Detection The Effect Of Low Level Laser Therapy On The Management Of Alveolar Osteitis

Kamal Sahib Mizal[1,3], Asma Ben Cheikh[2], Muntathar Muhsen Abusanna[3], Eya Moussaoui[4]

[1]*B.D.S MCs in oral and maxillofacial surgery , a student in Sousse Faculty of Medicine of Sousse, University of Sousse Kamalalturfi@alameed.edu.iq*

[2]*Associate Professor in Preventive and Community Medicine Prevention and Security of Care Department, Sahoul University Hospital, Sousse Faculty of Medicine of Sousse, University of Sousse asmasmams@yahoo.fr*

[3]*B.D.S C.A.B.M.S OMFS University of Alameed dr.muntather@gmail.com*

[4]*Department of Dental Medecine, SAHLOUL Hospital (Sousse), University of Monastir, Sousse, Tunisia. Research Laboratory: LR 12SP10: Functional and Aesthetic Rehabilitation of Maxillary, Tunisia Email: eyamouss@gmail.com*

KEYWORDS
Dry Socket, Socket Depth, Low-Level Laser Therapy, Granulation Tissue Formation.

ABSTRACT
alveolar osteitis is a common complication occurs after tooth extraction, this complication can affected healthy people although it is cause is unknown. Therefore, alveolar osteitis management has always based on empirical treatment rather than scientific knowledge. The present study detect the efficacy of low levellaser therapy (LLLT) the healing of alveolar osteitis. Materials and methods: Patients who diagnosed with alveolar osteitis at the Al Ameeed dental clinic in AL Ameed University / College of Dentistry were enrolled in a randomized controlled clinical trial. Sixty patients has been divided equally into two groups for received different treatments: the first group received traditional therapy which include socket curettage and irrigation with saline, while the second group received low-level laser therapy. All the dry sockets were assessments on day 0 before intervention and then on day 4th and 7th of follow up. the pain, depth, piresocket inflammation and perisocket tenderness of dry socket were evaluated in each visit.
Results: Two therapy groups were established using 60 dry socket patients. The median of pain score, granulation tissue formation, tenderness, inflammation of the socket show there are significant improvement of group II LLLT compared to the conventional treatment.
Conclusion: The low-level laser therapy has a superior effect on the reduction period of the healing process of alveolar osteitis. On the other hand the conventional therapy may improve the sign and symptoms of the alveolar osteitis but don't reduce the time of healing process.

1. Introduction

Alveolar osteitis , sometimes referred to as dry socket, is the dominant problem that often occurs after tooth extraction. The incidence of alveolar osteitis following routinely tooth extraction is a cause for concern , with documented rates varying between 1 and 4%(1)(2). The possibility of dry socket in the teeth of the lower jaw is tenfold higher than in maxillary teeth, and it could reach 45% after surgical removing of the lower third molar(3).

The etiology of alveolar osteitis or dry socket (DS), is a topic of debate with the opinions being divided into two main schools of thought. The first suggests that there is a complete absence of a blood clot, with extensive efforts being made to understand why clot formation fails. The second concept proposes that a blood clot initially forms but is then dissolved, leaving an empty socket behind(4).

Traditionally, the treatment of a dry socket has been based on practical experience rather than scientific evidence(6).

Treatment approaches for the dry sockets have involved the application of hyaluronic acid as a wound dressing to harness its antioxidant properties, honey (7)to promote regenerative growth, turmeric(8), zinc oxide eugenol for its pain-relieving and germ-killing effects, and biocompatible fibrous filler materials like Peshawar Djambi(9). In addition, topical rifampicin has also been used for its antibacterial efficacy (10). This involves placing vitamin-C dressings inside the socket(11) .

Traditionally, the practice of irrigating dry sockets has entailed the utilization of physiological saline and chlorhexidine (10). While these therapies may help alleviate symptoms and protect the wound,

they do not specifically target the underlying problems associated with wound deterioration and the objective of regenerative therapy (12).

The current standard procedure for managing dry sockets involves meticulously removing debris from the sockets using a moderate curettage technique, and then flushing the area with a saline solution. The socket is then allowed to undergo spontaneous biological repair.(12)

The etiology and therapeutic alternatives for dry sockets remain a topic of continuous contention. To create a regenerative medicine approach for treating alveolar osteitis, scientists need a thorough understanding of the factors that control wound healing mechanisms, since alveolar osteitis is a disorder marked by slow wound healing. In the field of dentistry, the present methods for healing wounds within the mouth involve the use of concentrate growth factor (CGF) (13) ,platelet-rich plasmaor PRP, (14) low level laser therapy (LLLT) (15)and Low-intensity pulsed ultrasound treatment (LIPUS) (16).

