Lasers in Dental Science (2023) 7:103–109
https://doi.org/10.1007/s41547-023-00185-2

ORIGINAL ARTICLE

Comparison of the effect of wavelength 660 with 808 nm diode as a low level laser on non-surgical periodontal treatment in chronic periodontitis: a double-blind split-mouth randomized controlled clinical trial

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Received: 8 December 2022 / Accepted: 19 April 2023 / Published online: 2 May 2023

Abstract

Background and purpose Previous studies have shown the effectiveness of low level lasers in non-surgical periodontal treatments as an adjunctive agent. The aim of this study is to evaluate and compare two wavelengths of 660 and 808 nm as low level lasers therapy in non-surgical periodontal treatment on periodontal clinical parameters in patients with chronic periodontitis.

Materials and methods This randomized controlled split-mouth clinical trial study was conducted on 71 patients with chronic periodontitis with a periodontal pocket depth ≥ 5 mm or clinical attachment loss ≥ 3 mm in premolar teeth. Clinical periodontal parameters including clinical attachment loss (CAL), gingival index (GI), and pocket probing depth (PPD) were measured in premolar teeth. Scaling and root planning of teeth in the whole mouth were done in one session. Then the laser was irradiated randomly with two wavelengths of 660 nm and 808 nm in two different quadrants. Laser treatment with an energy density of 4 J/cm^2 was repeated at intervals of 1, 3, and 7 days after the initial treatment. Re-evaluation of the clinical parameters was done 1, 3, and 6 months after the treatment of the patients. Data were analyzed with SPSS 26, using the Friedman, Wilcoxon, and Mann–Whitney comparative tests.

Results Periodontal clinical parameters improved significantly 1, 3, and 6 months after the intervention in both groups (P-value < 0.0001), and these changes were greater in the 660 wavelengths. There was a significant difference between the two groups in PPD, GI, and CAL parameters (P-value < 0.0001).

Conclusion The results of this clinical trial study showed that red laser (660 nm wavelengths) significantly improved periodontal clinical parameters compared to infrared laser (808 nm wavelengths).

Keywords Non-surgical periodontal treatment · Low level laser therapy · Laser · Chronic periodontitis

Introduction

Chronic periodontitis is an inflammatory disease caused by infection with periodontopathic bacteria that results in the progressive destruction of the tooth supporting tissues and eventually tooth loss [1, 2]. Periodontal treatment is based on removing the source of infection by mechanical debridement including scaling and root planning (SRP) of the tooth surface which reduce or eliminate of the supragingival and subgingival microbial biofilm, as well as eliminating the factors that favor its deposition in order to prevent disease progression [3, 4]. Despite clinical and microbiological improvements in most cases, none of the current mechanical instruments alone is efficient in completely eliminating calculus and bacterial deposits from the periodontal pocket [5]. Antimicrobial chemotherapy may further suppress periodontal pathogens and increase the benefits obtained by conventional mechanical treatment. The inefficiency of some antimicrobial drugs (i.e., systemic antibiotics) is probably due to the development of drug-resistant strains and the resulting side effects like possible allergic reactions,

