

Oral Medicine and Surgical Sciences Issue (Oral Medicine, Oral and Maxillofacial Surgery, Oral Pathology, Oral Biology)

1-1-2020

## BIO-Modulation Effect Of Low Intensity Laser as an Adjunct to Mechanical Debridement of Periodontitis

Reham Kabeel

*Demonstrator of Periodontology and Oral Medicine and Diagnosis Department, Faculty of Dental Medicine, Misr University for science and technology, Cairo, Egypt, rehamqabeel2.992009@gmail.com*

Hamdy Nasaar

*Professor of Oral Medicine, Periodontology, Oral Diagnosis and Dental Radiology Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt*

Naglaa Elkilani

*Professor and the head of Oral Medicine, Periodontology, Oral Diagnosis and Dental Radiology Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt*

Naglaa Elwakeel

*Professor of Oral Medicine, Periodontology, Oral Diagnosis and Dental Radiology Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt*

Follow this and additional works at: <https://azjd.researchcommons.org/journal>



Part of the [Other Dentistry Commons](#)

---

### How to Cite This Article

Kabeel, Reham; Nasaar, Hamdy; Elkilani, Naglaa; and Elwakeel, Naglaa (2020) "BIO-Modulation Effect Of Low Intensity Laser as an Adjunct to Mechanical Debridement of Periodontitis," *Al-Azhar Journal of Dentistry*. Vol. 7: Iss. 1, Article 14.

DOI: <https://doi.org/10.21608/adjg.2019.7843.1106>

This Original Study is brought to you for free and open access by Al-Azhar Journal of Dentistry. It has been accepted for inclusion in Al-Azhar Journal of Dentistry by an authorized editor of Al-Azhar Journal of Dentistry. For more information, please contact [yasmeenmahdy@yahoo.com](mailto:yasmeenmahdy@yahoo.com).



## BIO-Modulation Effect of Low Intensity Laser as an Adjunct to Mechanical Debridement of Periodontitis

Reham A. Kabeel<sup>1\*</sup>, Hamdy A. Nasaar<sup>2</sup>, Naglaa S. Elkilani<sup>3</sup>, Naglaa M. Elwakeel<sup>4</sup>

Codex : 14/2001

azhardentj@azhar.edu.eg

<http://adjg.journals.ekb.eg>

DOI: 10.21608/adjg.2019.7843.1106

### ABSTRACT

**Purpose:** The current study was conducted to elaborate the clinical, osteocalcin biomarker radiographic effect of biomodulation effect of low intensity laser as an adjunct to mechanical debridement in the treatment of patient suffering of chronic periodontitis. **Material and methods:** This current study was conducted on twelve (12) healthy patients that were alienated randomly into two groups: Group A (non lased, control group) twelve (12) patients side with one stage mechanical debridement without using of the low intensity laser as an adjunctive treatment; Group B (Test group, lased) twelve (12) patients side with three stage treatment high level laser decontamination, mechanical debridement with the application of biomodulation six sessions of low intensity laser. **Results:** lased group showed a significant increase in the clinical parameter, osteocalcin biomarker level after three and six months in comparison with control group after three and six months follow up. **Conclusion:** The using of laser decontamination, low intensity laser with conventional mechanical debridement showed an improvement in the treatment outcome of chronic periodontitis.

### KEYWORDS

*Keywords: periodontitis, low intensity laser, biomodulation, laser.*

### INTRODUCTION

Chronic Periodontitis is a complex inflammatory disease. Which lead to periodontium tissue destruction <sup>(1)</sup>. It Consist of iterative interactions between the inflammatory system and the immune system

A paper extracted from Master thesis titled "Biomodulation effect of low intensity laser as an adjunct to mechanical debridement of chronic periodontitis"

1. Demonstrator of Periodontology and Oral Medicine and Diagnosis Department, Faculty of Dental Medicine, Misr University for science and technology.
2. Professor of Oral Medicine, Periodontology, Oral Diagnosis and Dental Radiology Department, Faculty of Dental Medicine for Girls, Al-Azhar University.
3. Professor and the head of Oral Medicine, Periodontology, Oral Diagnosis and Dental Radiology Department, Faculty of Dental Medicine for Girls, Al-Azhar University.
4. Professor of Oral Medicine, Periodontology, Oral Diagnosis and Dental Radiology Department, Faculty of Dental Medicine for Girls, Al-Azhar University.

