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RADIONUCLIDE DIAGNOSTICS OF JOINT INJURY IN PATIENTS WITH DIABETES

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Переконливих ефективних способів ранньої діагностики уражень суглобів на сьогодні вкрай мало. Рентгенологічні зміни на ранніх стадіях хвороби відсутні, інші лабораторні тести не специфічні і не завжди корелюють з активністю запального процесу.

***Метою роботи** було вивчення за допомогою радіонуклідного методу стану артеріального та венозного кровотоку, наявності запальних процесів в області колінних та гомілковоступневих суглобах у хворих на цукровий діабет 1 та 2 типу.*

***Матеріали та методи.** Обстежено 152 хворих на цукровий діабет. В залежності від типу цукрового діабету хворі були розподілені на дві групи – 58 пацієнтів були з цукровим діабетом 1 типу (19 чоловіків та 39 жінок), з цукровим діабетом 2 типу – 94 пацієнти (19 чоловіків та 51 жінка). Середній вік хворих в групі з цукровим діабетом 1 типу становив 42,3±1,8 роки, тривалість цукрового діабету – 21,1±1,3 роки. В групі з цукровим діабетом 2 типу середній вік хворих становив 61,3±1,0 роки, тривалість цукрового діабету – 13,1±0,9 років. Серед обстежених хворих на цукровий діабет 1 типу артропатія була діагностована у 34 (58,6 %), контрольною групою слугували пацієнти без ураження суглобів – 24 (41,4 %). У хворих на цукровий діабет 2 типу артропатію виявлено у 68 (72,3 %) обстежених, патології суглобів не було у 26 (27,7 %) хворих. Метод радіонуклідної діагностики нижніх кінцівок складався з двох методик: радіонуклідної ангіографії та радіонуклідної сцинтиграфії.*

***Результати.** При проведенні радіонуклідних досліджень гемодинаміки у хворих на цукровий діабет 1 типу з артропатіями в порівнянні з хворими без ураження суглобів відсутні зміни кровотоку в судинах великого і середнього калібру, а також артеріолах і капілярах нижніх кінцівок при наявності виражених порушень венозного відтоку. Для хворих на цукровий діабет 2 типу із артропатіями виявлено значне уповільнення швидкості кровотоку в судинах великого і середнього калібру, а також артеріолах і капілярах, що супроводжується порушенням венозного відтоку.*

***Висновки.** Застосований метод радіонуклідної діагностики стану кровотоку та наявності діабет-асоційованої артропатії колінних та гомілково-ступневих суглобів при одноразовому введенні радіофармпрепарату є одним з найінформативніших методів ранньої діагностики зазначеної патології, а порушення венозного відтоку при незмінному артеріальному кровотоку у хворих на цукровий діабет 1-го типу може бути диференційним критерієм діабет-асоційованої артропатії у хворих на цукровий діабет 1 та 2 типу*

***Ключові слова:** цукровий діабет, діабет-асоційована артропатія, радіосцинтиграфія, судинні порушення, фактори ризику, гемодинаміка*

1. Introduction

Nowadays, the issue of early diagnosis of joint pathology in patients with DM remains extremely important: in most cases, the patient can not specify the time and cause of symptoms. Quite a long time of the disease, even in the presence of histopathological changes and radiographic signs has an asymptomatic course. Early diagnosis and timely effective treatment are considered as components of comprehensive rehabilitation of patients, including arthropathy in combination with DM [1–3]. The variability of the onset of most joint diseases, the similarity of symptoms in the early stages of joint pathology, the lack of clear diagnostic criteria for various forms of arthropathy in the onset force specialists to look for certain clinical signs, laboratory or instrumental markers that allow early stages selection of adequate and timely therapy to provide a more favorable outcome and social prognosis [4–6].

The arsenal of instrumental methods for diagnosing joint lesions is quite large, but not all of them are equivalent in terms of information. Thus, radiological methods of research are indicative in the late stages of the disease, radiological – give an idea of the localization of areas with increased blood flow, but are not specific. The introduction into clinical practice of sensitive and accurate methods of radionuclide diagnosis has expanded the possibilities of detecting preclinical stages of diabetic arthropathy [7, 8].

