EFFECT OF PHOTOBIOMODULATION ON PERIODONTITIS

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Abstract

Background: The aim of this study was to evaluate the effect of photobiomodulation in a form of low-level laser therapy (LLLT) as an adjunct to conventional periodontal therapy in patients with moderate to advanced periodontitis.
Methods: All 50 systemically healthy patients who were included in the study initially received conventional periodontal therapy. Both groups received the treatment at baseline, included scaling and root planing (SRP) using ultra-sonic scalers and hand instruments by the same operator under local anesthesia to minimize patient discomfort for the entire dentition in a single visit.
The laser group (n = 25) received LLLT as an adjunct to the conventional periodontal therapy. The LLLT was of intensity 2.5 J/cm2 and a wavelength 980 nanometer. Three laser sessions were given at the first and second weeks, followed by two sessions during the third week, and then sessions were applied once weekly during the fourth and fifth weeks (a total of 10 sessions for every site).
Plaque index (PI), gingival index (GI), pocket depth (PD), clinical attachment level (CAL) and visual analogue scale (VAS) were all measured at the baseline and after treatment. Data were collected and statistically analyzed.
Results: The control group showed significant improvement in all of the primary outcome variables except for the VAS scores after treatment. The LLLT group also showed a more significant and substantial improvement in all of the parameters, including the VAS scores, after treatment. When the LLLT groups were compared to the control group, all of the parameters showed a clear and significant improvement.
Conclusion: Photobiomodulation in a form of LLLT as an adjunctive therapy to non-surgical periodontal treatment improves periodontal healing and reduce post-operative pain.

Keywords: Photobiomodulation, Periodontitis, Gingivitis, Low-level Laser, Periodontal surgery, Scaling, Root Planing, Visual Analogue scale

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1. INTRODUCTION

Periodontal disease is the most common oral condition of human population **(Raitapuro-Murray et al. 2014)**. Inflammation is a primary response of the periodontal tissue to damage. It is a fast-working first line of defense against infections. Periodontal diseases start as gingival inflammation (termed gingivitis) which can progress into the deep periodontal tissues with alveolar bone loss (termed periodontitis). Gingivitis and periodontitis represent.
the type of chronic inflammation, which if left untreated will result in teeth loss **(Newman et al. 2018).**

Photobiomodulation is the term used to describe either the process of stimulation or inhibition of biological processes. Both processes, i.e., stimulation and inhibition, could be beneficial in biological systems. A decision was made to replace the term "low-level laser therapy (LLLT)" and all other coherent and non-coherent non-monochromatic light-emitting diodes (LEDs) with comparable parameters to low-power lasers with the term "photobiomodulation" **(Anders et al. 2015)** & **(Hamblin 2016)**. In the current study and for the sake of simplicity, the old terminology is used synonymously with the new one “photobiomodulation”.

The objective of this study was to evaluate the effects of photobiomodulation using low-level laser application with a wavelength of 980 nm in gingival sulcus on periodontitis.

2. SUBJECTS AND METHODS

A total of 50 patients with chronic periodontitis were recruited from the outpatient clinic of Oral Medicine, Faculty of Dentistry, Cairo University, Egypt and also from the outpatient clinic of Misr University for Sciences and Technology (MUST). Full medical history was obtained using the Cornell Medical Index. Eligible patients were randomly assigned (1:1) by a computer-based randomization method, into 2 groups: ***Group I (control group):*** Included twenty-five patients; they received the standard of care treatment for periodontitis (full mouth scaling and root planing at baseline) ; ***Group II (study group):*** included twenty-five patients, were treated with low-level laser therapy in addition to the standard of care treatment for periodontitis. The low-level laser with the of intensity 2.5 J/cm^2 and a wavelength 980 nanometer was used.

The inclusion criteria were: *Gender:* Males and females; Age ranged from 20 to 40 years; patients were free from any systemic disease as evidenced by Burket's Oral Medicine health history questionnaire **(Glick 2015)**; patients able to return for the follow up visits and can perform oral hygiene measures; clinically diagnosed generalized moderate to severe chronic periodontitis having more than 30% of sites with clinical attachment loss (CAL) $\geq$ 3 mm **(Armitage 2014)**; patients agreed to sign a written consent after understanding the nature of the study.