Low-level laser therapy (LLLT) was discovered by Endre Mester when he observed hair regrowth in mice after exposing them to laser light(17). This technique is photochemical and activates skin cells(18), resulting in increased growth of fibroblasts (19).

Dental and oral surgery clinics now offer the option of low-level laser therapy (LLLT). The aims of the present clinical trial is determine the effect of low level laser therapy (LLLT) on management of alveolar osteitis.

2. Methodology

a pilot randomized controlled clinical study take place in AL Ameed University / faculty of dentistry ,from August 2022 to December 2023. The University of Al-Ameed's Research Ethics Committee gave its approval to the study (number: UAM/EC/5/2017). Patients were referred to the oral surgery department after being diagnosed with alveolar osteitis. And then randomally divided in two groups . The study include the Patients with alveolar osteitis after nonsurgical tooth extraction between the ages of 28 and 50 years. The study exclude the patients who did not finish the follow-up or who declined to participate. Prior to starting treatment, each group had a periapical radiography of the socket done to rule out fractures of the alveoli, retained apices, and bone fragments. Additionally, those with these cases were not accepted. All patients give informed consent and information about were their dry socket condition. Following the presentation of two therapy choices, sixty patients were divided into two groups at randomized method .

Under local anesthetic, the dry socket in group I was gently debridment and then rinsed with saline. In group II after debridement and irrigation, The buccal, occlusal , lingual wall of the socket were irradiated by Low-Level Laser Therapy (LLLT) in accordance with the correct laser safety procedures. Elexxion pico diode laser was utilized for thirty seconds. were 1 centimeter from the laser's point of origin. Operating in continuous wave mode 1, it produced 200 mW at 6 J and 808 nm.

Demographic information (age, gender), peri-socket inflammation, tenderness score (socket depth, quantity of granulation tissue formation), and visual analog pain scale (ranging from 1 to 10) were among the data gathered. The measurement of the amount of granulation tissue formation, the pain score, and the amount of inflammation and tendreness surrounding the socket assess on 0,4thand 7th day of follow up in each groups. Numerical rating scales were used to measure the pain, and they usually comprise a range of numbers from 0 to 10, with the endpoints denoting "no pain" and "worst possible pain," respectively, representing the extremes of the pain experience. Patients select the number that most closely matches the level of discomfort they are experiencing(20).

The per-socket inflammation and tenderness assessed are recorded in Table 1

Table 1: Perisocket tenderness and inflammation assessment

Perisocket inflammation	Score
Normal pink perisocket gingiva	0
Mild redness at perisocket gingiva	1
Moderate redness with increase vascularity at perisocket gingiva	2
Severe redness with increase vascularity at perisocket gingiva extending to vestibule	3
Perisocket tenderness	Score
No perisocket tenderness on palpation	0
Perisocket tenderness on palpation	1
Perisocket tenderness on slight touch	2
Perisocket tenderness on slight touch extending to vestibule and cheek	3

During each visit, the depth of the socket used by the WHO probe was measured as the height from the bottom of the sockets to the level of the cementoenamel junction of the neighboring tooth. The cementoenamel junction of the nearest tooth is considered a point of reference because it is a more reliable and fixed point.

Statistical Analysis

The statistical software program SPSS (version 25.0, SPSS Inc., Chicago, IL, USA) was used to analyze the data. If the continuous variables did not follow a normal distribution, they were reported as medians with their 25th and 75th percentiles, or as means ± standard deviations. The number of instances of each category, represented by absolute frequencies, and the proportion of each category to the total number of observations, represented by relative frequencies, were both used to summarize the categorical variables. This involves using Fisher's exact test and chi-square to compress categorical variables. Statistical tests including the Anova test, the Kruskal-Wallis test, the Student t-test, and the Mann-Whitney U-test are used to compress continuous variables. When the p-value is less than 0.05, statistical significance is established:

3. Results and discussion

The study revealed no significant difference in participant age across groups, as indicated in Table 1.

Table 1 shows that there are no significant differences between the groups.

	Control	LLLT	P
Age mean±SD	36.67±9.4	43.5±8.8	0.075

Pain score

On the first day, pain levels were approximately similar in both groups before intervention . However, by the fourth and seventh days of follow up , the LLLT group exhibited significant improvement and reduction in pain, as indicated in Table 2.