\* Corresponding author Email: rehamqabeel2.992009@gmail.com

of the susceptible host, sub gingival micro biota and modifying environmental factors<sup>(2)</sup>.

Periodontal disease management is aiming to bacterial load reduction. It can be reached by conventional scaling and root planning (SPR), or by the host modulation therapy (HMT)<sup>(3)</sup>. Conventional (SPR) can improve all clinical parameters<sup>(4)</sup>, but it shows some limitations as in case of Unfavorable tooth root anatomy and moderate deep periodontal pockets<sup>(5)</sup>.

Laser in periodontal treatment is considered as a valuable addition, it improves the therapeutic outcomes<sup>(6)</sup>. Low level lasers (LLL) are used in the activation of antimicrobial agent, and cellular biostimulation after the conventional (SPR)<sup>(6)</sup>.

(LLL) is recommended due to it is analgesic, biostimulation and photochemical role in anti inflammation. (LLL) dosage ( $10^{-2}$ : $10^2$  J/cm<sup>2</sup>) and (600:1000 nm) wave length<sup>(6)</sup>. Laser periodontal pocket decontamination improves mRNA expression of vascular endothelial growth factor, transforming growth factor- $\beta$  and insulin growth factor in gingival fibroblast, thus leading to metabolism of connective tissue<sup>(7)</sup>.

LLL increases the production of ATP through the mitochondrial respiratory chain, which allows the proliferation of osteoblast and fibroblast<sup>(8,9)</sup>. LLL can provide angiogenesis and vasodilatation thus improve the local microcirculation which leading to decrease tissue inflammation and edema<sup>(10)</sup>. LLL can suppresses periodontal inflammation by modulation of the local immune response to decrease the release and production of proinflammatory cytokines, such as prostaglandin E<sub>2</sub>, interleukin-1 $\beta$  and tumor necrosis alpha<sup>(11,12)</sup>.

Several studies prove the osteoblast biological role, and elaborate the bone derived osteocalcin (OC). OC remarked as the most sensitive serum marker which demonstrates the osteoblastic activity in bone formation. OC plays an important role in regulate the bone matrix mineralization<sup>(13)</sup>.

Many clinical trials, demonstrate the additional aid of the LLLT in periodontal non surgical

treatment<sup>(14,15)</sup>. LLL can decrease the bleeding index (BI), probing pocket depth (PPD), clinical attachment level (CAL), plaque index (PI) and matrix metalloproteinase-8 level in the gingival crevicular fluid, over the short term<sup>(16)</sup>.

Several studies in vivo and vitro demonstrate the photobiomodulation effect of LLL which can improve osteoblastic proliferation via the incensement of growth factor and cofactor of bone mineralization<sup>(17)</sup>. Other studies elaborated the LLL effect on the bone morphogenic (BMP-2) gene expression, osteocalcin, transforming growth factor  $\beta$ 1<sup>(18)</sup>, thus stimulate the mineralization of bone<sup>(19)</sup>.

## MATERIAL AND METHODS

### Study design

This current study was a randomized clinical trial on 24 sides chosen from the out-patient clinic of Periodontology, Oral Medicine and radiology department, faculty of Dental Medicine for Girls, Al-Azhar University.

### Sample Size:

The sample size of 24 patient's sides (12 sides in each group) will be sufficient to detect the difference. Total numbers of patients were alienated randomly into two groups.

(Control group): twelve (12) patients side with one stage mechanical debridement without using of the low intensity laser as an adjunctive treatment.

(Laser group): twelve (12) patients side with three stage treatment laser decontamination, mechanical debridement with the use of bio modulation six sessions of low intensity laser.