The exclusion criteria were: Smokers; pregnant or lactating females; systemic and/or local antimicrobial or anti-inflammatory drug therapy within the last 3 months prior to the start of the study; periodontal treatment during the last six months prior to the initiation of this clinical trial; vulnerable groups as prisoners, mentally disabled, etc.

All parameters were recorded by an examiner blinded to the type of treatment at baseline, and at one, and 3 months after the baseline. In teeth presenting more than one site with PD $\geq$ 6 mm, the deepest site was selected and designated as the study site for the collection of clinical data. Six readings were recorded for each tooth: Mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual using University of Michigan O probe with William's markings (*Hu-Friedy Mfg. Co., LLC, UK)* for measurement of the following clinical parameters: Plaque index (PI) **(Löe & Silness 1963)**; gingival index (GI) **(Löe & Silness 1963)**; probing depth (PD) Probing depth (PD) **(Polson et al. 1980)**; clinical attachment level (CAL) **(Ramfjord 1967)**. Pain assessment was done using the Visual Analogue Scale (VAS).

Interventions and treatment protocol

1. **Phase I therapy:** Was done to all patients at baseline and included scaling and root planing (SRP) using ultra-sonic scalers and hand instruments by the same operator under local anesthesia to minimize patient discomfort for the entire dentition in a single visit.
2. **Adjunctive interventions:** Were given to the study group only [Group 2 (Laser group)]. At baseline, the operation site received LLLT directly after SRP according to the selected averages of the following parameters **(Pribac et al. 2016)** and **(Ren et al. 2016):**

(a) *Equipment:* Low-level laser
(b) *Intensity:* 2.5 J/cm^2
(c) *Wavelength:* 980 nanometers.
(d) *Duration of each session:* 30 s
(e) *Frequency of sessions:* Three laser sessions were given at the first and second weeks, followed by two sessions during the third week, and then sessions were applied once weekly during the fourth and fifth weeks (a total of 10 sessions for every site).
(f) *Total duration of adjunctive intervention:* Five weeks

3. **Maintenance phase:** For the 3 months study period, detailed instructions in self-performed plaque control measures were given to all patients, including tooth brushing and dental flossing. Patients were evaluated in biweekly recall visits for reinforcement.

The sample size was calculated using R, (Rcmdr) and Jamovi software. All the statistical tests were made under the level of alpha $\leq$ 0.05. The research protocol was reviewed by the research ethics committee at the Faculty of Physical Therapy, Cairo University (Ethical approval number **No. P.T.REC/012/004543**) and was conducted according to the declaration of Helsinki.

3. RESULTS

Control Vs Laser Group at Pre-treatment Phase

There were no significant differences between the control and the laser group pertaining to all the parameters of the current study at the startup point. The descriptive statistics for all of the parameters in the current study at startup are presented in **Table (1).** At the pre-treatment phase, there were no significant differences between the control and the laser groups regarding all the parameters used in the current study. This is shown in **Table (2).**

Table (1): Descriptive Statistics with Shapiro-Wilk Test for Normality of Data at Startup.

	Groups	PI	GI	PD	CAL	VAS
N	Control	25	25	25	25	25
	Laser	25	25	25	25	25
Mean	Control	4.54	3.63	4.62	4.21	2.8
	Laser	4.5	3.59	4.74	4.01	3.12
SD	Control	0.774	0.788	0.835	0.612	0.816
	Laser	0.782	0.813	0.855	0.546	0.833
Shapiro-Wilk p	Control	0.149	0.357	0.041	0.022	<.001
	Laser	0.12	0.176	0.041	0.327	<.001

*Note: **N:** Number of cases, **SD:** standard deviation, **p:** p-value*

Table (2): Independent Samples t-test for the Control and Laser Groups at Startup

Parameter	Test Type	Statistic	df	*p*
PI	Student's t	0.173	48	0.864
	Welch's t	0.173	48	0.864
GI	Student's t	0.143	48	0.887
	Welch's t	0.143	48	0.887
PD	Student's t	-0.499	48	0.62
	Welch's t	-0.499	48	0.62
CAL	Student's t	1.192	48	0.239
	Welch's t	1.192	47.4	0.239
VAS	Student's t	-1.372	48	0.176
	Welch's t	-1.372	48	0.176

*Note: **df:** degrees freedom, **p:** p-value*

Parameters of Control Group Pre- and Post-Treatment

In the control group, the conventional treatment resulted in a substantial improvement in all the parameters of the study except for the Visual Analogue Scale (VAS) which failed to show a statistically significant improvement albeit of the numerical decrease in the mean of the VAS scale (2.80 before treatment and 2.64 after treatment, p-value = 0.406).