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toxicity, and gastrointestinal complications, which also have to be considered [6, 7]. In recent years, various studies have been conducted to increase the effectiveness of non-surgical periodontal treatment, including the use of low level lasers [8]. Today, due to its anti-inflammatory and biostimulation effect, low level laser is commonly used in non-surgical periodontal treatment as an adjunctive agent [9]. Studies show that low level lasers with different wavelengths do not have the same effect on the tissue due to different penetration depths [10]. In contrast to the thermal effects of high-power lasers, low-level laser therapy (LLLT) is recommended for its photochemical role in anti-inflammation, biostimulation, and analgesia within the domains of low-power output (within the mW range), low-energy dosage (0/1–100 J/cm^2), and appropriate wavelengths (600–1000 nm) [11]. Medrado and his colleagues showed that in acute and chronic inflammation, low level laser reduces the exudative phase while increasing the proliferative processes [12]. The laser's energy causes photochemical, photophysical, or photobiological effects in cells and tissues [13]. The most common types of low level laser therapy include helium-neon lasers and diode lasers [14]. Low level laser is used in various dental treatments such as post-surgery care, bone reconstruction, nerve repair, and relief of oral-facial pain [15], and also, it is used as adjunct in scaling and toot planning [16]. It has been stated that the use of low level laser along with scaling reduces the growth of microbial plaque after treatment [17]. Low level laser improves local microcirculation through angiogenesis and increases blood flow speed, which leads to a reduction of inflammation and tissue edema [18]. Low level lasers exert their effects by the photobiomodulation (PBM) method by improving cell function at the mitochondrial level, plasma endorphin level, collagen synthesis, and angiogenesis [8, 19]. The exact mechanism of action of PBM on living tissues is not known; however, evidence suggests that complex IV of the respiratory chain, known as cytochrome c oxidase, acts as a photoreceptor upon red and infrared laser irradiation. In this way, laser radiation on tissues stimulates cytochrome c oxidase, which leads to an increase in electron flow in the respiratory chain and accelerates the synthesis of adenosine triphosphate (ATP). Following ATP accumulation, cell metabolism changes due to more cAMP production and increased intracellular Ca2 concentration. In addition, changes induced by laser irradiation appear to activate nuclear factor kappa B (NF-κB). PBM can repair tissue, increase DNA and RNA synthesis, relieve pain, control anti-inflammatory, and prevent apoptosis [20, 21]. In vitro and laboratory studies have shown low level lasers by modulating the local immune response and by reducing the production and release of some pro-inflammatory cytokines, such as tumor necrosis factor alpha (TNF), interleukin-1 and prostaglandin E2, progress gingivitis, and periodontitis [22–25]. It is very important to pay attention to the dose range in the use of low level laser, and according to the studies conducted in the reconstruction processes, the use of lower power has a better effect in the long term. Arndt–Schulz law should be taken into account when determining the dose. Very low doses have no constructive effects and very high doses prevent irritation. According to this rule, the therapeutic window is between 0.01 and 10 J/cm^2 [26, 27]. Lasers with wavelengths in the red and near-infrared range are less absorbed by water and blood, so they have a greater penetration depth (5–10 mm) [28, 29]. Considering that the effect of low level laser in the non-surgical treatment of chronic periodontitis has been proven in previous studies [28, 30, 31], this study aimed to compare the effect of two wavelengths of 660 (red) and 808 (infrared) nm as low level laser on clinical periodontal parameters in patients with chronic periodontitis.

Materials and methods

Subjects

The patients were selected from those referring to the Department of Periodontics, Faculty of Dentistry, Golestan University of Medical Sciences. Seventy-one patients (30 males and 41 females) with an age range of 30–50 years were selected. The subjects were selected using convenient sampling technique and signed informed consent forms after receiving explanations about the study procedures. The inclusion criteria were as follows: (1) patients were aged between 30 and 50 years; (2) had moderate to severe chronic periodontitis (PPD $\geq$ 5 mm or CAL $\geq$ 3 mm) in premolars teeth. The exclusion criteria include: (1) taking antibiotics for more than 1 week in the last 3 months; (2) performing periodontal treatments in the last 6 months; (3) having a systemic disease affecting the periodontium tissue; (3) pregnant and lactating women; (4) alcohol and drug addiction; (5) having a removable or fixed prosthesis in the premolar teeth; (6) premolar teeth with grade 3 mobility; (7) smoking.

Study design

The present study was a single-center, double-blind, randomized clinical trial which used a split-mouth design. The study protocol was approved by the Ethics Commission of Golestan University of Medical Sciences, Iran (IR.GUMS.REC.1399.196). This trial was registered at the Iranian Registry of Clinical Trials identifier was IRCT20201005048942NT. Written informed consent was obtained from all subjects.