Table 2: Show the difference in the pain between groups on the 0, 4th, and 7th day of follow-up

PAIN	Control	LLLT	P
DAY0	9[8-10]	9[8-10]	0.313
DAY4	5[5-6]	1[1-2]	0.000
DAY7	3[2-4]	0[0-0]	0.000

The pre socket inflammation

The perisocket inflammation PSI was shown on day 0. There were no significant differences, but on

days 4th and seventh highly significant improvement in group II as shown in Table 3.

Table 3 shows the improvement of inflammation between groups on days 0, 4, and 7.

PSI	Control	LLLT	P
DAY0	2[2-3]	2[2-3]	0.422
DAY4	2[2-2]	1[0-1]	0.000
DAY7	2[1-2]	0[0-0]	0.000

The pre socket tenderness

The tenderness around the socket was assigned by gentle pressure with a blinded probe or WHO probe from the buccal vestibule and then around the socket. The data showed there was no significant difference on day 0, but during the follow-up after treatment, it was shown there was are highly significant reduction in group II on days 4th and 7th, as shown in Table 4

Table 4 shows the difference in tenderness around the socket on the 0th, 4th, and 7th days.

PST	Control	LLLT	P
DAY0	3[2-3]	2[2-3]	0.016
DAY4	2[2-2]	1[0-1]	0.000
DAY7	2[1-2]	0[0-0]	0.000

Depth of the socket

The depth of the socket decreases when granulation tissue forms inside it. This measurement helps to understand the extent of granulation tissue formation during the healing process, playing a crucial role in the overall recovery. The data indicates no differences on day 0, but following the intervention, there was a significant increase in granulation tissue formation in the group II LLLT on the 4th and 7th day, as shown in Table 5 below.

Table 5 shows the difference in depth of the socket between groups on the 0,4th, and 7th day

Depth of the socket	Control	LLLT	P
DAY0	11.5[11-12]	11.5[11-13]	0.461
DAY4	9.5[8-10]	4[1-5]	0.000
DAY7	4[3.5-6]	1[1-1]	0.000

Discussion

We are concerned about the global prevalence of alveolar osteitis, which has been shown to range from 1 to 4% following routine tooth extractions. When extracting the mandibular third molar, the risk of problems is 10 times higher than when extracting the upper teeth, and it can even approach 45%(21). Dentists frequently underestimate the intensity of pain endured by persons suffering from dry sockets and can fail to deliver sufficient care. The irritation resulting from the dry socket may occasionally extend to the facial vestibule as well as towards the cheek, albeit typically without any accompanying rise in body temperature. This verifies that classic dry socket is a distinct condition that impacts the lower or upper jawbone without generating systemic issues.(22) . despite the nature and extent of the wound's damage, wound healing is an intricate biological process that comprises interrelated stages. These can be classified as blood vessel development, inflammation, granulation tissue development, and remodeling of tissues and regeneration. These phases are components of a biological sequence that leads to the regeneration of tissue and the closure of wounds(23) (24).Therefore, the current study utilized the inflammation score, granulation tissue formation score, pain score, and discomfort around the socket as measures to evaluate the healing of the dry socket across different groups.

The traditional approach used in this study led to bleeding and blood clotting in a damaged tooth

socket, which did not heal successfully after the first treatment. Gently cleaning the socket and rinsing it with saline help remove dead tissue that the body can't get rid of naturally. Even though a new clot formed, the patients' good overall health meant that their ability to heal was not affected. The present study findings are consistent with previous research, such as the study by Kamal et al., which indicated that conventional dry socket treatment does not impede the natural healing process(25). In group II, Minimal Laser Therapy (LLLT) proves advantageous as a result of its photo-biostimulation effects. These benefits encompass the stimulation of wound healing, the mitigation of inflammation, and the relief of pain. Low-level laser therapy (LLLT) induces tissue stimulation without inducing any permanent alterations(26). These strategies are accomplished by stimulating inherent biological processes, decreasing the level of tumor necrosis factor-alpha during the initial stage of inflammation (which is dependent on the dosage), modifying the dimensions and permeability of the artery lumen, and modifying neurotransmitter activity(27). Several research in the medical field have shown that Low-Level Laser Therapy (LLLT) significantly accelerates the skin wound healing process(28). Granulation tissue is a form of nascent connective tissue that comprises minuscule blood vessels. It develops on the surface of an injury as a component of the healing process, forming an elastic barrier that is challenging for germs to penetrate. It is fragile and prone to fracturing, which can lead to the occurrence of alveolar osteitis or dry socket.Low-level laser treatment (LLLT) is thought to stimulate the development of granulation tissue in the socket by various potential pathways. LLLT has the ability to promote the replication of fibroblasts, the cells responsible for the production of granulation tissue.

