

## Color light therapy

in the treatment of diabetic neuro- and angiopathy and ulcers of the lower extremities

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### SUMMARY

**Introduction.** The use of visible light of various spectral composition for medicinal purposes has long history and is due to its role in various processes of the biosphere.

**Methods.** A search was carried out through Internet resources for the period from 1991 to December 2020 publications containing the clinical results of the use of color light therapy in the treatment of patients with diabetic neuro and angiopathies and ulcerative lesions of the lower extremities in peer-reviewed domestic and foreign scientific journals.

**Results.** Analysis of the results showed that color light therapy in a positive way affects sensory-motor and microcirculatory disorders in the lower extremities in patients with diabetes mellitus, promotes faster scarring of ulcers and reduces the healing time.

**Conclusion.** The use of color light therapy in the complex treatment of patients with sugar diabetes with neuro and angiopathy is a promising direction that helps to reduce the percentage of disability and improve the quality of life, which is of great medical, social and economic importance.

**Key words:** color light therapy, diabetes, diabetes mellitus, diabetic neuropathies lower extremities, diabetic angiopathies of the lower extremities, diabetic ulcers of the lower extremities, optical incoherent radiation, LEDs.

### RESUME

**Background.** The use of visible light of various spectral composition has a long history of use for medical purposes and is due to its role in various processes of the biosphere.

**Methods.** A search was conducted in via Internet resources for the period from 1991 to December 2020 for publications containing results of clinical results of color therapy in treatment of patients with diabetic neuro and angiopathy and ulcers of low extremities in Russian and International scientific journals.

**Results.** Analysis of selected publications showed that color therapy has positive influence on sensory-motor and microcirculatory disorders in the lower extremities in patients with diabetes mellitus, promotes faster scarring of ulcers and reduces the healing time.

**Conclusion.** Application of color therapy in complex therapy of patients with diabetic neuro and angiopathy is a perspective direction which facilitates a decrease of disability and improves quality of life that has important medical, social and economic importance.

**Keywords:** color therapy, diabetes mellitus, diabetic neuropathy of lower extremities, diabetic angiopathy of lower extremities, diabetic ulcers of lower extremities, optical noncoherent emission, light emitting diodes.

### INTRODUCTION

Diabetes mellitus is an endocrine disease associated with a chronic increase in blood glucose levels due to absolute or relative deficiency of the pancreatic hormone insulin [1]. The disease is characterized by a chronic course, causes a violation of all types of metabolism, damage to the vascular, nervous and other systems of the body, which leads to specific complications. Diabetes mellitus is currently one of the most important medical and social problems of our time, has become the leading non-communicable disease in the 21st century, and, according to experts from the World Health Organization (WHO), this pathology ranks first among diseases leading to disability, and third - by mortality [2]. Diabetes mellitus in terms of prevalence outstrips

all non-communicable diseases: over the past 20 years, the number of patients in the world has almost tripled, and, according to the UN and WHO, 1 patient dies from diabetes every 7 seconds in the world, 12 people get sick every 10 seconds, about 4 die every year, 6 million patients. Experts of the World Diabetes Federation, taking into account the rate of spread of diabetes mellitus, predict that the number of patients with diabetes mellitus in the world will increase by 1.5 times and by 2030 will reach 552 million people [3]. Recently, it has been assumed that one of the reasons for the development of diabetes mellitus against the background of a genetic predisposition is the external environment (geological factors and microelement composition of the area), which initiates the prevalence of this disease in the region [4]. It is likely that not the last role in the occurrence of endocrinological diseases,

## METHODS

### Characteristics of the considered treatment methods

Diabetes mellitus, first of all, is dangerous for its specific complications, such as neuro- and angiopathy, retinopathy, nephropathy, ulcerative lesions of the legs, diabetic foot syndrome, etc., which are much harder to fight than the disease itself [6, 7]. Diabetic distal symmetric sensory-motor polyneuropathy is considered the most common type of diabetic neuropathy, which is based on a neuroischemic mechanism. Depending on the isolated or combined lesion of the peripheral nervous system, arterial and microvasculature, neuropathic, ischemic and mixed (neuroischemic) forms are distinguished [8]. All these processes play a leading role in the development of ulcerative defects of the legs and feet in patients with diabetes mellitus, which later forms into diabetic foot syndrome.