Periodontal assessments

All the patients included in the study received information about the etiology of periodontal disease and instructions for maintaining adequate biofilm control, including interdental cleaning with dental floss and interdental toothbrushes. One week later, the oral hygiene of the subjects was checked, and if there was no progress in oral hygiene compared to the previous session, the patient was excluded from the study. All subjects underwent a comprehensive clinical examination by a single examiner who was an expert periodontist and blinded to the group assignment. Three patients were included for intraexaminer reproducibility. The examiner measured the PD twice, 2 days apart in each patient, and observing more than 95% of recordings being within 1 mm. Periodontal parameters were recorded at baseline (day 0), 1, 3, and 6 months after the therapies in both groups. The severity of periodontal disease was evaluated using gingival index (GI), clinical attachment level (CAL), and probing pocket depth (PPD). Gingival status recordings were made for each tooth according to established GI (Loe & Silness 1963) criteria. PPD was measured from the gingival margin to the base of the pocket with a Williams' periodontal probe (Hu-Friedy, Chicago, IL, USA). CAL was defined as the distance from the cemento-enamel junction to the bottom of the pocket. PPD and CAL were measured in six areas (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual) of premolar teeth.

Periodontal treatment

After recording periodontal clinical parameters, SRP treatment was performed on the whole mouth in one session by a general practitioner under the supervision of an expert periodontist. SRP was performed under local anesthesia (Lidocaine HCl 2% and Epinephrine 1:100,000 Daroopakhsh, Iran) using an ultrasonic device (Woodpecker UDS-K LED/China) and hand instruments (Gracey curettes; Hu-Friedy, Chicago, IL, USA) with no time limitation.

Immediately after SRP, the premolar teeth in two different quadrants (PPD ≥ 5 mm or CAL ≥ 3 mm) according to the inclusion criteria were randomly assigned by coin toss to receive diode red (wavelength of 660 nm InGaAlp) laser or diode infrared (wavelength of 808 nm AsGaAl) laser.

The laser light was irradiated at a distance of 5 mm from the periodontal pocket in a non-contact manner from the buccal and lingual (six sites per tooth: mesiofacial, midfacial, distofacial, mesiolingual, midlingual, and distolingual) areas and in a continuous mode with a handpiece area of 0.5 cm^2 (optic cap D). Laser of 660 nm with a power of 150 mW for 7 s for each site and 808 nm laser with 250 mW power for 4 s for each site were irradiated. The total energy dose was 48 J/cm^2 for each of the wavelengths in each session. Laser light irradiation was repeated on days 1, 3, and 7 days after the initial treatment. Laser irradiation was performed by an experienced masked periodontist who was not involved in the treatment phase. Patients did not receive any further periodontal treatment for 6 months. All patients were under control during the study period to maintain the study conditions (Fig. 1).

Statistical analysis

Data were analyzed with SPSS 26.0 software. The normality of clinical periodontal variables was investigated with the Shapiro–Wilk and Kolmogorov–Smirnov tests, and the assumption of normality was not established in any of the parameters and at different times. Friedman's non-parametric test was performed to compare the parameters in each group at the time points before, 1, 3, and 6 months later. Two-by-two comparisons in each group were performed with the Wilcoxon signed ranks test supplemented by Bonferroni's post hoc test. Mann–Whitney test was used for two-by-two comparison of the groups. The significance level of all tests was 0.05.

Results

The sample was composed of 41 females and 30 males, totaling 71 patients with a mean age of 40.66 ± 9.7 years. The mean depth of PPD, CAL, and GI 1 month after the intervention with 660 and 808 nm lasers decreases significantly and then shows a slight increase during the study. The results of Friedman's non-parametric test show that the changes of the parameters during the study are significant (P-value < 0.0001) (Tables 1 and 2).

The results of the Wilcoxon comparison test with Bonferroni correction show that CAL, PPD, and GI were significant at all times of the two-by-two comparison in both groups (P-value < 0.0001) (Table 3).