The patients were selected according to selected criteria (The patients were free from any systemic diseases as evaluated by modified Cornell medical index, Presence of at least seven natural teeth to provide reasonable number of teeth matched chronic periodontitis with a PD  $\geq$  6 mm and attachment loss  $\geq$  4 mm, non-smoker and non-pregnant women). The selected patients signed an informed consent.

### Study procedures:

All patients in this study were received conventional scaling and root planning using hand instruments and ultrasonic scalar followed by oral hygiene instructions.

### Laser application:

In laser group laser disinfection to the pockets will be done first by 300 $\mu$ m (non initiated tip), holed parallel to the tooth long access of each tooth (continuous mode CP2, with peak power 1.60W, average power 0.80W, pulse length 1.00ms and pulse interval 1.00ms).

Specific protective glasses were used for patient, dentist. One week after the completion of initial therapy, the laser group will receive laser therapy and continued once a week per 6 weeks. Laser application was done by using laser tip for biostimulation. (Wavelength 940 $\pm$ 10nm, power output 0,5watt).

### Clinical evaluation:

- Bleeding index (BI) and Plaque index (PI) were recorded at baseline, 3, 6 months for each patient around the healing abutment.
- Probing depth (PD): The distance from the base of the pocket to the gingival margin was measured using Williams's periodontal probe with the following graduations: [1, 2, 3, 5, 7, 8, 9 and 10 millimeters (mm)].
- Clinical attachment level (CAL): The distance from the cement-enamel junction (CEJ) to the base of the periodontal pocket is CAL. The readings were recorded at the same location of PD.
- Collection of GCF samples and osteocalcin biochemical bone markers:

At each three appointment (baseline, 3 and 6 months), GCF samples were collected from one pocket site. Level of osteocalcin in GCF samples will be determined by using a commercially available means of Enzyme Linked Immune sorbent Assay (ELISA).

## RESULTS

### Clinical evaluation results:

**Bleeding Index:** by comparing the bleeding index at baseline between control and laser group there was no significant difference was found at P value 0.231, while by comparing the bleeding at three month between laser and control group there was a significant difference at P value 0.000, while by comparing the bleeding at six month between lased group and control group there was a significant difference at P value 0.004.

**Plaque Index:** by comparing the plaque index at baseline between laser and control group, there was no significant difference was found at P value 0.051, while by comparing the plaque index at three month between control and laser group there was a significant difference at P value 0.000, while by comparing the plaque index at six month between lased group and control group there was a significant difference at P value 0.028.

**Probing depth:** by comparing the probing depth at baseline between laser and control group, there was no significant difference was found at P value 0.722, while by comparing the probing depth at three month between control and lased group there was a significant difference at P value 0.011, while by comparing the probing depth at six month between laser and control group there was a significant difference at P value 0.022.

**Clinical attachment loss:** by comparing the clinical attachment loss at baseline between lased and non lased control group there was no significant difference was found at P value 0.712, while by comparing the clinical attachment loss at three month between laser and control group there was a significant difference at P value 0.004, while by comparing the clinical attachment loss at six month between laser and control group there was a significant difference at P value 0.000.

**Table (1)** Descriptive analysis of Absolute change in clinical parameters within the study groups through the whole study period.

	At zero Point	After 3 months	After 6 months	Significance Test (ANOVA test)	P value
●Bleeding index in Laser group (mean ±SD)	2.50±0.30	0.32±0.18	0.41±0.29	t=256.64	0.000*
●●Bleeding index in control group (mean ±SD)	2.66±0.30	1.10±0.30	0.99±0.53	t=66.70	0.000*
●Plaque index in Laser group (mean ±SD)	2.13±0.38	0.55±0.23	0.12±0.22	t=159.39	0.000*
●●Plaque index in control group (mean ±SD)	2.40±0.35	0.97±0.25	0.41±0.35	t=127.09	0.000*
●Probing depth in Laser group (mean ±SD)	3.72±0.43	2.56±0.43	2.40±0.50	t=29.44	0.000*
●●Probing depth in control group (mean ±SD)	3.65±0.51	3.15±0.59	2.95±0.58	t=4.84	0.014*
●Clinical attachment loss in Laser group (mean ±SD)	1.50±0.28	0.63±0.24	0.35±0.27	t=62.37	0.000*
●●Clinical attachment loss in control group (mean ±SD)	1.46±0.26	1.00±0.29	0.75±0.22	t=21.83	0.000*

\*Significant difference ( $p$  value<0.05).