### Electronic databases

The review analyzes publications presented in domestic and foreign press and available through Internet resources (e.Library, PubMed, EMBASE, CINAHL, Cochrane Library, Web of Science).

### Publication search algorithm

The search was carried out from 1991 to December 2020 using the keywords: color light therapy, phototherapy, chromotherapy, diabetes, diabetes mellitus, diabetic neuropathies, diabetic angiopathies, diabetic leg ulcers, diabetic foot, visible optical incoherent radiation, LEDs.

### Selection criteria for articles

The selection of articles for the analytical review was focused on original articles published in peer-reviewed scientific journals, randomized controlled trials that compared the results of using color light therapy with data from control studies (placebo) using visible optical radiation of the same wavelength (color), their combination or in combination with other standard treatments. In the case of finding articles identical in content by the same authors in the process of processing the resulting data set, the results were combined.

### Results of generalized analysis of publications

The results of the use of color light therapy in the treatment of complications caused by diabetes mellitus (peripheral neuro- and angiopathies, ulcers of the lower extremities) are shown in table. 1 and tab. 2.

The effectiveness of the use of color light therapy in the treatment of diabetic peripheral neuro- and angiopathies

Diabetic neuro- and angiopathies of the lower extremities are the most common lesions in diabetes mellitus, and the use of color light therapy in complex treatment is a prerequisite for reducing complications leading to disability (Table 1).

Table 1

Clinical results of the use of color light therapy in the treatment of diabetic peripheral neuro- and angiopathies

No	Disease	author (authors)	Options impact	results	Lite-ratura
1.	Diabetes cheskaya neuropathy lower unkindness	Turova E.A., Iskandaryan A. G., A. V. Kochetkov	Red color (660 nm) on both front the surface of the legs and stop, 15-30 minutes, course - 15 procedures, 5 times a week, 3-4 weeks.	Faster regression of pain symptoms and reduction violations of all kinds sensitivity, restoration of motor and autonomic functions.	[nine]
2.	Diabetes cheskaya neuropathy lower unkindness	Turova E.A., Kostina L.N., Kochetkov A.V., Iskandaryan A.G.	Irradiation with red color (660 nm) and infrared radiation (860 nm) front surfaces shins and feet.	Potential of the clinical results of the basic treatment program, IR radiation (860 nm) corrects pain syndrome and symptoms irritation, red light (660 nm) - sensory and reflex disturbances.	[ten]
3.	Distal diabetes cheskaya neuropathy	Sheverova I. V., Barantsevich E.R., Roshkovskaya L.V.	Laser and LED radiation red color (670 nm), 10 sessions.	Restoration of vibration sensitivity (more than 48%), an increase in the speed of the impulse, an increase in M-responses to stimulation tests, laser and LED radiation give an equally positive effect.	[eleven]
4.	Diabetes cheskaya neuropathy lower unkindness	Kashirina E. Zh., Bryzgalina CM., Chechening G.I., Evdokimova O.O.	Red (660 nm), 4 mW / cm <sup>2</sup> , IR radiation (870 nm), 15 mW / cm <sup>2</sup> , daily - feet and popliteal fossa or feet and segments L2-L4 paravertebral from both sides every other day.	Reducing pain in the lower extremities and the disappearance of seizures in calf muscles.	[12]
5.	Diabetes cheskaya angiopathy lower unkindness	Kiryanova V.V., Vorokhobina N.V., Chaban A.A., Egorova G.I., Veselovsky A.B.	Red color (680 nm), contact to projection popliteal artery, front tibial artery and dorsal arteries of the foot.	Improvement of the condition microcirculation compared to traditional drug therapy.	[13]
6.	Diabetes cheskaya angiopathy	A. M. Korobov, Pavlov S.V., Klapouschak	Green (525nm), blue (470nm) and red (625nm),	In patients, the syndrome of "thermal amputation" disappeared, edema decreased, pain decreased,	[fourteen]

	lower unkindness	A.Yu., Kolupaeva T.V., Kozyr E.V., Boykacheva O. M.	10 minutes each, 3 days.	numbness and cramps in the legs stopped.	
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table 2