This therapy can speed up the production of granulation tissue, which fills the socket after a tooth extraction (29). Additionally, LLLT has the potential to enhance blood circulation in the area being treated. The augmented blood circulation can transport vital nutrients and oxygen to the recovering socket, hence stimulating the development of granulation tissue.(29) .As previously stated, Low-Level Laser Therapy (LLLT) may have anti-inflammatory effects, which are important since excessive inflammation can impede tissue recovery. LLLT promotes the production of granulation tissue by lowering inflammation and creating a more conducive environment(30). More ever LLLT has the potential to enhance the synthesis of differentiation factors, which are important signaling molecules involved in tissue regeneration and repair. Augmented growth factors can also amplify the development of granulation tissue (31).

Following curettage, dry sockets that had formed a new blood clot were subjected to low-level laser therapy on their buccal, occlusal, and lingual surfaces. On the fourth day, the inflammation surrounding the socket diminished to a score of 1 on a scale ranging from 0 to 1, and the discomfort in the socket dropped to a score of 1 on a scale ranging from 1 to 2. On the seventh day, the depth of the socket dropped to 4 on a scale ranging from 1 to 5. By the seventh day, all sockets except for two have completely healed, with a reduction in soreness and tenderness, and patients have resumed their normal diet.

Biostimulation at the cellular and molecular levels enhances the healing process of oral wounds.This process promotes the activity of growth factors like platelet-derived growth factors and insulin-like growth factors, which in turn enhance fibroblast proliferation and collagen formation. Low-level laser therapy (LLLT) stimulates the growth and movement of human gingival fibroblast cells and also induces various biological effects such as protein synthesis and release of growth factors(30)(32)

The identification of effective treatments for dry sockets is challenging because it requires a deeper understanding of its causes. Based on the study, treatments that utilize regenerative molecular or light stimulation are more effective than conventional therapies which depend on the human body's natural healing mechanism. Studies have demonstrated that Low-Level Laser Therapy (LLLT) is superior to conventional approaches in enhancing the healing process of dry socket wounds.

LLLT reduces inflammation, promotes tissue regeneration, and provides pain relief. This study aligns with the findings of Atarchi et al. . (33), which show that photodynamic therapy significantly

improves measures such as bleeding scores and gingival inflammation in individuals with periodontitis. Furthermore, the pain-relieving impact of low-level laser treatment is ascribed to the uptake of laser energy by nociceptors, which subsequently hinders both A and C sensory fibers (34) .

Finally , The results of this study are consistent with existing research, which shows that Low-Level Laser Therapy (LLLT) at wavelengths of 660 and 808 nm has a beneficial effect on the growth of new blood vessels in removed sockets (35). Angiogenesis is a crucial process in tissue regeneration that involves the growth of new blood vessels through the sprouting of arteries, the multiplication of endothelial cells, and the formation of tubular structures. This mechanism facilitates the delivery of oxygen and nutrients to the developing tissue, hence enhancing cell proliferation, mobility, and protein synthesis. Prior studies have also confirmed the consistent efficacy of Low-Level Laser Therapy (LLLT) in facilitating the formation of new blood vessels(30).There are many limitations of the study, such as a small sample size and no finding of a histological study to record precisely the amount and number of cells formed; also, we need further study on the effect of LLLT according to type, dose, and power. Also, the followed up of the study was more difficult, especially after 7 days.

The recommendation of the study is that are larger sample size and histological study should include, future studies for determining the quality and quantity of GT formed in the socket and detect the effect of LLLT in new bone density formed in the socket.

4. Conclusion and future scope

Dry socket occurrence causes serious pain and distress in healthy patients after basic tooth extraction. LLLT has significant role in producing GT and relieving pain symptoms within the initial seven days of treatment.

Conflict of interest

The authors declare no conflicts of interest.

Author contributions

K.S.M.contributed to the conception or design of the work and was responsible for the acquisition of data. A.C performed the statistical analysis. M.M.A and E.M contributed to the interpretation of results. K.S.M ,E.M and A.C drafted the work. All authors approved the final version of the manuscript and are responsible for all aspects of the work.