Osteocalcin: by comparing the osteocalcin at baseline between lased and non lased control group there was no significant difference was found at P value 0.431, while by comparing the osteocalcin three month between lased and non lased control

group there was a significant difference at P value 0.253, while by comparing the osteocalcin at six month between control and laser group there was a significant difference at P value0.465 .

**Table (2)** Descriptive analysis of absolute change in ELISA from zero point to 3&6 months between groups

	Laser Group	Control Group	Significance Test (Student t test)	P value
Osteocalcin at zero point (mean±SD)	21.46±2.42	22.26±2.48	t=0.80	0.431
Osteocalcin after 3months (mean±SD)	25.08±2.42	23.98±2.16	t=1.17	0.253
Osteocalcin after 6 months (mean±SD)	24.03±2.11	23.40±1.99	t=0.74	0.465

\*Significant difference ( $p$  value<0.05).

## DISCUSSION

In the present investigation chronic periodontitis patients were selected because this condition is the most common one affected 36% of Western Europe population and 47.2% of American population as reported<sup>(20,21)</sup>.

Clinical evaluation of chronic periodontitis patient include radiographic evidence of alveolar bone loss, measurement of clinical attachment loss (CAL), pocket depth (PD), gingival inflammation signs and plaque index (PI)<sup>(22)</sup>.

Periodontal therapy primary goal is to arrest inflammation process. Periodontal treatment aim to establishment of micro flora and local environment compatibility with the periodontal health, which can be evaluated through the reduction of PI, BI, PD and CAL<sup>(23)</sup>.

The patients submitted to the present study were selected as having mild to moderate chronic periodontitis since those patients indicated for conventional periodontal treatment alone or combined with other adjunctive treatment such as dental lasers. In the present investigation, chronic periodontitis patients with systemic diseases were excluded since one of these diseases will act as a risk factor that may affect the results of the current study<sup>(24,25)</sup>.

As regard to gingival crevicular fluid (GCF) analysis to assess the Osteocalcin bone hormone which is the most important biomarkers which is play a major role in the periodontitis<sup>(26)</sup>. So the present study select osteocalcin as a biochemical marker to detect the response of periodontitis to treatment with conventional scaling and root planning compared with conventional scaling and root planning and laser decontamination and low level laser biostimulation<sup>(27)</sup>.

Laser can maximize pocket decontamination during the periodontal treatment, by providing antiseptic prosperity into the non vascularised tissues (dentine and bone), which overcome the

resistance of sub gingival biofilm to antibiotics<sup>(28)</sup>.

Several clinical trials show that the use of adjunctive laser periodontal therapy provides possible avoidance of surgical periodontal therapy intervention<sup>(29-35)</sup>. Many studies proved that not all the patients treated with conventional SRP alone responded to the treatment, thus laser adjunctive therapy have been encouraged recently<sup>(36-44)</sup>.

Diode lasers common wavelengths 810, 940, 980 and 1,064 nm. several studies demonstrate the thermal effect of laser on dental soft tissue, At 50°C, deactivation of most nonspore-forming bacteria, which is include periodontopathic anaerobes<sup>(45)</sup>. At 60°C Both coagulation and homeostasis of the inflamed sulcular epithelium are achieved<sup>(46)</sup>. Low-level laser therapy (LLLT) is one of such a novel techniques which can simplify and improving the outcomes of mechanical root surface management. It is also known as biostimulation therapy.

It has to be noted that the present study did potentially provide that patients with LLLT secondary to the HLLT provided. The true effects of LLLT as a result of HLLT investigated and evaluated cellular modulation and activity<sup>(47)</sup>.

