative complication such as pain, swelling, or bleeding. -Near complete healing in 2 weeks and complete healing with no scar at the 1-month follow-up.

Diode laser versus conventional technique for Frenectomy [40]	Twenty patients and 10 patients in each group aged 18 to 45 years	Diode laser Parameters: •980 nm •1.5 W in 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
Diode versus CO_2 laser therapy in the treatment of high labial frenulum attachment [41]	Diode group and CO_2 group 26 patients between 7 to 12 years	Diode laser Parameters: •980 nm •2.5 W •Continuous mode •1.000 Hz CO_2 laser Parameters: • 10600 nm •4.5 W • Super pulse wave • 80 Hz	-Both lasers showed a good performance but diode laser had better results in wound healing, gingival recession, periodontal parameters and pain -CO_2 laser group showed fewer bleeding cases on average compared with the diode laser treatment.
The versatility of 980 nm diode laser in dentistry [42]	(1) A 21-year-old female with ankyloglossia (2) A 65-year-old female with poor denture fit needing vestibuloplasty and frenectomy 3) A 10-year-old male patient with pigmented gingiva in the mandible and maxilla ;4) A 14-year-old female was referred from an orthodontist to uncover impacted maxillary right canine. Exposure of the tooth allows an orthodontist to attach a bracket to the tooth 5) A 25-year-old female patient who had a gingival maxillary frenum with a nodule. Recall after 10 days	1)Diode laser 980 nm ,1.5 W, continuous-wave 2) Diode laser 980 nm, 1.5 W, continuous-wave 3) Diode laser 980 nm, slowly sweeping motion in contact mode, 1.5 W 4) Diode laser 980 nm, output power of 1.5 W in continuous-wave 5) Diode laser 980 nm, output power of 1.5 W in continuous-wave	1) 100% experienced a normal healing process with no postoperative complications. 2) Favorable outcomes of laser surgery were observed on follow-up sessions.
Soft tissue applications of Er,Cr:YSGG laser in pediatric dentistry [43]	Case 1: Mucocele excision in a 9-year-old boy Case 2: A pyogenic granuloma excision for an 8-year-old boy Case 3: Maxillary frenectomy for a 12-year-old boy Case 4: Gingival fibroma excision for a 6-year-old girl Case 5: Exposure of unerupted teeth for a 7-year-old child Case 6: Lingual frenectomy for a 1-year-old girl	Er,Cr:YSGG Parameters: •1.75 W, 20 Hz Er,Cr:YSGG Parameters: •2780 nm •20 Hz, 1.5 W, 26.54 J/cm^2	Good postoperative healing and comfort

***PI: plaque index, GI: gingival index, PD: pocket probing depth, CAL: clinical attachment level, BOP: bleeding on probing**

Conclusion

Lasers have been considered as an adjunct or alternate to conventional treatments such as conventional surgical scalpel technique for both hard and soft tissue procedures in the field of periodontology due to ablation with minimum pain, swelling and discomfort, shorter surgical time, less need for suturing and anesthetics, better wound healing, less bleeding, detoxification effect, and a clean surgical site whilst these opportunities may not be available during conventional treatments.

The use of this new innovation in modern dentistry should be based on the proven benefits;10600 nm CO_2, 1064 nm Nd:YAG, 2780 nm Er,Cr:YSGG and 808, 810, 940, 975 and 980 nm diode lasers are significantly useful for soft tissue procedures. According to the majority of studies, conventional periodontal therapy associated with laser application might not have any significant superiority over the conventional treatment only. The erbium lasers seem to have the most promising and suitable characteristics for both soft and hard tissue procedures. Despite the most fortunate results of the lasers in the field of periodontology, the need for additional education, relatively high cost, and different properties of different wavelengths should be considered in implementation of a safe and favorable procedure.

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Conflict of interests

The authors declare that they have no conflict of interests.

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