Advances in nuclear medicine and technology in recent years, due to the use of scintillation gamma cameras with computers and osteotropic radiopharmaceuticals (RPH), labelled with short-lived isotopes, allowed to obtain high-quality images of the skeletal system with minimal radiation exposure to the patient, and also made it possible to make diagnostic observations of damage to the skeletal system of any origin [9]. The most important

diagnostic information in radionuclide examination of bones using phosphate or phosphonate complexes labelled with 99 tons of technetium (99 pTs) can be obtained by performing two-, three-phase scintigraphy [4, 9, 10]. The first phase is the stage of blood flow assessment, the second is the assessment of soft tissue blood supply, and the third is the scintigraphic examination of skeletal bones. Increased accumulation of RPH in bone tissue is observed in areas with high osteoblastic activity, which includes inflammation, which is characteristic of joint damage.

Radionuclide research methods have recently been widely used in clinical practice, but in the literature we have found only a few publications on their use in joint diseases in patients with diabetes [4, 5, 10].

The aim of our work was to study with the help of radionuclide method the state of arterial and venous blood flow, the presence of inflammatory processes in the knee and ankle joints in patients with DM 1 and 2 types.

2. Materials and methods

The study was conducted on the basis of SI "V. P. Komisarenko Institute of Endocrinology and Metabolism of the National Academy of Medical Sciences of Ukraine" within the research "Develop an algorithm for diagnosing vascular lesions in patients with overweight and obesity on the background of carbohydrate metabolism disorders" 2017–2019. The study followed the principles of bioethics: the main provisions of the Council of Europe Convention 04.04.1997), GCP (1996), the Helsinki Declaration of the World Medical Association on the ethical principles of scientific medical research with human participation (1964–2000) and the order of the Ministry of Health of Ukraine No. 281 of 01.11.2000. All surveyed persons personally and voluntarily signed an informed consent to participate in the study. The study was approved by the Commission on Biomedical Ethics of "V. P. Komisarenko Institute of Endocrinology and Metabolism of the National Academy of Medical Sciences of Ukraine" (Minutes No. 8 of April 14, 2016).

152 patients with DM were examined. Depending on the type of DM, patients were divided into two groups – 58 patients were with type 1 DM (19 men and 39 women), with type 2 DM – 94 patients (19 men and 51 women). The average age of patients in the DM 1 type group was 42.3±1.8 years, the duration of DM – 21.1±1.3 years. In the DM 2 type group, the average age of patients was 61.3±1.0 years, the duration of DM was 13.1±0.9 years.

The mean age of patients with type 1 DM is expected to be lower than in the group of patients with type 2 DM ($p<0.001$). The duration of DM is lower in the group of patients with DM 2 type ($p<0,001$). No differences in gender were found.

Among the examined patients with DM 1 type arthropathy was diagnosed in 34 (58.6 %), the control group were patients without joint damage – 24 (41.4 %). In patients with DM 2 type arthropathy was found in 68 (72.3 %) subjects, joint pathology was not in 26 (27.7 %) patients.

The method of radionuclide diagnosis of the lower extremities consisted of two methods: radionuclide angiography and radionuclide scintigraphy.

The studies were performed on a scintillation gamma camera G G C 301 T S K T B "Horizon" with a low-energy general purpose collimator. Data were recorded using the Antics program to collect information, which was then processed using the Spect Works software package. The condition of the vascular and skeletal system of the joints was studied using methylenediphosphonate manufactured by Polatom (Poland). The examination was performed in the supine position, the gamma camera detector was centered so that the knee or ankle joints came into view. In the elbow vein of the patient when applied to the forearm cuff sphygmomanometer, the pressure in which is brought to 200 mm Hg, was injected radiopharmaceutical (RPH) 99m sodium T-pertechnetate with an activity of 500–600 MBq in a volume of 0.8–1 ml and performed recording an angiogram of the knee or ankle joints. The program provides registration of 60 frames for 1 min with the subsequent computer processing according to standard programs and allocation of zones of interest (knee or ankle joints) and reception of curves "activity – time" in the form of schedules. Qualitative criteria for assessing the hemodynamics of the joints were: time of complete blood flow (CBF), s; time of rapid blood flow (TRBF), which characterizes the blood flow in the vessels of large and medium caliber of the lower extremities, in the knee or ankle joints, s; time of slow blood flow (TSBF), which characterizes the blood flow in the arterioles and capillaries of the lower extremities in the knee or ankle joints, s, and venous outflow efficiency (VOE), which is calculated as the ratio of the difference between maximum and minimum amplitude amplitude (in imp./s) [6]. Radionuclide osteoscintigraphy was performed 2.3–3 h after administration of 99mTc-methylenediphosphonate. The gamma camera detector was centered on the joints. Scintigram recording was completed automatically after the accumulation of 200,000 pulses. The processing of the results on the computer consisted of contrasting, smoothing, selection of areas of interest with subsequent determination of the area, average and total activity of the lesion and symmetrical unaffected area, as well as the percentage of asymmetry between them. Criteria for evaluating the data of osteoscintigraphy of the knee joints were: average and total activity (imp./s), as well as the percentage of asymmetry of the total activity between the affected and unaffected knee [4].