By comparing the effect of LLL single session and LLL multiple sessions. Multiple LLL application during the periodontal treatment show favorable effect on the of proinflammatory mediators reduction, which is in equivalent with some present perspectives<sup>(48,49)</sup>. It was indicated that multiple laser sessions through the periodontal treatment may induce extra Favorable sound effects<sup>(50,51)</sup>.

The present research proves that there were significant differences in the laser group and control group in the bleeding index at 3 and 6 months observation period when compared to baseline. By comparing the bleeding index between the two groups there was significant difference in the laser group. These results are expected due to the laser anti inflammatory effect which produces a good homeostasis<sup>(52,53)</sup>.



As regard to plaque index score recorded in the present investigation the results showed that no significant differences between the study groups & there is highly significant difference in lased group and non lased control group at 3, 6 months observation period when compared to base line, this could be attributed to patients cooperation and motivation during the observation period of the study <sup>(54,55)</sup>.

With reference to periodontal (PD) and (CAL), the results of the existing study show highly significant decrease in measurements of (PD) and (CAL) increase between the two groups at different observation period. There was a significant reduction in both PPD and CAL in the lased grouping than the non lased control group <sup>(56,57)</sup>.

Osteocalcin level in the present study showed marked raise in the lased group at 3 months when compare to the baseline, this result is parallel to the findings of several authors, in vitro study elaborated the result of low level diode laser therapy on osteocalcin level by using hypoxic culture of human osteoblasts recorded the special effects of LLL on osteoblasts in the gene expression of bone morphogenic protein 2 (BMP-2), osteocalcin, transforming growth factor  $\beta$ 1 (TGF- $\beta$ 1) <sup>(58)</sup>, motivation of bone cells propagation and mineralization <sup>(59)</sup> which in parallel with other experimental study which used LLL (wavelength 808 nm, power 2 w, frequency of 37 J/cm per site) with exposure time 5 seconds per site after osteotomy in Wister Rats. That study approved the significant increase in osteocalcin level by using immune histochemistry <sup>(60)</sup>.

## CONCLUSION

The use of LLL application in the current study procedure within this parameter (940  $\pm$ 10 wave length, 0.5 watt, six sessions applied once per week)

1. Enhancement in clinical parameter as a sign for the inflammation reduction.
2. Development in bone density and marginal bone level which has been calculated by radiographic assessment.

3. Upgrading in osteocalcin level was related to the enhancement of clinical parameter and bone regeneration in periodontitis patient.
4. Osteocalcin can regard as a sensitive biological marker to evaluate the periodontal treatment outcome.

## REFERENCES

1. Bartold PM, Van Dyke TE. Periodontitis: a host-mediated disruption of microbial homeostasis. Unlearning learned concepts. *Periodontol* 2000. 2013; 62: 203–17.
2. Socransky SS, Haffajee AD. The bacterial etiology of destructive periodontal disease: current concepts. *J Periodontol* 1992; 63 (Suppl 4): 322–331.
3. Oringer RJ; Research, Science, and Therapy Committee of the American Academy of Periodontology. Modulation of the host response in periodontal therapy. *J Periodontol*. 2002;73:460–70.
4. Ipshita S, Kurian IG, Dileep P, Guruprasad CN, Singh P, Pradeep AR. Host modulation therapy: An updated review, *JCRI*. 2017; 4: 55–8.
5. Rabbani GM, Ash MM Jr, Caffesse RG. The effectiveness of subgingival scaling and root planing in calculus removal. *J Periodontol*. 1981; 52: 119–23.
6. Ishikawa Y I, Aoki A, Takasaki AA, Mizutani K, Sasaki KM, Izumi. Application of lasers in periodontics: true innovation or myth? *Periodontol* 2000. 2009; 50: 90–126.
7. Utani KM, Aoki A, Coluzzi D, Yukna R, Wang CY, Pavlic V, Izumi Y. Lasers in minimally invasive periodontal and peri-implant therapy, *Periodontol* 2000. 2016; 71: 185–212.
8. Centy IG, Blank LW, Levy BA, Romberg E, Barnes DM. Carbon dioxide laser for de-epithelialization of periodontal flaps. *J Periodontol*. 1997; 68: 763–9.
9. Silveira PCL, Streck EL, Pinho RA. Evaluation of mitochondrial respiratory chain activity in wound healing by low level laser therapy. *J Photochem Photobiol, B* 2007;86:279–82.
10. Hakki SS, Bozkurt SB. Effects of different setting of diode laser on the mRNA expression of growth factors and type I collagen of human gingival fibroblasts. *Lasers Med Sci*. 2012;27:325–31.
11. Schaffer M, Bonel H, Sroka R. Effects of 780 nm diode laser irradiation on blood microcirculation: preliminary findings on time-dependent T1-weighted contrast-enhanced magnetic resonance imaging (MRI). *J Photochem Photobiol, B* 2000;54:55–60.