**Clinical Results of Color Light Therapy**  
in the treatment of diabetic ulcers of the lower extremities

No.	Disease vanie	author (authors)	Options impact	results	Lite-ratura
1.	Diabetic ulcers shins	Minatel DG, Frade MAC, França SC, Enwemeka CS	Combined exposure: red (660 nm) and IR (890 nm), 100 mW / cm <sup>2</sup> , 30 sec, 2 times a week, 90 days.	The mean rates of granulation and ulcer healing were higher after treatment, healing was faster than in the placebo group.	[19]
2.	Diabetic ulcers feet	Landau Z., Migdal M., Lipovsky A., Lubart R.	Visible light (400-800 nm), 180 mW / cm <sup>2</sup> , 4 min a day, twice a day, 12 weeks.	As a result of treatment, scarring of ulcers was observed in 9 out of 10 patients (90%), in the "placebo" group - in 2 out of 6 patients (33%), a decrease in the size of ulcers after treatment - in 89%, in the "placebo" group - 54% ...	[twenty]
3.	Diabetic ulcers feet	Rundo A.I., V.A. Kosinets	Blue color (0.47 ± 0.03 μm) 2 mW 10 min, red color (0.67 ± 0.02 μm) 2 mW 10 min, 7 procedures every other day.	Reduction (by 7 days) of the duration of the purification phase, early (by 3 days) the appearance of granulations, a decrease (by 3-5 days) of edema, hyperemia and the amount of wound discharge.	[21]
4.	Diabetic ulcers feet	Boyko V.V., Ivanova Yu.V., Mushenko E.V., A.M. Korobov	Red (660 nm), green (525 nm), blue (470 nm) and violet (405 nm) color, 20 min daily, 7-10 sessions during 7-10 days.	Reduction of perifocal edema for 2-3 days, for 5-7 days improving the quality of granulations and the degree of epithelialization of ulcers, on the 10-12th day reduction of the area surface of ulcers, 14-21 days of complete healing.	[22]
5.	Diabetic and nondiabetic ulcers shins	Frangež I., Cankar K., Frangež HB, Smrke DM	Combined impact 625; 660 and 850 nm, pulsed, 2.4 J / cm <sup>2</sup> , at a distance of 10 cm, 5 min 3 times in week, 8 weeks.	In both groups of patients (with and without diabetes): rapid granulation and healing of ulcers, increased microcirculation.	[23]
6.	Diabetic ulcers shins	Frangež I., Nizič-Kos T., Frangež HB	Combined impact 625; 660 and 850 nm, pulsed, 2.4 J / cm <sup>2</sup> , at a distance of 10 cm, 5 minutes three times a week, 8 weeks.	Reduction of the area of the tongue after treatment to 56% of the initial, in the control - up to 65%, faster healing of ulcers.	[24]

In the complex rehabilitation of patients with stage 2 distal neuropathy, in addition to basic drug therapy and physiotherapeutic procedures (exercise therapy, baths, massage), light therapy was used using a cylindrical rigid photomatrix "TERAFOT ATC 01/660" [9]. The study was conducted on 62 patients aged 42 to 68 years, who were randomly assigned to two equal groups: the main group and the comparison group. In the main group, patients underwent color light therapy procedures, which included irradiation with red color (wavelength 660 nm) of the anterior surfaces of both legs and feet for 15-30 minutes in a course of 15 procedures 5 times a week for 3-4 weeks. Patients in the comparison group received only basic drug therapy in combination with physiotherapeutic procedures and exercise therapy. The use of color therapy in

patients of the main group were accompanied by a faster rate of regression of pain symptoms and a decrease in impairment of all types of sensitivity, as well as a faster recovery of motor and autonomic functions than in the comparison group. According to the results of neurodiagnostics, it was found that red color light therapy with a wavelength of 660 nm is more effective in restoring the functioning of sensory fibers than motor fibers.