Statistical processing of the obtained data was performed using the methods of variation statistics of the standard package for statistical calculations Statistica 5.0 Microsoft OffiseExel 2003. The paper presents statistical indicators of mean values (denoted as M), as well as the standard deviation (SD), the standard error of the mean value (m). Student's t-test was used to compare the mean absolute values in different study groups. The difference in the obtained results was considered statistically significant at the value of $p\leq0.05$.

3. Results

Studies show that in patients with DM 1 type with DA with localization in the knee joints compared with

patients with DM 1 type without joint damage there are no changes in blood flow in vessels of large and medium caliber (average levels of CBF and TRBF probably did not differ, p>0.05), as well as in the arterioles and capillaries of the lower extremities (no significant difference TSBF was detected, p>0.05) in the presence of severe venous outflow disorders (a probable difference in mean VOE values, p<0.001) (Table 1) .

In the analysis of radionuclide studies of hemodynamics of the lower extremities under the conditions of localization of DA in the ankle joints in patients with DM 1 type it was found that in patients with DM1 type with DA in comparison with patients with DM 1 type without joint damage also no changes in blood flow both in vessels of large and medium calibre (average levels of CBF and TRBF probably did not differ; p>0.05), and in arterioles and capillaries of the lower extremities (no probable difference TSBF was detected; p>0.05) in the presence of severe venous disorders outflow (a probable difference in the average values of VOE; p<0.001) (Table 2).

In patients with DM 2 type with localization of DA in the knee joints, a probable increase in blood flow time was found in vessels of large and medium calibre (CBF, p<0.01; TRBF, p<0.01), in arterioles and capillaries (TSBF, p<0.01). Against the background of impaired blood flow in the arteries also revealed a violation of venous outflow (VOE, p<0.01) (Table 3).

Patients with DM 2 type with localization of DA in the ankle joints revealed similar vascular disorders as in patients with DM 2 type with localization of DA in the knee joints – a probable increase in blood flow time in vessels of large and medium calibre (CBF, p<0.01; TRBF, p<0.01), in arterioles and capillaries (TSBF, p<0.01). Against the background of impaired blood flow in the arteries also revealed a violation of venous outflow (VOE, p<0.01) (Table 4).

Table 1

Radionuclide indicators of hemodynamics of knee joints in patients with DM 1 type (M±m)

Groups of patients	CBF, s		TRBF, s		TSBF, s		VOE, %	
	RL	LL	RL	LL	RL	LL	RL	LL
Without arthropathy, n=12	8.7±1.1	10.5±1.2	4.7±0.3	5.1±0.6	4.6±0.9	5.4±1.1	62.0±3.5*	53.5±3.1*
With arthropathies, n=17	8.2±1.2	9.3±0.9	4.9±0.4	3.9±0.7	4.5±0.6	3.9±0.8	34.2±3.2	35.9±3.6

*Notes: RL – right limb, LL – left limb; * – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.001*

Table 2

Radionuclide indicators of hemodynamics of ankle joints in patients with DM 1 type (M±m)