Acknowledgement and funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Ethical approval

All of the participants were given thorough information about the study and the procedures involved, and their informed consent was acquired on a form approved by the ethics committee of the AL Ameed University /College of Dentistry (Number: UAM/EC/5/2017.

Reference

[1] Donnell CC, Clark M V., Corbett IP. Do children get dry socket?—The incidence and pattern of presentation of alveolar osteitis in children and adolescents following dental extractions. Oral Surg. 2023;16(1). **https://doi.org/10.1111/ors.12755**

[2] Oualha, L. *et al.* Complication de l'extraction des dents de sagesse: Présentation d'un cas. *Med. Buccale Chir. Buccale* **18**, 53–56 (2012).

[3] Ayachi, R., Oualha, L., Moussaoui, E., Soufi, S. & Douki, N. [Mandibular osteitis on a periapical granuloma mimicking an osteosarcoma: a case report]. *Odontostomatol. Trop.* **39**, 20–6 (2016).

[4] Tarakji B, Saleh LA, Umair A, Azzeghaiby SN, Hanouneh S. Systemic Review of Dry Socket: Aetiology, Treatment,

and Prevention. J Clin Diagnostic Res. 2015;9 (4)

[5] Mamoun, J. Dry socket etiology, diagnosis, and clinical treatment techniques. *Journal of the Korean Association of Oral and Maxillofacial Surgeons* vol. 44 at

[6] Dubovina, D. *et al.* The use of hyaluronic and aminocaproic acid in the treatment of alveolar osteitis. *Vojnosanit. Pregl.* **73**, (2016).

[7] Ansari, A. *et al.* A study to evaluate the efficacy of honey in the management of dry socket. *Contemp. Clin. Dent.* **10**, (2019).

[8] Lone, P. A., Ahmed, S. wakeel, Prasad, V. & Ahmed, B. Role of turmeric in management of alveolar osteitis (dry socket): A randomised clinical study. *J. Oral Biol. Craniofacial Res.* **8**, (2018).

[9] Supe, N. B. *et al.* Efficacy of alvogyl (Combination of Iodoform + Butylparaminobenzoate) and zinc oxide eugenol for dry socket. *Ann. Maxillofac. Surg.* **8**, (2018).

[10] 1Çebi, A. T. Evaluation of the effects of intra-alveolar irrigation with clindamycin, rifampicin and sterile saline in alveolar osteitis treatment. *J. Stomatol. Oral Maxillofac. Surg.* **121**, (2020).

[11] Halberstein, R. A. & Abrahmsohn, G. M. Clinical management and control of alveolalgia (‘dry socket’) with vitamin C. *Am. J. Dent.* **16**, (2003).

[12] Kamal, A., Salman, B., Razak, N. H. A. & Samsudin, A. R. A comparative clinical study between concentrated growth factor and low-level laser therapy in the management of dry socket. *Eur. J. Dent.* **14**, 613–620 (2020).

[13] Prataap, N. *et al.* Platelet-rich plasma and incidence of alveolar osteitis in high-risk patients undergoing extractions of mandibular molars: A case-control study. *J. Pharm. Bioallied Sci.* **9**, (2017).

[14] Masuki, H. *et al.* Growth factor and pro-inflammatory cytokine contents in platelet-rich plasma (PRP), plasma rich in growth factors (PRGF), advanced platelet-rich fibrin (A-PRF), and concentrated growth factors (CGF). *Int. J. Implant Dent.* **2**, (2016) https://link.springer.com/article/10.1186/s40729-016-0052-4

[15] Tanaka, E., Kuroda, S., Horiuchi, S., Tabata, A. & El-Bialy, T. Low-Intensity Pulsed Ultrasound in Dentofacial Tissue Engineering. *Annals of Biomedical Engineering* vol. 43 at https://doi.org/10.1007/s10439-015-1274-y (2015).

[16] Karim, M., Husein, A., Qamruddin, I., Liszen, T. & Alam, M. K. Original article To evaluate the effects of Low-level laser therapy (LLLT) on wound healing of extraction socket: A systematic review. *Bangladesh J. Med. Sci.* **22**, (2023).

[17] Chung, H. *et al.* The nuts and bolts of low-level laser (Light) therapy. *Ann. Biomed. Eng.* **40**, (2012).

[18] Hamad, S. A., Naif, J. S. & Abdullah, M. A. Effect of Diode Laser on Healing of Tooth Extraction Socket: An Experimental Study in Rabbits. *J. Maxillofac. Oral Surg.* **15**, (2016).

