Comparative evaluation of the effects of high-intensity and low-intensity laser radiation on microcirculation in patients with gonarthrosis

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SUMMARY

Sixty patients with gonarthrosis aged from 40 to 75 years old were examined. The patients were randomly divided into two groups: 1st group (30 patients) received high intensity laser radiation; 2nd group (30 patients) received low intensity laser radiation.
As a result of the conducted research it was found that high intensity laser radiation is more efficient and leads to more vivid positive changes in the microcirculation of patients with gonarthrosis. The changes in microcirculation were based on the normalization of the myogenic and neurogenic tonus of the arterioles, strengthening oscillation of the endothelial range. As a result of local mechanisms activation of tissue blood flow there occurs adequate modulation of the microcirculatory bloodstream, which is aimed at the elimination of congestive phenomena in the capillary and venular level of the microcirculation bloodstream.
We should note that in the long-term more significant were the positive changes in the state of the venular level of the microcirculation bloodstream.
Keywords: gonarthrosis, laser Doppler flowmetry, microcirculation, high intensity laser therapy, low intensity laser radiation.

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INTRODUCTION

Osteoarthrosis takes one of the leading positions (up to 60%) among all joint diseases [1]. According to the data of long-term observations, most widely used medications for treatment of this category patients have limitations to the indications for use. Besides, they are able to cause allergic reactions and have side effects. Therefore, a further search of effective methods of treatment of patients with osteoarthrosis by using modern physical therapy techniques is undoubtedly very promising and necessary [2-4].
In recent years, new physiotherapy methods, particularly the usage of high intensity laser radiation (HIL-therapy), have been applied in medical practice [5; 6]. However, to date there is little research on the scientific justification of the use of this factor.

PURPOSE OF THE STUDY

A comparative study of the effect of low intensity and high intensity laser radiation on the microcirculation in patients with stages I and II gonarthrosis.

METHODS OF THE STUDY

The study involved 60 patients with stages I and II gonarthrosis (GA) 1-2 aged between 40 and 75 years, 51 of them were diagnosed with oligoarthrosis, and nine patients were diagnosed with polyosteoarthrosis. Patients were divided by the random number method into two groups:

Group 1 (30 patients) received high-intensity laser pulses delivered by a BTL-6000 HIL device, wavelength of 1064 nm, pulse mode, frequency of 25 Hz, a dose of 10 J/cm^2, onto the projection area of joint spaces and popliteal region, 4 minutes per field, alternate days, a course of 10 treatment sessions;

- Group 2 (30 patients) received low-intensity laser impact using a "Mustang 2000" device, wavelength of 890 nm, pulse mode, frequency of 80 Hz, pulse power of 40mW, onto the projection area of joint spaces and popliteal region, 4 minutes per field, alternate days, a course of 10 treatment sessions.

In this study, the state of the capillary blood flow was evaluated by laser Doppler flowmetry (LDF), which was carried out using a "LAKK-M" laser capillary blood flow analyzer. The skin of the anterior surface of the knee joint in supine position was studied, at room temperature not less than 20°C.

In the course of the study, the following indicators of LDF-signal were recorded and calculated: mean value of microcirculation index (MI) and its standard deviation (σ).
Analysis of the amplitude and frequency of the rhythmic components of fluxmotions (fluctuations in the flow of red blood cells measured by LDF) was conducted based on the use of the mathematical apparatus technique of the wavelet transform.
Using wavelet analysis, we calculated and analyzed the amplitude and frequency of rhythmic components:

Group I - rhythms caused by the secretory activity of the endothelium (E);
Group II - neurogenic fluctuations arising from the sympathetic adrenergic effects on the smooth muscle in the arterioles and metarterioles (N);
Group III - myogenic rhythms caused by the own internal activity of myocytes by pacemaker mechanism (M);
Group III - myogenic rhythms caused by the own internal activity of myocytes by pacemaker mechanism (M);
Group IV - respiratory rhythms (D);
Group V - cardiac rhythms (C).
Valuation of the amplitude (A) indices of each rhythm was carried out by strength of LDF-signal (M): A rhythm/M × 100%, and against the value of its maximum spread (σ): A rhythm/3σ ×100%.

RESULTS OF THE STUDY AND DISCUSSION

Before the treatment, most patients with GA had distinct clinical manifestations of osteoarthrosis, the most important of which were pain during movement, at rest and pain after getting up or a period of inactivity. Increase in the affected joint circumference compared with the symmetric healthy one, tenderness to palpation, rough crepitus during movement, restrain of movements of various degrees, changes in gait were objectively found. All patients received small doses of nonsteroidal anti-inflammatory drugs (NSAIDs).
According to the LDF, disorders of microcirculation (MC) were revealed, which allowed dividing all patients into two groups according to the classification proposed V.I. Makolkin:
Group A (91%) - Patients with the congestive-stagnant type;
Group B (9%) - Patients with the normocirculatory type of microcirculation.

Table 1

Dynamics of LDF-factors under the influence of prolonged treatment effects of high intensity and low intensity laser radiation

Amax / 3σ x 100%	E	N	M	D	C
Normal range	14.1±0.9%	17.1±0.8%	15.0±0.9%	7.9±0.8%	5.7±0,7%
Group 1 before treatment	12.39±0.21%	19.74±0.7%	17.74±0.5%	12.3±0.8%	8.1±0.3%
Group 1 after treatment	13.87±0.1% ***	17.5±0.4% **	15.2±0.3% ***	9.1±0.4% **	7.0±0.2% **
Group 2 before treatment	12.37±0.22%	19.76±0.7%	17.91±0,6%	12.7±0.8%	8.0±0.3%
Group 2 after treatment	13.0±0.11%**	18.1±0.4% *	16.03±0.4% *	9.9±0.5% **	7.3±0.4% **

Note: statistical significance of P before and after treatment: * — < 0.05, ** — < 0.01, *** — < 0.001.