The mean of PI at the end of the treatment period was 3.84 vs 4.54 for the startup point (p-value 0.004 and Cohen's d 0.855). The mean for the GI at the end of the treatment period was 3.04 vs 3.63 for the startup point (p-value 0.006 and Cohen's d 0.824). The mean for the PD at the end of the treatment period was 3.58 vs 4.62 for the startup point (p-value <.001 and Cohen's d 1.46). The mean for the CAL at the end of the treatment period was 3.50 vs 4.21 for the startup point (p-value 0.002 and Cohen's d 1.461).

Student's t-test and Welch's t-test are shown in **Table (3).** Box plots for all parameters are shown in **Figure (1).** From **Table (3)**, it was evident that the Cohen's d for the effect size is greater than 0.8 for all parameters except for The VAS scale, indicating a larger effect of the treatment on periodontitis **(Cohen 1992).**

Table (3): Student's and Welch's t-test for the control group

Parameter	Test Type	Statistic	df	*P*	Effect size(Cohen's d)
PI	Student's t	3.02	48.0	0.004	0.855
	Welch's t	3.02	47.4	0.004	0.855
GI	Student's t	2.91	48.0	0.005	0.824
	Welch's t	2.91	45.3	0.006	0.824
PD	Student's t	5.16	48.0	<.001	1.460
	Welch's t	5.16	42.3	<.001	1.460
CAL	Student's t	5.17	48.0	<.001	1.461
	Welch's t	5.17	35.2	<.001	1.461
VAS	Student's t	0.84	48.0	0.405	0.238
	Welch's t	0.84	39.3	0.406	0.238

*Note: **df:** degrees freedom, **p:** p-value*

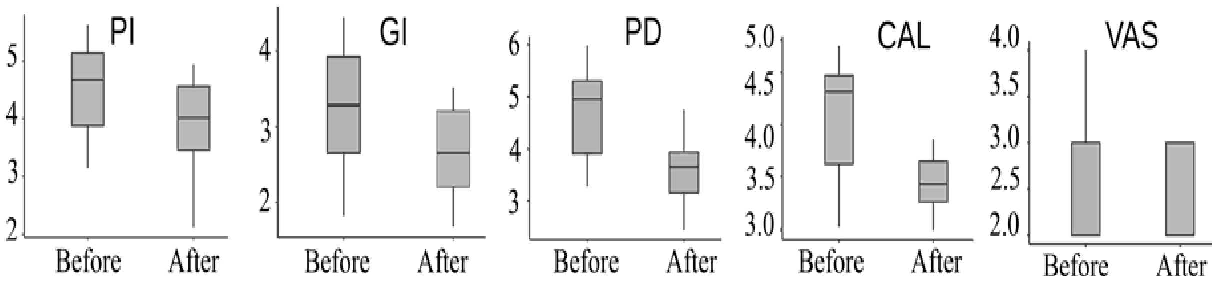

Figure 1: Box plot for all parameters used in the current study of the control group before and after treatment.

Parameters of Laser Group Pre- and Post-Treatment

In the laser group, there was a significant improvement in all parameters used in the current study. The mean of PI at the end of the treatment period was 2.33 vs 4.50 for the startup point (p-value <.001 and Cohen's d 2.46). The mean for the GI at the end of the treatment period was 2.58 vs 3.59 for the startup point (p-value <.001 and Cohen's d 1.65). The mean for the PD at the end of the treatment period was 2.84 vs 4.74 for the startup point (p-value <.001 and Cohen's d 2.64). The mean for the CAL at the end of the treatment period was 2.49 vs 4.01 for the startup point (p-value <.001 and Cohen's d 3.55). The mean for the VAS at the end of the treatment period was 1.92 vs 3.12 at the startup point (p-value <.001 and Cohen's d 1.51).

