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EFFECTS OF BLUE LED ON VENOUS ULCER HEALING IN DIABETICS

EFEITOS DO LED AZUL NA CICATRIZAÇÃO DE ÚLCERA VENOSA EM DIABÉTICOS

EFECTOS DEL LED AZUL EN LA CICATRIZACIÓN DE LA ÚLCERA VENOSA EN DIABÉTICOS

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ABSTRACT

Ulcers in patients with Diabetes Mellitus are frequent and considered one of the most relevant complications during the clinical course of the disease. To analyze the application of blue light-emitting diode (LED) in tissue repair of venous ulcer of the lower limb. It consisted of the application of blue LED, with a wavelength around 680 THz and 620 THz at the wound site, for 10 minutes, 2 times a week, for 5 weeks. Assessment tools for pain and neuropathic symptoms, sensitivity tests, daily photographic record, measurement of ulcer size and wound closure time index were used. Improvement in tissue repair of wounds was observed, reaching total closure on both sides and reduction of referred pain intensity. LED as a curative treatment of chronic diabetic ulcers showed effectiveness in the rate of total wound closure and improvement of neuropathic symptoms.

Descriptors: *Diabetes Mellitus; Diode lasers; Venous ulcer; Wound Healing; LED.*

RESUMO

Úlceras em pacientes com Diabetes Mellitus são frequentes e consideradas uma das complicações de maior relevância durante a evolução clínica da doença. Analisar a aplicação do light-emitting diode (LED) azul no reparo tecidual de úlcera venosa de membro inferior. Consistiu na aplicação de LED azul, com comprimento de onda em torno de 680 THz e 620 THz no local da ferida, durante 10 minutos, 2 vezes por semana, durante 5 semanas. Foram utilizados instrumentos avaliativos de dor e sintomas neuropáticos, testes de sensibilidade, registro fotográfico diário, mensuração do tamanho das úlceras e índice do tempo de fechamento completo da ferida. Foi observada melhora no reparo tecidual das feridas, atingindo fechamento total em ambos os lados e redução da intensidade de dor referida. O LED como tratamento curativo de úlceras diabéticas crônicas mostrou efetividade na taxa de fechamento total da ferida e melhora de sintomas neuropáticos.

Descritores: *Diabetes Mellitus; Lasers de Diodo; Úlcera Venosa; Cicatrização de Feridas; LED.*

RESUMEN

Las úlceras en pacientes con Diabetes Mellitus son frecuentes y consideradas una de las complicaciones más relevantes durante el curso clínico de la enfermedad. Analizar la aplicación del diodo emisor de luz azul (LED) en la reparación tisular de úlcera venosa del miembro inferior. Consistió en la aplicación de LED azul, con una longitud de onda alrededor de 680 THz y 620 THz en el sitio de la herida, durante 10 minutos, 2 veces por semana, durante 5 semanas. Se utilizaron herramientas de evaluación de dolor y síntomas neuropáticos, pruebas de sensibilidad, registro fotográfico diario, medición del tamaño de la úlcera e índice de tiempo de cierre de la herida. Se observó mejoría en la reparación tisular de las heridas, alcanzando el cierre total de ambos lados y reducción de la intensidad del dolor referido. La LED como tratamiento curativo de las úlceras diabéticas crónicas mostró efectividad en la tasa de cierre total de la herida y mejoría de los síntomas neuropáticos.

Descriptores: *Diabetes Mellitus; Láseres de diodo; Úlcera venosa; Cicatrización de la herida; LED.*

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INTRODUCTION

Diabetes Mellitus (DM) is a chronic metabolic disease of multiple origin, resulting from the insufficiency and/or inability of insulin to adequately exert its effects. Complications such as cardiovascular disease, retinopathy, nephropathy, angiopathy and neuropathy, arise as a result of elevated levels of glucose and protein glycation. Small sores that can develop on the feet of patients with DM are commonly labeled as diabetic foot ulcers and often go unnoticed, in most cases resulting from neuropathies and/or vasculopathies [1,2].