The results of the Mann–Whitney non-parametric test show that the mean difference in the PPD in the interval of 1

Table 1 Mean (standard deviation) of the periodontal parameter at different time intervals for the 660 nm group

Periodontal parameter	Baseline	1 month	3 months	6 months	P-value
PPD	4.40 ± 0.62	2.26 ± 0.55	2.30 ± 0.58	2.36 ± 0.53	<0.0001
CAL	3.35 ± 0.58	1.50 ± 0.54	1.58 ± 0.63	1.75 ± 0.67	<0.0001
GI	2.13 ± 0.43	1.12 ± 0.16	1.06 ± 0.14	1.06 ± 0.15	<0.0001

PPD (probing depth pocket); *CAL* (clinical attachment level); *GI* (gingival index); Friedman test

Table 2 Mean (standard deviation) of the periodontal parameter at different time intervals for the 808 nm group

Periodontal parameter	Baseline	1 month	3 months	6 months	*P*-value
PPD	4.38 ± 0.65	2.52 ± 0.59	2.57 ± 0.56	2.61 ± 0.52	<0.0001
CAL	3.28 ± 0.57	1.81 ± 0.57	1.92 ± 0.65	2.07 ± 0.61	<0.0001
GI	2.13 ± 42	1.18 ± 0.25	1.25 ± 0.16	1.25 ± 0.18	<0.0001

PPD (probing depth pocket); *CAL* (clinical attachment level); *GI* (gingival index); Friedman test

month (0–1 Δ month) at the wavelength of 660 nm is 2.14 ± 0.052 mm and at the wavelength of 808 nm is 1.91 ± 0.054 in the interval of 3 months (Δ0–3 months) at the wavelength of 660 nm, it is 2.10 ± 0.054 and at the wavelength of 808 nm, it is 1.85 ± 0.059 and in the interval of 6 months (0–6 Δ months), it is 2.04 ± 0.055 at the wavelength of 660 nm and 1.76 ± 0.056 at the wavelength of 808 nm, which show a significant difference between the two wavelengths (*P*-value < 0.0001). The mean difference of CAL in the interval of 1 month (0–1 Δ month) is 1.84 ± 0.051 at the wavelength of 660 nm and 1.46 ± 0.051 at the wavelength of 808 nm, in the 3 months (Δ0–3 months), it is 1.76 ± 0.056 at the wavelength of 660 nm and 1.35 ± 0.058 at the wavelength of 808 nm and in the 6 months (0–6 Δ months), it is 1.59 ± 0.060 at the wavelength of 660 nm and 1.20 ± 0.054 at the wavelength of 808 nm, which show a significant difference between the two wavelengths (*P*-value < 0.0001). The mean difference of GI in the interval of 1 month (Δ0–1 month) is