12. Lim W, Choi H, Kim J. Antiinflammatory effect of 635 nm irradiations on in vitro direct/indirect irradiation model. *J Oral Pathol Me*. 2015;44:94–102.
13. Safavi SM, Kazemi B, Esmaili M, Fallah A, Modarresi A, Mir M. Effects of low-level He-Ne laser irradiation on the gene expression of IL-1b, TNF-a, IFN-c, TGF-b, bFGF, and PDGF in rat's gingiva. *Lasers Med Sci*. 2008;23:331–5.
14. Clemens TL, Karsenty G. The osteoblast: an insulin target cell controlling glucose homeostasis. *J Bone Miner Res*. 2011; 26:677–80.
15. Calderin S, Garcia-Nunez JA, Gomez C. Short-term clinical and osteoimmunological effects of scaling and root planning complemented by simple or repeated laser phototherapy in chronic periodontitis. *Lasers Med Sci*. 2013;28:157–66.
16. Qadri T, Miranda L, Tuner J, Gustafsson A. The short-term effects of low-level lasers as adjunct therapy in the treatment of periodontal inflammation. *J Clin Periodontol*. 2005;32:714–9.
17. Pyo SJ, Song WW, Kim IR, Park BS, Kim CH, Shin SH, Chung IK, Kim YD. Low-level laser therapy induces the expressions of BMP-2, osteocalcin, and TGF-β1 in hypoxic-cultured human osteoblasts. *Lasers Med Sci*. 2013;28(2):543–50.
18. Abd-Elaal AZ, El-Mekawii HA, Saafan AM, El Gawad LA, El-Hawary YM, Abdelrazik MA. Evaluation of the effect of low-level diode laser therapy applied during the bone consolidation period following mandibular distraction osteogenesis in the human. *Int. J. Oral Maxillofac Surg*. 2015;44(8):989–97.
19. Fernando Russo Costa do Bomfim I, Valeria Regina Gonzalez Sella II, Ronaldo Luís Thomasini III, Helio Plapler. Influence of low-level laser irradiation on osteocalcin protein and gene expression in bone tissue. *Acta Cir Bras*. 2018;33(9):736–43.
20. Sheiham A and Netuveli GS. Periodontal diseases in Europe. *Periodontol 2000*. 2002; 29:104–21.
21. Evans G, Eke P, Wei L. Periodontitis among adults aged ≥30 years: United States, 2009–2010. *MMWR Surveill Summ*. 2013;62:129–35.
22. Renvert S and Persson G. A systematic review on the use of residual probing depth, bleeding on probing and furcation status following initial periodontal therapy to predict further attachment and tooth loss. *J Clin Periodontol*. 2002; 29: 82–9.
23. Heitz-Mayfield L, Trombelli L, Heitz F, Needleman I, and Moles D. A systematic review of the effect of surgical debridement vs. nonsurgical debridement for the treatment of chronic periodontitis. *J Clin Periodontol*. 2002; 29:92–102.
24. Abramson J. The Cornell medical index as an epidemiological tool. *Am J Public Health*. 1966; 56: 287–98.
25. Miller G, Kaplan A, Guest G. Documenting medications used in adult patients 1987–1991. *J. Am. Dent. Association*. 1992; 123:40–8.
26. Perozini, Leao, and Qewiroz. GCF biochemical markers in periodontal disease. *Quintessence International*. 2010; 41.
27. Özçaka Ö, Nalbantsoy A, Bıçakçı N, Köse T, Buduneli N. Plasma Levels of C-Telopeptide Pyridinoline Cross-Links of Type I Collagen and Osteocalcin in Chronic Periodontitis. *Inflammation*. 2011;34.
28. Aoki A, Mizutani K, Schwarz F, Sculean A, Yukna RA, Takasaki AA, et al. Periodontal and peri-implant wound healing following laser therapy. *Periodontol 2000*. 2015; 68: 217–69.
29. Dias SBF, Fonseca MVA, dos Santos NCC, Mathias IF, Martinho FC, Santamaria MS Jr, Jardim APN, Santamaria MP. Effect of GaAlAs low-level laser therapy on the healing of human palate mucosa after connective tissue graft harvesting: randomized clinical trial. *Lasers Med Sci*. 2015; 30: 1695–702.
30. Dowst-Mayo L. Dental hygiene lasers: why you should use lasers. *RDH*. 2012;32: 54–60.
31. Ge L, Shu R, Li Y, Li C, Luo L, Song Z, Xie Y, Liu D. Adjunctive effect of photodynamic therapy to scaling and root planning in the treatment of chronic periodontitis. *Photomed Laser Surg*. 2011; 29: 33–7.
32. LeBeau J. Laser technology: its role in treating and managing periodontal disease. *Compend Cont Ed Dent*. 2012;33:370–1.
33. Passanezi E, Damante CA, Rubo De Rezende ML, Greggi SLA. Lasers in periodontal therapy. *Periodontol 2000*. 2015;67: 268–91.
34. Saglam M, Kantarci A, Dundar N, Hakki SS. Clinical and biochemical effects of diode laser as an adjunct to non-surgical treatment of chronic periodontitis: a randomized, controlled clinical trial. *Lasers Med Sci*. 2014; 29: 37–46.
35. Sgolastra F, Petrucci A, Severino M, Graziani F, Gatto R, Monaco A. Adjunctive photodynamic therapy to non-surgical treatment of chronic periodontitis: a systematic review and meta-analysis. *J Clin Periodontol*. 2013; 40: 514–26.