Venous ulcers are prevalent complications of DM and are responsible for significant morbidity, mortality and health expenses. The 9th edition of the International Diabetes Federation atlas of DM shows that there are about 463 million adults with DM worldwide, it is estimated that 19 to 34% of patients with DM will be affected with diabetic foot ulcer during their lifetime, and an estimated 9.1 to 26.1 million people will develop diabetic foot ulcers annually [3].

Over time, the chronic complications of DM may appear, among them, ulcerations and amputations of extremities are among the most serious and with the greatest socioeconomic impact[4]. Evidence has shown that approximately 30 to 60% of all lower extremity amputations are performed in people with DM, and over 85% of these amputations are preceded by foot ulcerations that progress to deep infection or gangrene[5]. Considering these impacting factors on patient well-being, the development of efficient solutions that accelerate the rate of wound healing is of vital importance.

Standard treatment approaches, including debridement of necrotic tissue, wound maintenance, and infection control, often do not produce the desired result. Therefore, additional treatment options such as negative pressure dressings, hyperbaric oxygen therapy, topical application of carbon dioxide, and photobiomodulation are often employed[6].

Among treatments for diabetic ulcers, photobiomodulation is a low-cost, non-invasive and pain-free alternative that promotes the ulcer repair process through multiple mechanisms, considered a strong asset in tissue repair, increasing local circulation, stimulating the development of fibroblasts, accelerating the synthesis of collagen in the damaged tissue and increasing the release of growth factor, in addition to increasing the synthesis of extracellular matrix and anti-inflammatory action and when associated with health education strategies, as already evidenced in other clinical conditions[7], can have promising results in its evolution [4,5].

It also stands out as another property of photobiomodulation, its possible benefits in the reduction of neuropathic symptoms through the mechanisms of stimulation and release of cytokines, increase of circulation growth factors, production of ATP by mitochondria from cellular oxygen consumption, corroborating a greater vasodilation and nerve regeneration [8].

Based on the possible effects of photobiomodulation in the healing process and improvement of neuropathic pain, this study aims to analyze the application of blue light-emitting diode (LED) in tissue repair of a patient with venous ulcer of the lower limb.

METHODS

This is a randomized clinical trial, carried out by a team of researchers linked to a Nucleus of Technological Innovation in Human Rehabilitation of a Federal University in the state of Ceará. The study was conducted over the period corresponding to the years 2020 to 2022, in a Primary Health Care Unit (UAPS), located in the city of Fortaleza (CE), with patients who had venous ulcers in the leg and foot region and had a diagnosis of Diabetes Mellitus. This manuscript presents a partial clipping of the results of the total number of 20 patients included in the research.

The Neuropathic Symptom Scale (NSS)[9], Visual Analogue Pain Scale (VAS)(10), Neuropathic Commitment Score (NEC)(11), assessment of Plantar Protective Sensitivity (SSP)(12), measurement of the

Ankle-Brachial Index (ABI)[13,14], pachymetry to record the dimensions of the lesion and photographs to follow the evolution of the tissue repair.

The protocol consisted of applying blue LED, with a wavelength around 680 THz and 620 THz at the wound site, for 10 minutes. The treatment was carried out twice a week for 5 weeks.

The research participant was positioned in dorsal decubitus on the stretcher, cleaned and sterile. First, there was a photographic record of the lesion, with a digital camera at a distance of 20 centimeters, with the lower limbs in a neutral position. To measure the wound area, a sterilized caliper was used, positioned on the ulcer. The application of the LED was carried out in the two wounds, 01 being located in the LID and the other in the LLL. Each wound received 10 minutes of application per day of treatment (figure 1).

At the end of the application, the volunteers received guidance on self-care and self-monitoring in DM, on adequate and continuous hydration of the skin and performing regular physical exercises. After 10 consultations, a reassessment took place and the results could be measured.