Groups of patients	CBF, s		TRBF, s		TSBF, s		VOE, %	
	RL	LL	RL	LL	RL	LL	RL	LL
Without arthropathy, n=12	11.2±1.1	10.3±1.1	9.7±0.8	8.6±0.6	4.9±0.8	5.8±1.1	43.0±2.5*	43.5±3.6*
With arthropathies, n=17	13.2±1.4	9.3±0.9	8.9±0.4	9.6±0.9	4.5±0.6	6.7±0.8	29.1±3.2	30.5±2.4

*Notes: RL – right limb, LL – left limb; * – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.001*

Table 3

Radionuclide indicators of hemodynamics of knee joints in patients with DM 2 type (M±m)

Groups of patients	CBF, s		TRBF, s		TSBF, s		VOE, %	
	RL	LL	RL	LL	RL	LL	RL	LL
Without arthropathy, n=12	14.1±1.5^	13.3±1.1^	7.2±0.8^	6.1±0.6^	6.9±1.3^	7.1±1.1^	75.0±2.9*	73.8±3.1*
With arthropathies, n=17	21.8±2.1	19.3±1.8	10.9±1.1	11.7±1.9	12.8±1.9	10.8±1.4	37.2±3.4	38.5±3.6

*Notes: RL – right limb, LL – left limb; ^ – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.05; * – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.001*

Table 4

Radionuclide indicators of hemodynamics of ankle joints in patients with DM 2 type (M±m)

Groups of patients	CBF, s		TRBF, s		TSBF, s		VOE, %	
	RL	LL	RL	LL	RL	LL	RL	LL
Without arthropathy n=12	16.2±1.3^	15.9±1.1^	9.9±0.7^	10.6±0.7^	6.8±079^	6.9±1.1^	58.4±2.1*	61.3±3.1*
With arthropathies n=17	25.6±1.3	28.3±1.4	13.8±0.8	15.6±0.9	9.5±0.6	10.7±0.8	33.1±2.2	32.0±2.6

*Notes: RL – right limb, LL – left limb; ^ – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.05; * – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.001*

Therefore, in patients with DM 1 type with arthropathy in comparison with patients without joint damage there are no changes in blood flow in vessels of large and medium calibre, as well as arterioles and capillaries of the lower extremities in the presence of severe venous outflow disorders.

For patients with type 2 DM with arthropathy, a significant slowing of blood flow in large and medium-sized vessels, as well as arterioles and capillaries, as evidenced by a probable increase in CBF, TRBF and TSBF in the vessels of the feet, accompanied by venous outflow disorders.

Osteoscintigraphy data show that in patients with DM 1 type with the presence of DA in the knee joints there is an increase in both average, $p<0.01$, and total activity, $p<0.01$ (Table 5). A pronounced increase in the percentage of the asymmetry coefficient of the total activity of both knee joints, $p<0.01$, confirms the presence of an inflammatory process in the knee joints.

Osteoscintigraphy data in patients with DM 2 type with the presence of DA in the knee joints are similar to those obtained in patients with DM 1 type. We found an increase in both mean, $p<0.01$ and total activity, $p<0.01$. A pronounced increase in the percentage of the asymmetry coefficient of the total activity of both knee joints, $p<0.01$, confirms the presence of an inflammatory process in the knee joints of patients with DM 2 type (Table 6).

In the analysis of radionuclide indicators of osteoscintigraphy of the ankle joints in patients with DM 1 type, we found an increase in both mean, $p<0.01$, and total activity, $p<0.01$ (Table 7). A pronounced increase in the percentage of the asymmetry coefficient of the total activity of both knee joints, $p<0.01$, confirms the presence of an inflammatory process in the ankle joints of patients with DM 2 type (Table 8).

Table 5

Radionuclide indicators of osteoscintigraphy of knee joints in patients with type 1 DM (M±m)

Groups of patients	Average activity, imp/s		Total activity, imp/s		Coefficient of asymmetry, %	
	RL	LL	RL	LL	RL	LL
Without arthropathy, n=12	41.6±2.3^	42.0±2.3^	16487.0±320.1^	16640.7±338.4^	106.6±3.3^	107.6±2.6^
With arthropathies, n=17	57.7±4.3	57.8±3.7	26751.9±2706.9	27494.2±2596.1	169.8±22.5	168.9±20.0

Notes: RL – right limb, LL – left limb; ^ – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.05

Table 6

Radionuclide indicators of osteoscintigraphy of knee joints in patients with type 2 DM (M±m)