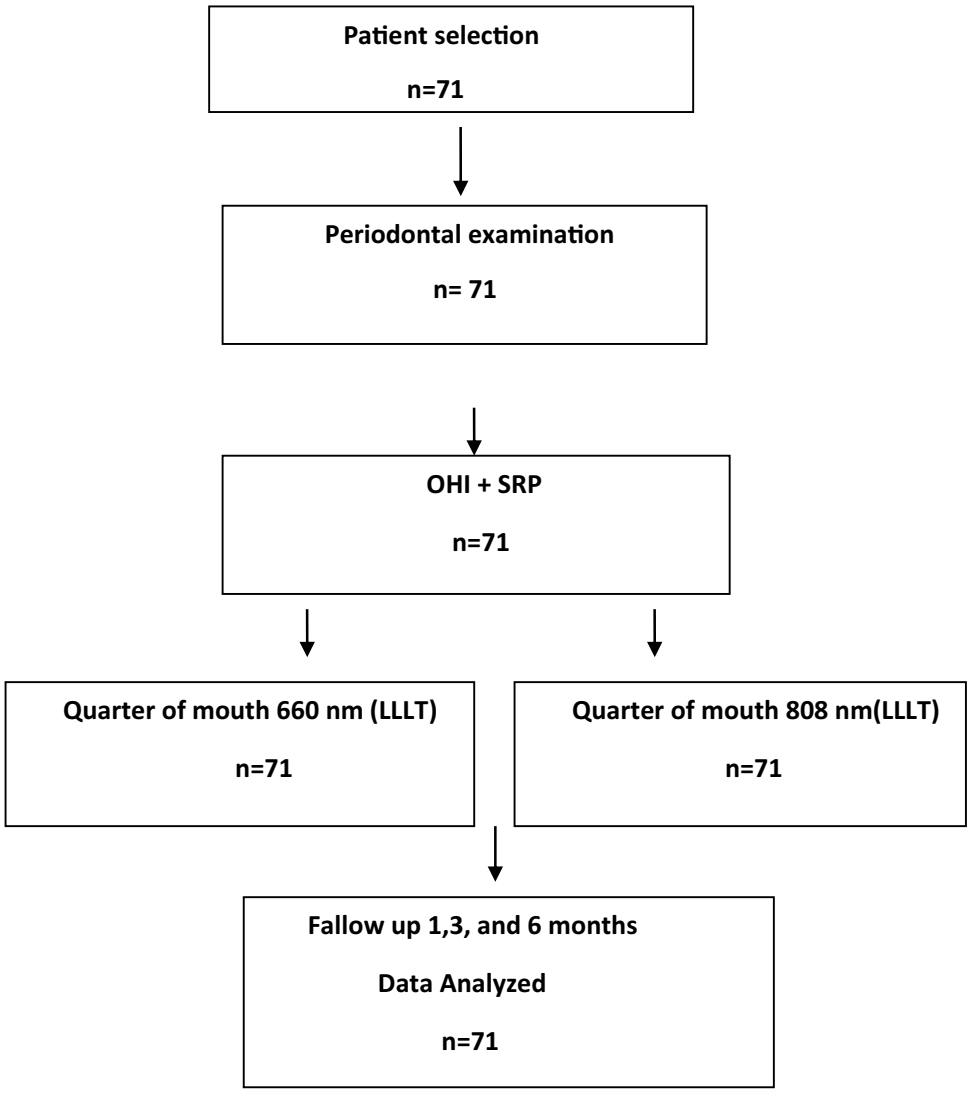

Fig. 1 Flowchart of the study design

Table 3 Comparison of two-by-two parameters based on time for both groups

Clinical parameter	Comparison	660 nm wavelength			808 nm wavelength		
		Mean difference	SE	*P*-value	Mean difference	SE	*P*-value
PPD	PPD0*PPD1	2.14	0.052	<0.0001	1.91	0.054	<0.0001
	PPD0*PPD3	2.10	0.054	<0.0001	1.85	0.059	<0.0001
	PPD0*PPD6	2.04	0.055	<0.0001	1.76	0.056	<0.0001
CAL	CAL0*CAL1	1.84	0.051	<0.0001	1.46	0.051	<0.0001
	CAL0*CAL3	1.76	0.056	<0.0001	1.35	0.058	<0.0001
	CAL0*CAL6	1.59	0.060	<0.0001	1.20	0.054	<0.0001
GI	GI0*GI1	1.01	0.053	<0.0001	0.95	0.054	<0.0001
	GI0*GI3	1.07	0.051	<0.0001	0.88	0.052	<0.0001
	GI0*GI3	1.06	0.052	<0.0001	0.87	0.051	<0.0001

PPD (probing depth pocket); *CAL* (clinical attachment level); *GI* (gingival index); *SE* (standard deviation). Wilcoxon test/Bonferroni's post hoc

1.01 ± 0.053 in the wavelength of 660 nm and 0.95 ± 0.054 in the wavelength of 808 nm. In a 3-month interval (Δ0–3 months), it is 1.07 ± 0.051 at the wavelength of 660 nm and 0.88 ± 0.052 at the wavelength of 808 nm, and in the interval of 6 months (0–6 Δ months) in the wavelength of 660 nm, it is 1.06 ± 0.052 and in the wavelength of 808 nm, it is 0.87 ± 0.51, which shows a significant difference between the two wavelengths (*P*-value < 0.0001) (Table 4).