The LED device used in the protocol was developed by researchers linked to two federal public institutions of higher education in Brazil, located in Fortaleza and Brasília, containing 40 high-brightness LEDs, with a wavelength of 630nm. The device was connected to a constant electric current source of 220 volts, with constant doses of light. The emitter had an area of 10 cm and a height of 6 cm. In all applications, the device was previously sanitized, a sterile plastic protector was also placed to minimize the risk of contamination.

Data were tabulated in a Microsoft Excel 2010 spreadsheet. This research was approved by the Research Ethics Committee involving human beings, according to resolution 466/12, n 4.470.91. The volunteers were informed about the nature of the study and signed the Free and Informed Consent Form (TCLE).

RESULTS

The sample in question was admitted for treatment in June 2021. He was not using antibiotics, was sedentary, wore compressive stockings, and changed dressings daily at home.

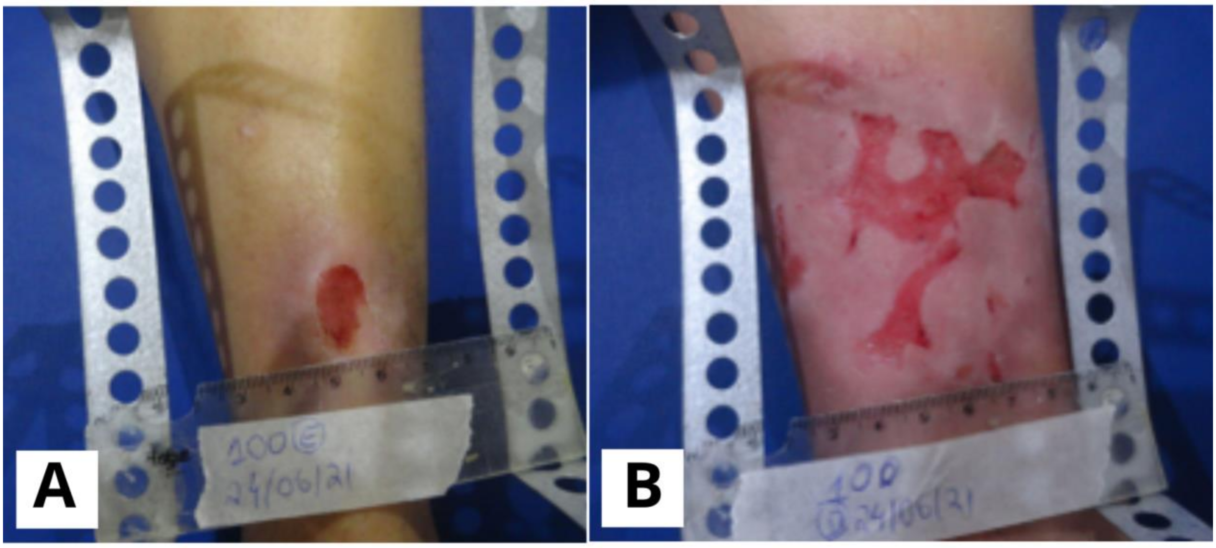
In the first evaluation, the measurement was performed in two affected places and had as initial values obtained 8.1 in height and 6.7 in width on the right side, and already on the left side 2.0 in height and 2.9 in width as shown in figure 1, after the fifth session with the application of the LED, a significant decrease was noticed and with the values of 5.3 height and 6.8 width on the right side and on the left side it had 0.6 height and 1.3 width, figure 2, after the tenth service was performed the final assessment, in which we had full closure of the wound site on both sides.

A decrease in the depth of the wound was observed and it was noted that the applied site had a lighter color, after the 10 sessions that were stimulated in the protocol, a decrease in pain was also noted in the first sessions, which was measured using the scale Analog EVA.