In another extended, comparative, randomized study of 92 patients with symmetric distal peripheral neuropathy type 2, color therapy was used using the TERAFOOT photomatrix, in which, in addition to red irradiation (wavelength 660 nm), radiation with a wavelength of 860 nm was used [10]. The study was carried out against the background of a basic program of complex rehabilitation treatment (diet, drug therapy, general turpentine baths, exercise therapy). The revealed effects of the use of color light therapy consisted in the potentiation of the clinical results of a comprehensive restorative basic treatment program. It was found that the use of 860 nm irradiation corrected pain syndrome and irritation symptoms to a greater extent, while 660 nm - sensory and reflex disorders.

A comparative assessment of the effectiveness of the combined use of laser and LED radiation with a wavelength of 670 nm (red color) was carried out in the treatment of 97 patients with type I and II diabetes mellitus with distal diabetic polyneuropathy [11]. All patients by the method of randomization were divided into a control group (34 people), in which only the basic drug therapy was carried out, and the main group (63 people), where, along with the basic therapy, the patients received a course of color therapy. In turn, two subgroups were identified in the main group, in the first of which patients (31 people) received laser therapy, in the second (32 people), therapy with LED radiation was carried out. The research results showed that after 10 sessions of LED and laser therapy, a restoration of vibration sensitivity was observed (more than 48%), an increase in the speed of the impulse, an increase in M-responses to stimulation tests. Unidirectionality in the manifestation of treatment results has shown that laser and LED radiation in the red wavelength range has an equally positive effect.

The study of the effectiveness of treatment of patients with diabetic neuropathy of the lower extremities with the inclusion of color light therapy in the complex of rehabilitation measures was carried out using the LED apparatus "GESKA-1" of red and IR radiation [12]. The patients were divided into two groups: the main group - 38 patients (8 men and 30 women, average age  $57.78 \pm 12.24$  years) and control - 20 patients (4 men and 16 women, average age  $56.1 \pm 14.82$  years). All patients in both groups received standard therapy for diabetic neuropathy of the lower extremities (compensation of carbohydrate and lipid metabolism, B vitamins, angioprotectors, antiplatelet agents, lipoic acid preparations). Patients of the main group received additional red color therapy (wavelength 660 nm) at 4 mW / cm<sup>2</sup> and IR radiation (wavelength 870 nm) at 15 mW / cm<sup>2</sup>... The exposure was performed locally on the projection of the neurovascular bundle (popliteal fossa), feet (dorsal and plantar surfaces) and segments of the spine (paravertebral at the L2-L4 level). The feet were irradiated daily, and the popliteal fossa and spinal segments were irradiated alternately, every other day for 2-4 minutes per one field, with a total procedure time of 12-24 minutes, a total of 10 procedures. The severity of pain in the lower extremities and the disappearance of cramps in the calf muscles after treatment in the main and control groups significantly decreased, and the decrease was significantly more pronounced in the group after the course of color therapy. As a result of the study, it was found that

In the treatment of diabetic angiopathy of the lower extremities, red radiation of the visible part of the spectrum (wavelength 670 nm) was used, the effect of which was carried out by contact on the projection of the popliteal artery, the anterior tibial artery and the dorsal artery of the foot [13]. Comparison with traditional drug therapy showed that this effect made it possible to improve the state of microcirculation of the lower extremities in patients with diabetic angiopathy.

In the complex treatment of 20 patients (10 men and 10 women aged 40 to 72 years) with diabetic angiopathies of the lower extremities, along with diet therapy, glycemic correction, hydropathic procedures and the intake of Mirgorod mineral water, color therapy was carried out using the Barva-SDS apparatus [14] ... Color therapy was carried out for three days in green (wavelength 525 nm), blue (wavelength 470 nm) and red (wavelength 625 nm) with a duration

each procedure 10 min. After the end of the course of color light therapy, it was found that the patients' syndrome of "thermo-amputation" disappeared, edema decreased, pain in the legs decreased, numbness and convulsions stopped.