36. Chanthaboury R, Irinakis T. The use of lasers for periodontal debridement: marketing tool or proven therapy J Can Dent Assoc. 2005; 71: 653–8.
37. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. Periodontol 2000.2004; 36:59–97.
38. Da Silva APB, Barros SP, Moss K, Preisser J, Marchesan JT, Ward M, Offenbacher S. Microbial profiling in experimentally induced biofilm overgrowth among patients with various periodontal states. J Periodontol.2016; 87: 27–35.
39. Fontana CR, Abernethy AD, Som S, Ruggiero K, Doucette S, Marcantonio RC, et al. The antibacterial effect of photodynamic therapy in dental plaque-derived biofilms. J Periodontal Res. 2009; 44: 751–759.
40. Hur Y, Choi SK, Ogata Y, Stark PC, Levi PA. Microbiologic findings in relation to risk assessment for periodontal disease: a cross-sectional study. J Periodontol.2016; 87: 21–6.
41. Low SB, Mott A. Laser technology to manage periodontal disease: a valid concept? J Evid Base Dent Pract.2014; 145–59.
42. Ishikawa I, Aoki A, Takasaki AA, Mizutani K, Sasaki KM, Izumi Y. Application of lasers in periodontics: true innovation or myth. Periodontol 2000.2009; 50: 90–126.
43. Snaz I, Alonso B, Carasol M, Herrera D, Sanz M. Nonsurgical treatment of periodontitis. J Evid Base Dent Pract.2012;51: 76–86.
44. Obradovic R, Kesic L, Mihailovic D, Antic S, Jovanovic G, Petrovic A, Pesevska S. A histological evaluation of a low level laser therapy as an adjunct to periodontal therapy in patients with diabetes mellitus. Lasers Med Sci. 2013;28:19–24.
45. Saglam M, Kantarci A, Dundar N, Hakki SS. Clinical and biochemical effects of diode laser as an adjunct to non-surgical treatment of chronic periodontitis: a randomized, controlled clinical trial. Lasers Med Sci. 2014; 29: 37–46.
46. Aoki A, Ando Y, Watanabe H, Ishikawa I. In vitro studies on laser scaling of subgingival calculus with an erbium: YAG laser. J Periodontol.1994; 65: 1097–106.
47. Posten W, Wrone DA, Dover JS, Arndt KA, Silapunt S, Alam M. Low-level laser therapy for wound healing: mechanism and efficacy. Dermatol Surg.2005;31:334–40.
48. Huang YY, Chen AC, Carroll JD, Hamblin MR. Biphasic dose response in low level light therapy. Dose Response.2009;7:358–83.
49. Soares DM, Ginani F, Henriques AG, Barboza CA. Effects of laser therapy on the proliferation of human periodontal ligament stem cells. Lasers Med Sci.2015;30:1171–4.