[19] https://link.springer.com/article/10.1007/s12663-015-0842-x

[20] Eshghpour, M., Ahrari, F., Najjarkar, N. T. & Khajavi, M. A. Comparison of the effect of low level laser therapy with alvogyl on the management of alveolar osteitis. *Med. Oral Patol. Oral y Cir. Bucal* **20**, (2015).

[21] Kesler, G., Shvero, D. K., Tov, Y. S. & Romanos, G. Platelet derived growth factor secretion and bone healing after ErYAG laser bone irradiation. *J. Oral Implantol.* **37**, (2011). https://doi.org/10.1563/AAID-JOI-D-09-00120.1

[22] Frampton, C. L. & Hughes-Webb, P. The Measurement of Pain. *Clin. Oncol.* **23**, (2011)

[23] Sharma, A., Singh, A. K., Warren, J., Thangapazham, R. L. & Maheshwari, R. K. Differential regulation of angiogenic genes in diabetic wound healing. *J. Invest. Dermatol.* **126**, (2006).

[24] Al-Zubaidy, E. Y., Ghani, B. A. & Ibrahim, N. R. Local application of Opuntia ficus-indica / Punica granatum oils on cutaneous wound healing: a histochemical study. *J. Baghdad Coll. Dent.* **35**, 28–34 (2023).

[25] Farhadi, F. *et al.* Evaluation of adjunctive effect of low-level laser therapy on pain, swelling and trismus after surgical removal of impacted lower third molar: A double blind randomized clinical trial. *Laser Ther.* **26**, (2017).

[26] Aras, M. H. & Güngörmüş, M. The effect of low-level laser therapy on trismus and facial swelling following surgical extraction of a lower third molar. *Photomed. Laser Surg.* **27**, (2009).

[27] de Matos Brunelli Braghin, R. *et al.* The effect of low-level laser therapy and physical exercise on pain, stiffness, function, and spatiotemporal gait variables in subjects with bilateral knee osteoarthritis: a blind randomized clinical trial. *Disabil. Rehabil.* **41**, (2019).

[28] Peimani, A., Abedi, P. & Hajjafari, H. Effects of Low-Level Laser Therapy on Tooth Socket Repair in Diabetic Male Rats: An Animal Study. *J. Res. Dent. Maxillofac. Sci.* **5**, (2020). https://doi.org/10.29252/jrdms.5.3.37

[29] Colombo, F. *et al.* Effect of low-level laser therapy (λ660 nm) on angiogenesis in wound healing: A

immunohistochemical study in a rodent model. *Braz. Dent. J.* **24**, 308–312 (2013).

[30] Kamal, A., Salman, B., Abdul Razak, N. H., Qabbani, A. Al & Samsudin, A. R. The Efficacy of Concentrated Growth Factor in the Healing of Alveolar Osteitis: A Clinical Study. *Int. J. Dent.* **2020**, (2020).

[31] Gupta, A. *et al.* Superpulsed (Ga-As, 904 nm) low-level laser therapy (LLLT) attenuates inflammatory response and enhances healing of burn wounds. *J. Biophotonics* **8**, (2015).

[32] Darendeliler, M. A., Darendeliler, A. & Sinclair, P. M. Effects of static magnetic and pulsed electromagnetic fields on bone healing. *Int. J. Adult Orthodon. Orthognath. Surg.* **12**, (1997).

[33] Atarchi, A. R. & Atarchi, Z. R. Efficacy of a single antimicrobial photodynamic therapy session as an adjunct to non-surgical periodontal therapy on clinical outcomes for periodontitis patients. A systematic review. *J. Baghdad Coll. Dent.* **35**, 76–87 (2023).

[34] Dalirsani, Z. *et al.* Effects of diode low-level laser therapy on healing of tooth extraction sockets: a histopathological study in diabetic rats. *Lasers Med. Sci.* **36**, (2021).

[35] Peplow, P. V., Chung, T. Y. & Baxter, G. D. Laser photobiomodulation of proliferation of cells in culture: A review of human and animal studies. *Photomedicine and Laser Surgery* vol. 28 at https://doi.org/10.1089/pho.2010.2771 (2010).

[36] Pavlov, O. V., Chepanov, S. V., Selutin, A. V. & Selkov, S. A. PLATELET-LEUKOCYTE INTERACTIONS: IMMUNOREGULATORY ROLE AND PATHOPHYSIOLOGICAL RELEVANCE. *Medical Immunology (Russia)* vol. 24 at