The effectiveness of the use of color light therapy in the treatment of diabetic ulcers of the lower extremities

Ulcerative lesions of the lower extremities are a common complication in diabetes mellitus, are characterized by a chronic course and difficult to treat. The developed alternative methods of treatment, including exposure to visible optical radiation (color light therapy), have, as shown by the results of experimental and clinical studies, a positive effect on the healing process of ulcers, reduce the level of secondary complications and, ultimately, improve the patient's quality of life [15–eighteen]. The results of the use of visible and IR radiation in the treatment of diabetic ulcers of the lower extremities (legs and feet) are shown in table. 2.

In the treatment of chronic diabetic leg ulcers, which did not respond well to other therapies, combined irradiation with red (wavelength - 660 nm) and IR radiation (wavelength - 890 nm), which was generated by a single LED emitter, was used [19]. The study was carried out in a double-blind manner on two groups of patients with leg ulcers, 14 people in each, one of which served as a "placebo" group, in the other, the patients received a course of light therapy for 90 days. Irradiation of leg ulcers in patients of both groups was carried out for 30 seconds twice a week with an intensity of 100 mW / cm<sup>2</sup>... The results of color therapy were traced at 15; thirty; 45; 60; 75 and 90 days of treatment. It was found that the average indicators of granulation and ulcer healing were significantly higher for the group of patients receiving combined irradiation with red and IR radiation than in the placebo group. The pooled results showed that ulcers healed faster in this group of patients after the color therapy course than in the placebo group. Thus, the combined exposure to red and IR radiation promotes rapid granulation and healing of diabetic ulcers that have not responded to other treatments.

Evaluation of the effectiveness in the treatment of leg or foot ulcers using visible optical radiation in a wide wavelength band - from 400 to 800 nm - was carried out by a double-blind, placebo-controlled method in 16 patients (10 treatment group, 6 placebo group) [20] ... Irradiation of ulcers was carried out at a distance of 2 cm twice a day for 4 minutes. 12 weeks with an intensity of 180 mW / cm<sup>2</sup>, while the spectral maximum of the radiation was in the range of 600–700 nm. The results were followed for 12 weeks, which showed that by the end of treatment, 9 out of 10 patients (90%) in the treatment group had all ulcers healed, while in the placebo group only 2 out of 6 patients (33%) had scarring. At the same time, the reduction in the size of ulcers in the treatment group was 89%, in the placebo group - 54%.

The study of the effect of light therapy in combination with standard therapy on the healing of ulcers and the state of blood flow in the vessels of the lower extremities was carried out on 80 patients with purulent-necrotic lesions of the feet on the background of diabetes mellitus [21]. All patients were divided into two groups: the control group, consisting of 50 people (34 men and 26 women, mean age 56.5 years), and the main group, 48 people (16 men and 14 women, mean age 58.7 years). In the control group, standard treatment was carried out: antibiotic therapy, diet therapy, administration of short-acting insulins, correction of the main types of metabolism, indicators of the hemostasis system and rheological properties of blood, detoxification and replacement infusion-transfusion therapy. Patients of the main group, in addition to standard therapy, additionally received color light therapy by irradiating ulcers for 10 minutes. blue ( $0.47 \pm 0.03$  microns) and red ( $0.67 \pm 0.02$  microns) colors with an intensity of 2 mW each. Evaluation of the effectiveness of treatment was carried out on 1; 3-5; 7 and 14 days according to the duration of the phases of the wound process, clinical symptoms and blood flow in the deep femoral artery. As a result of the treatment, it was found that in the main group there was a reduction in the duration of the purification phase (by 7 days), early appearance of granulations (by 3 days), and on days 3-5 - a statistically significant decrease in edema, hyperemia and the amount of wound discharge. In the same group, on days 1 and 14, a decrease in the systolic blood flow velocity was noted, while in the control group, there were no changes in the blood flow velocity at the indicated periods.