The WHODAS 2.0 questionnaires[15] and the Diabetes Self-Care Activities Questionnaire[16,17] were applied, in which they were applied in the initial and final evaluation, thus having data to be compared, with a satisfactory result in an improvement in awareness of the patient in the practice of physical activities, diets and better monitoring of blood glucose.

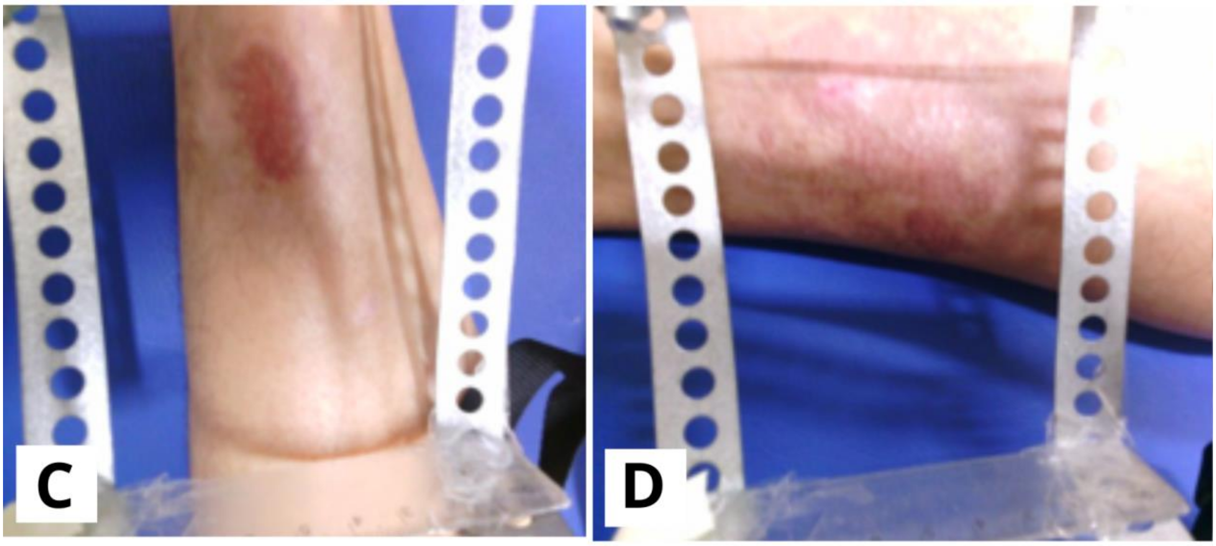
The patient's evolution showed a satisfactory result, with excellent healing, followed by the report of pain relief, and the improvement of sensitivity in certain areas that were reduced in sensitivity, the results obtained corroborate that the use of phototherapy through LED, promotes tissue repair with the use of 2 to 3 (two to three times) a week, is more effective in healing, thus becoming a biomodulator therapy, The treatment ended on July 7, 2021.

Photo 1 - Photographic record of the lesions at the time of the evaluation. A: lesion in the left lower limb; B: lesion in the right lower limb.



Source: The authors, 2021.

Photo 2 - Photographic record of the lesions at the end of the treatment. A: lesion in the left lower limb; B: lesion in the right lower limb.



Source: The authors, 2021.

DISCUSSION

Similar clinical studies carried out with a larger sample and longer duration of follow-up corroborate the findings found in this study. The trials found mention the treatment of chronic diabetic wounds, which generally do not respond to other forms of treatment due to the presence of underlying conditions that interfere with the healing process, such as diabetic neuropathy and complications such as involvement by vascular comorbidities [4,18–21].

Romaneli et al. [21] performed a prospective, uncontrolled, multicenter clinical trial in 12 clinical centers located in Italy. The sample population of the study included 99 individuals with chronic ulcers of different etiologies: Diabetic Foot Ulcers - UPD (n=52), Venous Ulcers - UV (n=32) and Pressure Ulcers UP (n=15), with an average duration of 35.5 months of injury. The study sought to evaluate the effectiveness of a Photobiomodulation/LED protocol in the treatment of these wounds. The treatment initially consisted of cleaning the area to be treated with saline solution and applying a 2mm thick layer of photoconverter chromophore gel, fortnightly, associated with the specific standard treatment for each type of ulcer.