This is shown in **Table (4)** and also illustrated in **Figure (2)**. **Table (4)**, showed that the Cohen's d for the effect size was greater than 0.8 for all parameters including that for The VAS scale, indicating a larger effect of the treatment on periodontitis **(Cohen 1992).**

Table (4): Student's and Welch's t-test for the laser group

Parameter	Test Type	Statistic	df	*P*	Effect size(Cohen's d)
PI	Student's t	8.7	48.0	<.001	2.46
	Welch's t	8.7	45.9	<.001	2.46
GI	Student's t	5.82	48.0	<.001	1.65
	Welch's t	5.82	31.2	<.001	1.65
PD	Student's t	9.34	48.0	<.001	2.64
	Welch's t	9.34	40.9	<.001	2.64
CAL	Student's t	12.56	48.0	<.001	3.55
	Welch's t	12.56	34.8	<.001	3.55
VAS	Student's t	5.32	48.0	<.001	1.51
	Welch's t	5.32	47.6	<.001	1.51
*Note: **df:** degrees freedom, **p:** p-value*					

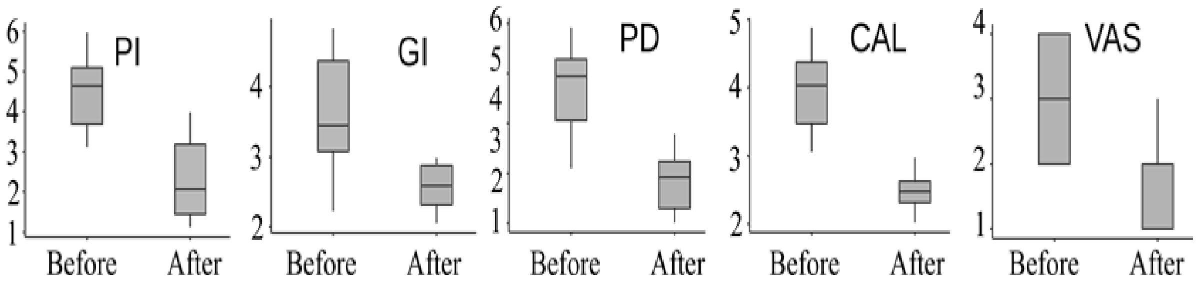

Figure 2: Box plot for all parameters used in the current study in the laser group before and after treatment.

Control Group Vs Laser Group after Treatment

Comparing the results of the laser group with that of the control group at the end of the experiment, it was evident that all parameters of the laser group were superior than that of the control one. The mean of PI for the laser group was 2.49 vs 3.58 for the control group (p-value <.001 and Cohen's d 1.64). The mean for the GI of laser group was 2.58 vs 3.04 for the control group (p-value 0.002 and Cohen's d 0.96). The mean for the PD of the laser group was 2.84 vs 3.58 for the control group (p-value <.001 and Cohen's d 1.32).

Table (5): Descriptive statistics with Shapiro-Wilk Test for Normality of Data After Treatment in the Two Groups.

	Groups	PI	GI	PD	CAL	VAS
N	Control	25	25	25	25	25
	Laser	25	25	25	25	25
Mean	Control	3.84	3.04	3.58	3.5	2.64
	Laser	2.33	2.58	2.84	2.49	1.92
SD	Control	0.862	0.61	0.569	0.3	0.49
	Laser	0.974	0.32	0.549	0.27	0.759
Shapiro-Wilk p	Control	0.055	0.02	0.81	0.25	<.001
	Laser	0.011	0.04	0.154	0.78	<.001

*Note: **N:** Number of cases, **SD:** standard deviation, **p:** p-value*

The mean for the CAL of laser group was 2.49 vs 3.50 for the control group (p-value 0.002 and Cohen's d 0.96). The mean for the PD of the laser group was 2.84 vs 3.58 for the control group (p-value <.001 and Cohen's d 3.56). The mean for the VAS of laser group was 1.92 vs 2.64 for the control group (p-value 0.002 and Cohen's d 0.96). The mean for the PD of the laser group was 2.84 vs 3.58 for the control group (p-value <.001 and Cohen's d 1.13). **Table (5 & 6)** and **Figure (3).**

The percent of improvement in the VAS after treatment for the laser group was 27.3% more than that of the control group. This improvement was statistically significant. As Cohen's d increase to >0.8 and up to 1.4, it indicated a large effect of the treatment **(Cohen 1992)**, **Table (6).**