50. Aykol G, Baser U, Maden I. The effect of low-level laser therapy as an adjunct to non-surgical periodontal treatment. J Periodontol. 2011;82:481–8.
51. Calderin S, Garcia-Nunez JA, Gomez C. Short-term clinical and osteoimmunological effects of scaling and root planning complemented by simple or repeated laser phototherapy in chronic periodontitis. Lasers Med Sci. 2013;28:157–66.
52. Pesevska S, Nakova M, Gjorgoski I. Effect of laser on TNF- $\alpha$  expression in inflamed human gingival tissue. Lasers Med Sci. 2012;27:377–81.
53. Roncati M, Gariffo A. Systematic review of the adjunctive use of diode and Nd:YAG lasers for nonsurgical periodontal instrumentation. Photomed Laser Surg. 2014; 32:186–97.
54. Cheng Y, Chen JW, Ge MK, Zhou ZY, Yin X, Zou SJ. Efficacy of adjunctive laser in non-surgical periodontal treatment: a systematic review and meta-analysis. Lasers Med Sci. 2016;31:151–63.
55. Slot DE, Jorritsma KH, Cobb CM, Van der Weijden FA. The effect of the thermal diode laser (wavelength 808–980 nm) in non-surgical periodontal therapy: a systematic review and meta-analysis. J Clin Periodontol. 2014;41: 681–92.
56. Smiley CJ, Tracy SL, Abt E, Michalowicz BS, John MT, Gunsolley J et al. Systematic review and meta-analysis on the nonsurgical treatment of chronic periodontitis by means of scaling and root planing with or without adjuncts. J Am Dent Assoc. 2015: 146: 508–24.
57. Hakki SS, Bozkurt SB. Effects of different setting of diode laser on the mRNA expression of growth factors and type I collagen of human gingival fibroblasts. Lasers Med Sci. 2012;27:325–31.
58. Bomfim FRC, Sella VRG, Zanaga JQ, Simionatto N, Nouailhetas VLA, Plapler H. RT-PCR standardization and bone mineralization after low-level laser therapy on adult osteoblast cells. Proc. SPIE 8926, Photonic Therapeutics and Diagnostics X. 2014;89.
59. Pyo SJ, Song WW, Kim IR, Park BS, Kim CH, Shin SH, et al. Low-level laser therapy induces the expressions of BMP-2, osteocalcin, and TGF- $\beta$ 1 in hypoxic-cultured human osteoblasts. Lasers Med Sci. 2013; 28: 543–50.
60. Abd-Elal AZ, El-Mekawii HA, Saafan AM, El Gawad LA, El-Hawary YM, Abdelrazik MA. Evaluation of the effect of low-level diode laser therapy applied during the bone consolidation period following mandibular distraction osteogenesis in the human. Int. J. Oral Maxillofac Surg. 2015; 44:989–97.