The LED was applied for 5 minutes at a distance of 5 centimeters from the wound. Treatment efficacy was tested through the rate and time of complete wound closure, wound area reduction, incidence of rupture after closure, and treatment impact on participants' quality of life. After 4 weeks of treatment, complete wound closure was achieved in 47 participants: 26 UV (50%), 16 UPD (50%) and 5 UP (33.3%). Mean wound area regression at last assessment was significant for UVs (41.0%; p<0.001) and UPDs (52.4%; p<0.001) [21].

Caetano et al[19] designed a randomized double-blind study with the objective of testing the hypothesis that the use of combined LED at a dose of 600 nm and 890 nm would promote the healing of chronic venous ulcers. The sample consisted of 20 participants divided into three groups: Group 1 (G1) received treatment based on the application of 1% silver sulfadiazine and placebo phototherapy (<0.3 J/cm (-3)). The second group (G2) received only the application of LED at therapeutic doses (3 J/cm (-2)) while group 3 (G3) was treated only with wound cleaning and application of silver sulfadiazine.

Participants were followed up for a period of >90 days or until wound healing, which was evaluated through analysis of photographic records. At the end of the study, the authors observed that the group treated with phototherapy at therapeutic doses presented faster wound healing when evaluated in the period of 30, 60 and 90 days of treatment. Ulcers between medium and large sizes show better response to the protocol (> or = 40% cure rate per month) when compared to the results obtained in G1 and G3 (p +/- 0.05) [19].

Another similar study carried out by Minatel et al.[22] used the same parameters of the previous study to test the hypothesis that phototherapy administered by LED would be effective in healing difficult-to-treat diabetic ulcers. The evaluation interval after starting treatment was 15, 30, 45, 60, 75 and 90 days. At the end of the study, a better healing rate and average granulation of the ulcer was observed in the group that received LED at therapeutic doses (3 J/cm (-2)) when compared to the results obtained in the placebo group (<0.3 J/cm (-3)). Ulcers treated with placebo tended to worsen during the initial 30 days, with no significant healing rate at the end of the 90 days of treatment. Group 2, on the other hand, showed 58.3% complete healing on day 90. 75% of the ulcers treated in group 2 achieved 100% healing, while only one ulcer reached 100% healing in the placebo group and no other ulcer reached > or = 90% healing.

Vitoriano et al.[23] carried out a comparative study with the objective of evaluating the effectiveness of laser and LED in tissue repair and improvement of neuropathic symptoms in patients with diabetic foot ulcers. The sample was randomized into two groups that contemplated the administration of therapeutic modalities distributed in 10 sessions with a frequency of twice a week and applied for 10 minutes. The Laser group received treatment of the wounds with GaAIAs lasers (830 nm, 30mW wavelength and power 0.84W/cm2), while the LED group received treatment with LED 850nm, 48 mW and power density of $1.05 W/cm^2$. After the end of the treatment, the LED group showed an efficiency of 55.84% in reducing the healing time. Both groups showed significant results in the improvement of neuropathic symptoms [4].

Frangež et al. [24] developed a randomized double-blind study of a sample spectrum of 60 participants with chronic diabetic wounds. Participants were randomly assigned to LED group, which received treatment with LED 2.4 J/cm2 and wavelength 625, 660 and 850 nm administered 3 times a week during the period of 8 weeks. And, placebo group that received treatment with a non-therapeutic light that simulated the LED. At the end of the treatment, a statistically significant reduction in the healing time and mean surface of the lesions was observed in the LED group when compared to the control group (p< 0.05).