The patients of Group A had an less – by 5% ($p < 0.01$) to the initial one. A significant decrease in Am/3σ × 100% indicator by 18% ($p < 0.001$) and by 12% ($p < 0.05$) against the initial values was discovered in groups, respectively, which implies normalization of the myogenic tone of arterioles (see Fig.).

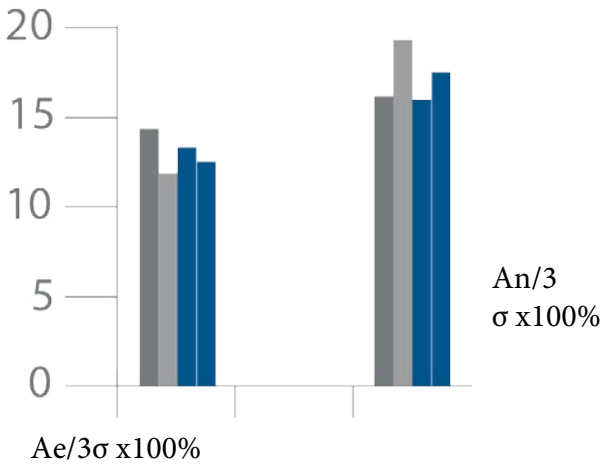

Fig. Dynamics of Ae/3σ factors x 100% and An/3 σ x 100% in patients with gonarthrosis before and after prolonged treatment with high intensity and low intensity laser radiation

As a result of applying sessions of high intensity laser radiation and low intensity laser radiation among patients with gonarthrosis, positive dynamics of Ac/3σ × 100% indicator, the state of the neurogenic tone of arterioles, was observed. It decreased by 14% ($p < 0.01$) and by 9% ($p < 0.05$) against the initial values in the groups, respectively. The above changes were accompanied by improvement in blood filling in the capillary and venular parts of the microcirculation bloodstream.

The data obtained by using LDF were correlated with regression of clinical symptoms and signs. Thus, the majority of patients experienced a significant reduction in the severity of pain on activity, which manifested in significant decrease in VAS in patients of Group 1 during the second and third treatment sessions by 39.4% and at the end of treatment - by 46.7%. In Group 2, the value decreased by 17.6% in the middle of the treatment, and by 25.1% at the end of the treatment. The intensity of pain at rest changed similarly. The patients of Group 1 experienced a significant decrease in pain intensity by 46.45% against the initial data after the second and third sessions, and by 78.78% by the end of treatment. In Group 2, pain intensity decreased by 19.97% in the middle of treatment and by 34.68% at the end of treatment.

Summarizing the results of the studies relating to the effect of high intensity laser radiation and low intensity laser radiation on the state of microcirculation among patients with gonarthrosis, it may be noted that positive changes in the microcirculatory hemodynamics were more significant when using high-intensity laser therapy. The changes in microcirculation were due to normalization of the myogenic and neurogenic tonus of arterioles, and increased oscillations of the endothelial range. Activation of the local mechanisms of tissue blood flow resulted in an adequate modulation of blood flow aimed at the elimination of congestion in the capillary and venular levels of the microcirculation bloodstream.

Analysis of afterhistory, according to LDF, confirmed that 12 months after the treatment with high intensity laser radiation the myogenic and neurogenic tonus decreased, but remained above the initial values (Table 2). Conspicuous is the fact that in the long-term period positive changes in the state of the venular level of the microcirculation bloodstream were more significant. Ad/3σ × 100% indicator improved by 26% by treatment sessions of high intensity laser radiation, whereas 12 months after the treatment it improved by 34%.

CONCLUSION

The immediate and long-term results of the conducted study demonstrated a more evident effect of high intensity laser radiation on the myogenic and neurogenic tonus of arterioles and function of microvascular endothelium compared with low intensity laser radiation. The positive dynamics of the microcirculation among patients that received laser radiation correlated with a significant regression of the pain syndrome. However, a more significant reduction in the intensity of pain as early as during the first sessions was identified only among patients treated with high intensity laser radiation.

It is fair to assume that the improvement of microcirculation revealed by us and, consequently, clinical symptoms and signs among patients with GA treated by high intensity laser radiation is based on more evident photothermal and photomechanical effects of the factor as compared to low intensity laser radiation. At the same time, it is necessary to conduct further clinical studies in patients with pain syndromes to determine the mechanisms of early analgetic effect of high intensity laser radiation as compared to low intensity laser therapy.

Table 2

Dynamics of LDF-factors 12 months after prolonged treatment with high intensity laser radiation

Amax / 3σ x 100%	E	N	M	D	C
Normal range	14.1±0.9%	17.1±0.8 %	15.0±0.9%	7.9±0.8%	5.7±0.7%
Group 1 before treatment	12.39±0.21%	19.74±0.7%	17.74±0.5%	12.3±0.8%	8.1±0.3%
Group 1 after treatment	13.87±0.1% ***	17.5±0.4% **	15.2±0.3% ***	9.1±0.4% **	7.0±0.2% **
Group 1 12 months after treatment	12.97±0.2% **	18.7±0.3%	16.1±0.6% **	8.2±0.8% ***	6.1±0.3% ***

Note: statistical significance of P— in comparison with values before treatment: * — < 0.05, ** — < 0.01, *** — < 0.001.

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