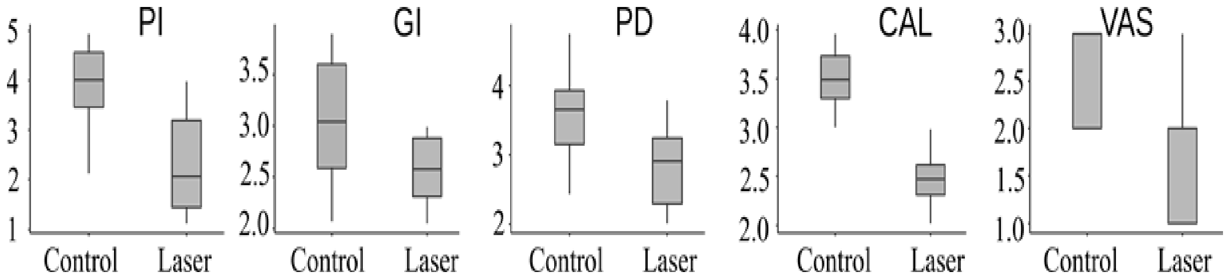

Figure 3: Box plot for all parameters used in the current study in the control and laser groups after treatment.

Table (6): Independent Samples t-test for Control and Laser Groups After Treatment

Parameter	Test Type	Statistic	df	*p*	Effect size(Cohen's d)
PI	Student's t	5.80	48	<.001	1.64
	Welch's t	5.80	47.3	<.001	1.64
GI	Student's t	3.38	48	0.001	0.96
	Welch's t	3.38	36.1	0.002	0.96
PD	Student's t	4.66	48	<.001	1.32
	Welch's t	4.66	47.9	<.001	1.32
CAL	Student's t	12.58	48	<.001	3.56
	Welch's t	12.58	47.2	<.001	3.56
VAS	Student's t	3.98	48	<.001	1.13
	Welch's t	3.98	41	<.001	1.13

*Note: **df:** degrees freedom, **p:** p-value*

4. DISCUSSION

In the current study, the therapeutic efficacy of LLLT was investigated as an adjunctive treatment on the healing process of gingival tissues during and after the conventional management of periodontitis.

It was hypothesized that LLLT would inhibit or reduce the inflammatory response associated with periodontitis, and also with the conventional treatment consisting of scaling and root planing and that it can impart protection to prevent or decelerate periodontitis development after treatment.

The results of the current study showed that there was a statistically significant improvement in all clinical parameters after conventional periodontal treatment in the control group, with the exception of the visual analogue scale. The beneficial effects of scaling, root planing combined with personal plaque control and oral hygiene in the treatment of periodontitis have been well documented. These improvements result from microbial shifts to a less pathogenic subgingival flora, a reduction of clinical inflammation, a reduction in PD, and a gain in clinical attachment **Badersten et al. (1984), Badersten et al. (1987)**, **Hughes & Caffesse (1978)** and **(Misra et al. 2023).** In the control group, visual analogue scale failed to show a statistically significant difference after completion of the conventional treatment. A finding which might indicates that conventional treatment might be insufficient for the induction of substantial changes in the subgingival microbial flora. This finding was proposed by **Sampaio et al. (2011)** as they stated that scaling and root planing alone does not cause a sufficiently deep change in the subgingival microbial composition to achieve and maintain a profile compatible with periodontal health. Also, **Goodson et al. (2012)** suggested that scaling and root planing do not lead to major clinical improvements in all subjects, especially in cases of advanced disease and deep periodontal pockets. One other possible explanation is that, although the visual analogue scale is a robust measure of pain, it has the drawback of adding extra potential sources of bias or mistake and lengthening the scoring process, particularly for illiterate personnel **(Lazaridou et al. 2018).** Also, **Mulder-van Staden et al. (2020)** stated that non-surgical periodontal therapy (NPT, i.e., scaling, root planing, and polishing) are the fundamentals of periodontal disease management, but NPT has its limitations in the complete removal of periodontal pathogens and is prone to both clinical and microbiological relapse. These limitations may be attributed to several factors, such as complex tooth anatomy, the presence of intrabony defects, limited access associated with the size of instrumentation, and the invasion of periodontal pathogens into the surrounding soft tissues. NPT may also only cause a temporary shift in the composition of the subgingival microflora, with periodontopathic bacteria persisting and potentially recolonizing treated sites. The lack of long-term successful treatment outcomes of NPT in some chronic periodontitis cases has emphasized the need for the identification of adjunctive management modalities.