Limitations of the study include the lack of blood glucose values on the day of the consultations, however, this is a relevant indicator that may have an influence on the results obtained. On the days when the patient received the treatment, before the application of the LED, a photographic record of the lesions was made and their size was measured with the caliper, however, there were losses of photographic data, justified by failure in the evaluation protocol on the day of the consultations or deletion of files from the memory of the machine used for the records.

CONCLUSION

Self-care measures associated with the treatment protocol consisting of 10 consultations with irradiation of chronic ulcers in the lower limbs with the blue LED (680 THz and 620 THz) twice a week, proved to be effective in the outcome of tissue repair and pain reduction and neuropathic symptoms in a patient with DM. The results of the study also point out that there is an innovative potential for health education with the patient with DM, which is of fundamental importance for the patient to become energetic in the process of managing the disease. Knowledge promotes adequate understanding of the evolution process and the consequences of lack of care or inadequate control. As limitations, it was observed that sociodemographic aspects can considerably influence therapeutic success.

SPONSERS

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REFERENCES

1. Houreld NN. Shedding light on a new treatment for diabetic wound healing: A review on phototherapy. Vol. 2014, The Scientific World Journal. 2014.
2. dos Santos Mendes-Costa L, de Lima VG, Barbosa MPR, dos Santos LE, de Siqueira Rodrigues Fleury Rosa S, Tatmatsu-Rocha JC. Photobiomodulation: systematic review and meta-analysis of the most used parameters in the resolution diabetic foot ulcers. Vol. 36, Lasers in Medical Science. 2021.
3. Everett E, Mathioudakis N. Update on management of diabetic foot ulcers. Vol. 1411, Annals of the New York Academy of Sciences. 2018.
4. Vitoriano NAM, Mont'Alverne DGB, Martins MIS, Silva PS, Martins CA, Teixeira HD, et al. Comparative study on laser and LED influence on tissue repair and improvement of neuropathic symptoms during the treatment of diabetic ulcers. Lasers in Medical Science. 2019;34(7).
5. Wang HT, Yuan JQ, Zhang B, Dong ML, Mao C, Hu D. Phototherapy for treating foot ulcers in people with diabetes. Vol. 2017, Cochrane Database of Systematic Reviews. 2017.
6. Frangez I, Cankar K, Ban Frangez H, Smrke DM. The effect of LED on blood microcirculation during chronic wound healing in diabetic and non-diabetic patients—a prospective, double-blind randomized study. Lasers in Medical Science. 2017;32(4).
7. Sampaio DB, Carvalho MLRB de, Mendes L dos S. Ações de prevenção ao papilomavírus humano: vivências com escolares. Cadernos ESP Ceará. 2020;14(1):100–5.
8. Shashi Kumar CG, Maiya AG, Manjunath Hande H, Vidyasagar S, Rao K, Rajagopal K v. Efficacy of low level laser therapy on painful diabetic peripheral neuropathy. Laser Therapy. 2015;24(3).
9. Moreira RO, Castro AP, Papelbaum M, Appolinário JC, Ellinger VCM, Coutinho WF, et al. Tradução para o português e avaliação da confiabilidade de uma escala para diagnóstico da polineuropatia distal diabética. Arquivos Brasileiros de Endocrinologia & Metabologia. 2005 Dec;49(6):944–50.
10. Lima HMN, Sauaia N, Costa VRL da, Coelho-Neto GT, Figueiredo P de MS. Perfil epidemiológico dos pacientes com hanseníase atendidos em Centro de Saúde em São Luís. Rev Bras Clin Med. 2010;8(4):323–7.
11. SILVA J, SOUSA-MUÑOZ R, FIGUEIREDO A, MELO J, FERNANDES B. Fatores de Risco para Perda de Sensibilidade Plantar em Diabéticos: Estudo Caso-controle em Ambulatório de Endocrinologia. Revista Brasileira de Ciências da Saúde. 2013 Jun 30;17(2):113–20.
12. Brinati LM, Diogo NAS, Moreira TR, Mendonça ÉT, Amaro MOF. Prevalência e fatores associados à neuropatia periférica em indivíduos com diabetes mellitus Prevalence and factors associated with peripheral neuropathy in individuals with diabetes mellitus. Revista de Pesquisa Cuidado é Fundamental Online. 2017 Apr 11;9(2):347–55.