Discussion

For the past decades, adjunctive use of low-intensity lasers has been investigated in the treatment of periodontitis. Recently, laser therapy, either as photodynamic or photobiomodulation therapy, has been suggested as a promising alternative treatment for bacterial control or modulation of host response, respectively [30]. The present study was designed to evaluate the efficacy of low-intensity red (660 nm) and near-infrared (808 nm) diode lasers as adjuncts in the treatment of chronic periodontitis. The results of this study showed that the red laser (wavelength 660 nm) group's reduction was significantly more in the 6 months after treatment. Periodontitis is an infectious-inflammatory disease that destroys the supporting tissue around the teeth. Evaluation of the progression of the severity or its improvement after periodontal treatments is done by examination of periodontal tissue and radiography survey [2]. Non-surgical periodontal treatment alone or with adjunctive treatments, including the use of low level laser, is a proven method in the treatment of chronic periodontitis. The primary objective of initial periodontal therapy is the disturbance, disruption, and control of the pathogenic plaque biofilms on the tooth surface [16]. Gingival inflammation is a risk factor in the onset or progression of chronic periodontitis, and this is one of the reasons why low level lasers are used to prevent or reduce inflammatory processes [29]. In addition, LLLT has been found to improve the local microcirculation by

Table 4 Mean difference of the periodontal variables at different time intervals for both groups

Clinical parameter		PPD		CAL		GI	
Wavelength		660 nm	808 nm	660 nm	808 nm	660 nm	808 nm
Evaluation point	Baseline	4.40 ± 0.62	4.38 ± 0.65	3.35 ± 0.58	3.28 ± 0.57	2.13 ± 0.43	2.13 ± 0.42
	One month	2.26 ± 0.55	2.47 ± 0.56	1.50 ± 0.54	1.81 ± 0.57	1.12 ± 0.16	1.18 ± 0.25
	Δ0–1 months	2.14	1.91	1.84	1.46	1.01	0.95
	P-value	>0.0001		>0.0001		>0.0001	
	3 months	2.30 ± 0.58	2.52 ± 0.59	1.58 ± 0.63	1.92 ± 0.65	1.06±0.14	1.25 ± 0.16
	Δ0–3 months	2.10	1.85	1.76	1.35	1.07	0.88
	P-value	>0.0001		>0.0001		>0.0001	
	6 months	2.36 ± 0.53	2.61 ± 0.52	1.75 ± 0.67	2.07 ± 0.61	1.06 ± 0.15	1.25 ± 0.18
	Δ0–6 months	2.02	1.76	1.59	1.20	1.06	0.87
	P-value	>0.0001		>0.0001		>0.0001	

PPD (probing depth pocket); *CAL* (clinical attachment level); *GI* (gingival index)