In the laser group, the current study showed that there was a significant improvement in all parameters, including the visual analogue scale, after the completion of treatment. This finding was in agreement with **Gündoğar et al. (2016), Ozturan et al. (2011) and Alagl (2015)** as they stated that LLLT is promising therapy that exerts a beneficial effect on the periodontal apparatus. This finding is expected since LLLT modulates biological function or induces a therapeutic effect in a non-destructive and non-thermal manner **(Rojas & Gonzalez-Lima 2011)** and **(Misra et al. 2023).**

It was shown that LLLT exerts a potent effect on the periodontal ligament cells particularly fibroblasts through the activation of basic fibroblast growth factor (bFGF), the later belongs to an important family of fibroblast growth factors which act as a pleiotropic growth factor involved in the proliferation and differentiation of many cell types originated from the neuroectoderm and mesoderm, and has therapeutic potential in wound healing, cardiac and cerebral vessel and nervous system disorders **(Silviya et al. 2022).**

It was proposed that the heat generated during the application of LLLT might be responsible for the beneficial effects of photobiomodulation. Although, an increase in temperature may be noticeable in actual practice, a little evidence exists that supports this view. This hypothesis can be verified in comparison studies where a similar temperature increase is induced by means other than exposure to visible light **(Rathod et al. 2022).**

Misra et al. (2023) found a similar result and they explained the improvement in study groups due to possibility of the efficiency done by LLLT along with proper oral hygiene practices followed by the participants on a regular basis in both groups.

The statistically significant improvement of the visual analogue scale reflects the enhanced effect of LLLT on the periodontal health in general. However, **Qadri et al. (2005)** found in their study that additive treatment with low-level lasers reduced periodontal gingival inflammation and pocket depth (PD); the results of the current study are parallel to this study. Contrary to findings of the current study, **Lai et al. (2009)** suggested that low-power laser did not result in any additional clinical benefit. This might be a result of their application shorter wavelength (wavelength of 632 nm) and having limited application sites. The use of different kinds of lasers, doses, and duration preclude a comparison of these findings with the current study.

Comparing the results of the control and the laser groups, the current study showed a statistically superior improvement in all of the parameters of the laser group at the end of the treatment period. As Cohen's d in all measurements exceeds >0.8, this finding indicates a larger effect of the treatment **(Cohen 1992).** These findings indicate in general the beneficial effects of LLLT on the healing process in cases of periodontitis. Cellular response to LLLT might result in increased adenosine triphosphate, modulation of reactive oxygen species, and engagement of transcription factors like redox factor 1. In addition to these, LLLT might promote the proliferation, maturation, and increased production of growth factors. Photobiomodulation, which is the main feature of LLLT, involves chromospheres and increased energy production that helps perform different cellular tasks. The release of nitrous oxide (NO) as a result of disassociation from cytochrome C oxidase (CCO) results in increased production of ATP **(Afzal & Ramlee 2020).**

Also, the beneficial effect of LLLT might be explained by the inhibition of the formation of dental plaque as was pointed out by **Pejcic & Mirkovic (2011). Pejcic & Mirkovic (2011)** proclaimed that the inhibition mechanism of dental plaque by the laser is not yet clear. Further experimental studies are needed to examine the effects of the laser on the metabolism of vital cells in dental plaque. This effect may help explain the laser light effect on gingival inflammation by decreasing plaque bacteria.

Again, the improvement in the VAS score might be attributed to the significant reduction of gingival inflammation as was reported by **Nakova et al. (1995),** which was the direct result of anti-inflammatory, anti-edematous effects of laser activity, and intensification of humoral and cellular immunity and acceleration of the reparatory and regeneratory capabilities. Also, **Pejcic & Mirkovic (2011)** reported that along with the primary benefit of being non-surgical, laser promotes tissue healing and reduces edema, inflammation, and pain.

5. CONCLUSION

Photobiomodulation in a form of LLLT as an adjunctive therapy to non-surgical periodontal treatment improves periodontal healing and reduce post-operative pain.

AUTHORS CONTRIBUTIONS

AM design of study, editing and final revision. **NA** data accrual, manuscript preparation and editing. **NN** dental assessment and treatment. **KI** oversight manuscript preparation, and editing.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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