The study was carried out on 25 patients (men and women) aged from 48 to 72 years with neuro-ischemic form of ulcerative lesions of the lower extremities, complicated by multi-

resistant microbial infection [22]. The treatment used photonic matrices "Barva-Flex" A.M. Korobov with red (660 nm), green (525 nm), blue (470 nm) and violet (405 nm) colors, with which the affected area was contact irradiated daily for 20 minutes, 7-10 sessions for 7-10 days. The color therapy scheme was as follows: with a pronounced purulent-necrotic process, treatment was started with exposure to red followed by a transition to blue and / or green; with pronounced edema of the extremity and perifocal inflammation, at the first stage, a blue and / or purple color was used, followed by a transition to green or red. Color light therapy was carried out against the background of standard treatment: fractional insulin therapy, drugs - lipoic acid, B vitamins, anticoagulant and angiotropic therapy, physiotherapy. Against the background of color therapy, perifocal edema decreased on days 2-3 of treatment, on days 5-7 the quality of granulations and the degree of epithelialization of ulcers improved, and on days 10-12 there was a reduction in the surface area of the ulcers. Complete healing of wounds was noted in 20 patients by 14-21 days, and in 5 more patients - 30 days after complex treatment. Thus, as a result of the standard treatment carried out in combination with color light therapy of foot ulcers complicated by infection in patients with diabetes mellitus, the healing of ulcers occurs more efficiently and in a shorter time. in 5 more patients - 30 days after complex treatment. Thus, as a result of the standard treatment carried out in combination with color light therapy of foot ulcers complicated by infection in patients with diabetes mellitus, the healing of ulcers occurs more efficiently and in a shorter time. in 5 more patients - 30 days after complex treatment. Thus, as a result of the standard treatment carried out in combination with color light therapy of foot ulcers complicated by infection in patients with diabetes mellitus, the healing of ulcers occurs more efficiently and in a shorter time.

Comparison of the effect of color light therapy on chronic ulcers of the lower extremities together with the assessment of the state of microcirculation in the skin outside the affected area was studied in patients with diabetic ulcers and ulcers caused by other etiological factors [23]. The study was conducted on 39 patients with diabetic ulcers of the lower extremities, which constituted the main group, and 40 patients with ulcers of the lower extremities, who had no history of diabetes mellitus, represented the control group. In turn, the patients of each group were divided into two groups (20 in the main group, 19 and 20 in the group without diabetes), who received true radiation (LEDs or light) and its imitation ("placebo"). Patients of the main group received LED color therapy with combined radiation with an energy of 2.4 J / cm<sup>2</sup> three wavelengths 625 nm, 660 nm and 850 nm in pulsed mode (kilohertz range, duty cycle 50%). In the control group, imitation of color therapy was used by irradiation with color in a wide range of wavelengths from 580 to 900 nm with an radiation energy of 0.72 J / cm<sup>2</sup>... Irradiation of ulcers in patients of the main and control groups was carried out distantly at a distance of 10 cm for 5 minutes. three times a week for 8 weeks. Microcirculation in patients of both groups was measured before and after the course of procedures using laser Doppler flowmetry. The results of the study showed faster granulation and healing of ulcers in patients of both groups (with and without diabetes) after a course of LED color therapy compared with the control group (imitation radiation) and placebo groups. A significant improvement in microcirculation was found in both groups of patients (with and without diabetes) after LED color therapy compared to the control groups.

In confirmation of the results of the previous study, treatment with identical parameters and exposure mode (625; 660 and 850 nm, 2.4 J / cm<sup>2</sup>, 5 minutes. three times per week, 8 weeks) was performed in 60 patients with chronic diabetic leg ulcer [24]. The results of the assessment of the healing process by the area of the ulcer surface showed that after 8 weeks the area of the ulcer in patients in the main group decreased to 56% of the initial one, while in the control group - to 65%. According to the results obtained, LED radiation with the above parameters significantly accelerates the healing of chronic ulcers of the lower extremities in patients with diabetes mellitus.

#### CONCLUSION

In conclusion, it should be noted that color light therapy has a positive effect on sensory-motor and microcirculatory disorders in the lower extremities in patients with diabetes mellitus, the effect is realized both at the local and systemic levels. As shown by the studies presented, color therapy promotes faster scarring of ulcers, thereby reducing the healing time, and has a positive effect on regional blood circulation in the lower extremities. The use of color light therapy in the complex treatment of the consequences of diabetes mellitus seems to be an extremely promising direction, which contributes to a significant improvement in the final results of therapy.

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