Mann–Whitney non-parametric test

angiogenesis and vasodilation, thus alleviating tissue edema and inflammation [14]. The results of using low level lasers in non-surgical periodontal treatment are not the same in different studies. The differences could contribute to the clinical characteristics of the study population, the parameter or protocol of LLLT, the methodology of assessment, and the observation period [28]. The depth of penetration diode lasers is different. Lasers with wavelengths in the red and near-infrared range exhibit less absorption by water and tissue chromophores (hemoglobin and melanin), thus penetrate deeper into tissue (5–10 mm). These properties make LLLT a promising treatment strategy for soft tissue wounds [15, 23]. The visible-red lasers mostly absorbed on the surface, but the infrared lasers penetrate about 3 to 5 cm depending on their wavelength [8]. Studies show that low level lasers with different wavelengths do not have same effect on the tissue due to different penetration depths [9]. The effect of laser energy in the tissue depends on two absorption and scattering factors, the energy scattering has an inverse relationship with the wavelength, that is, the shorter the wavelength, the lower the depth of laser penetration, and therefore, the surface scattering is greater. Therefore, 660 nm affects superficial tissues and accelerates wound healing, and 808 nm affects deeper tissues and treats chronic pain [10]. This therapeutic activity in our study may have contributed to a better result in the 660 nm laser group. Lee et al. [17] used 660 diode lasers to evaluate the effects of low level laser as an adjunct treatment for periodontitis in periodontal ligament cells. They reported that LLLT has an anti-inflammatory effect by inhibiting pro-inflammatory effects through upregulation of cAMP levels and down-regulation of NF-κB intracellularly, as well as reducing oxidative stress that causes bone resorption in periodontal tissues [24–26]. Pereira et al. [10] evaluated histologically and radiographically the effect of two different wavelengths of 660 and 808 nm as adjuvant treatment after scaling and root planning on periodontitis in rats. In this study, the amount of bone resorption after 14 days of follow-up was investigated in radiography. The results show that SRP along with 660 nm laser is more effective than 808 nm laser as an adjunct treatment in radiographic and histological findings and there is a significant difference between the two wavelengths. Yazicioglu and his colleagues [33] compared two wavelengths of 660 and 808 nm in the regeneration of the inferior alveolar nerve after nerve injury and reported that the 808 nm diode laser is an effective treatment for the regeneration of the inferior alveolar nerve after injury. Paying attention to the anatomy of the lower alveolar nerve, which is located in the depth of the bone tissue, this study shows that the 808 nm laser has a greater depth than the 660 nm laser. Evaluation of the level of clinical attachment showed that laser radiation with a wavelength of 660 nm during follow-ups of 1, 3, and 6 months had a significant relationship with the reduction of clinical attachment loss. The difference between the short-term (1 month) and long-term (6 months) follow-up of clinical attachment loss was significant in this wavelength. Clinical attachment level in the study of Freire et al. [30] and Chen et al. [28] is at the wavelength of 660 nm and in the study by Mishra et al. [9] and Aykol et al. [31] in the wavelength of 808, it is the same as the present study. In the present study, the evaluation of pocket probing depth showed that laser radiation with a wavelength of 660 during 1-, 3-, and 6-month follow-ups significantly reduces pocket depth. Pocket probing depth in the study by Freire et al. [24] and Chen et al. [30] at the wavelength of 660 nm and in the study by Mishra et al. [9] and Freire et al. [30] at a wavelength of 808 nm is consistent with the present study. The GI is used to check the intensity of inflammation in periodontium tissue. The results of the study show that the long-term effect of 660 laser is better than 808 in reducing the intensity of inflammation, which is due to the cumulative effect of 660 laser on the tissue level compared to 808 lasers. In addition, the GI index as a single test is not a good predictor of the progress of clinical attachment loss, but its absence is an excellent predictor of periodontal stability [32, 33]. According to the above results, the use of 660 nm wavelength is more effective compared to 808 nm wavelength in the treatment of inflammatory diseases such as chronic periodontitis. Since there are few similar studies comparing different laser wavelengths in the treatment of periodontal diseases, more clinical studies are needed in this field. The results of this research can be placed as a subset of non-surgical periodontal treatment methods and provide a new strategy in this field.

Conclusion

The results of this clinical trial study showed that red laser (wavelength 660 nm) improves periodontal clinical parameters more than infrared laser (wavelength 808 nm).

Authors' contribution All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by all authors. The first draft of the manuscript was written by ARA and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declarations

Ethics approval The study was approved by the Golestan University of Medical Sciences with the ethics code IR.GUMS.REC.1399.196 and the Iranian Registry of Clinical Trials (IRCT20201005048942NT).

Consent to participate Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare no competing interests.

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