13.Araújo ALGS de, Fidelis C, Santos VP dos, Araújo Filho JS de, Andrade J, Rêgo MAV. Frequência e fatores relacionados ao índice tornozelo-braquial aberrante em diabéticos. Jornal Vascular Brasileiro. 2016 Oct 10;15(3):176–81.
14.Santos VP dos, Alves CAS, Fidelis RJR, Fidelis C, Araújo Filho JS de. Estudo comparativo do Índice Tornozelo-Braquial em diabéticos e não diabéticos com isquemia crítica. Jornal Vascular Brasileiro. 2015 Dec;14(4):305–10.
15.Silveira C, Parpinelli MA, Pacagnella RC, Camargo RS de, Costa ML, Zanardi DM, et al. Adaptação transcultural da Escala de Avaliação de Incapacidades da Organização Mundial de Saúde (WHODAS 2.0) para o Português. Revista da Associação Médica Brasileira. 2013 May;59(3):234–40.
16.SEGALLA VC, XAVIER CA, BERNART JG, SCHUITEK R, CARDOSO T, NIGRO MVDAS, et al. Aderência ao autocuidado em indivíduos diabéticos. Revista Médica do Paraná. 2022 Jun 30;79(2):1653.
17.Modeneze DM, Vilarta R, Maciel É da S, Sonati JG, Souza MESN de, Boccaletto EMA. Nível de atividade física de portadores de diabetes mellitus tipo 2 (DM2) em comunidade carente no Brasil. Medicina (Ribeirão Preto). 2012 Mar 30;45(1):78–86.
18.Minatel DG, Frade MAC, França SC, Enwemeka CS. Phototherapy promotes healing of chronic diabetic leg ulcers that failed to respond to other therapies. Lasers in Surgery and Medicine [Internet]. 2009 Aug;41(6):433–41. Available from: https://onlinelibrary.wiley.com/doi/10.1002/lsm.20789
19.Caetano KS, Frade MAC, Minatel DG, Santana LÁ, Enwemeka CS. Phototherapy improves healing of chronic venous ulcers. Photomedicine and Laser Surgery. 2009;27(1).
20.Frangež I, Nizič-Kos T, Frangež HB. Phototherapy with LED Shows Promising Results in Healing Chronic Wounds in Diabetes Mellitus Patients: A Prospective Randomized Double-Blind Study. Photomedicine and Laser Surgery. 2018;36(7).
21.Romanelli M, Piaggesi A, Scapagnini G, Dini V, Janowska A, Iacopi E, et al. Evaluation of fluorescence biomodulation in the real-life management of chronic wounds: The EUREKA trial. Journal of Wound Care. 2018;27(11).
22.Minatel DG, Frade MAC, França SC, Enwemeka CS. Phototherapy promotes healing of chronic diabetic leg ulcers that failed to respond to other therapies. Lasers in Surgery and Medicine. 2009 Aug;41(6):433–41.
23.Vitoriano NAM, Mont'Alverne DGB, Martins MIS, Silva PS, Martins CA, Teixeira HD, et al. Comparative study on laser and LED influence on tissue repair and improvement of neuropathic symptoms during the treatment of diabetic ulcers. Lasers in Medical Science. 2019 Sep 4;34(7):1365–71.
24.Frangež I, Nizič-Kos T, Frangež HB. Phototherapy with LED Shows Promising Results in Healing Chronic Wounds in Diabetes Mellitus Patients: A Prospective Randomized Double-Blind Study. Photomedicine and Laser Surgery. 2018 Jul;36(7):377–82.