Groups of patients	Average activity, imp/s		Total activity, imp/s		Coefficient of asymmetry, %	
	RL	LL	RL	LL	RL	LL
Without arthropathy, n=13	45.1±3.7^	43.5±3.1^	19059.52592.9^	19203.52413.9^	108.278.6^	107.3±4.4^
With arthropathies, n=32	100.3±5.3	94.2±4.1	28873.2±1475.7	26378.3±1506.8	152.5±8.6	155.6±9.1

Notes: RL – right limb, LL – left limb; ^ – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.05

Table 7

Radionuclide indicators of osteoscintigraphy of ankle joints in patients with DM type 1 (M±m)

Groups of patients	Average activity, imp/s		Total activity, imp/s		Coefficient of asymmetry, %	
	RL	LL	RL	LL	RL	LL
Without arthropathy, n=12	58.8±3.8^	55.6±3.9^	16470.9±1367.5^	17012.3±1959.4^	119.4±5.6^	107.3±4.4^
With arthropathies, n=36	102.6±5.5	115.0±6.6	28808.1±2246.1	37140.9±3092.1	173.1±4.9	164.3±10.2

Notes: RL – right limb, LL – left limb; ^ – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.05

Table 8

Radionuclide indicators of osteoscintigraphy of ankle joints in patients with DM type 2 (M±m)

Groups of patients	Average activity, imp/s		Total activity, imp/s		Coefficient of asymmetry, %	
	RL	LL	RL	LL	RL	LL
Without arthropathy, n=13	43.1±3.6^	59.4±6.6^	21547.3±2273.5^	20544.1±3221.1^	131.0±12.0^	105.1±10.1^
With arthropathies, n=56	96.33±4.4	90.8±5.75	29749.4±1737.5	31036.3±3251.1	173.7±6.7	171.5±4.6

Notes: RL – right limb, LL – left limb; ^ – the difference is considered significant when comparing the rate between patients without arthropathy and with its presence, p<0.05

In the analysis of radionuclide indicators of osteoscintigraphy of the ankle joints in patients with DM 2 type, we obtained similar indicators with patients with DM 1 type with lesions of the joints increase in both average and total activity, $p<0.01$. A marked increase in the percentage of the asymmetry coefficient of the total activity of both knee joints, $p<0.01$, confirms the presence of an inflammatory process in the ankle joints of patients with DM 2 type.

4. Discussion

The development of osteoarthropathy in patients with both types of DM develops against the background of a long course of DM. It is known that prolonged metabolic changes in DM lead to impaired remodeling of the joint system [2, 5, 11]. Chronic hyperglycemia, due to an increase in the concentration of glucose in the synovial fluid, ligaments and capsule of the joint, causes the manifestations of osteoarthritis due to the activation of the polyol pathway of glucose metabolism and non-enzymatic glycosylation of proteins. The neurotoxicity of hyperglycemia leads to neuromuscular insufficiency, which also aggravates joint damage, leading to destabilization of the joint and worsening of degenerative-dystrophic changes in it [5, 11]. Despite its high prevalence in the population, DA remains a disease with poorly understood pathogenesis and unclear etiology. Although the main attention in recent years has been paid to articular cartilage, as well as the adjacent subchondral bone, interest in the possible role of vascular disorders, including venous, in the development of OA has not faded in recent decades [12, 13]. Subchondral bone is a multivascularized tissue and microvascular, mostly venous, lesions in this area have long been known [6]. In the analysis of radionuclide studies in patients with DM 2 type, we found violations of hemodynamics in the arteries of the lower extremities of various calibers. This can be explained by the fact that DA develops on the background of diabetic angiopathy. It is important to note that to date, many researchers have found a link between impaired bone metabolism and mediacalcinosis of the arteries, which occurs in patients with DM much more often than in the general population [14, 15].

The question of the participation of venous vascular pathology in the formation and course of the joint syndrome in OA remains unresolved. Impaired venous circulation of the lower extremities in patients with OA is determined by increased venous pressure and the phenomena of stagnation in peripheral veins. Decreased regional blood flow, venous tone disorders and venous outflow are recognized as one of the main causes of impaired blood supply to the joint and are associated with local inflammatory activity, periarticular changes in the knee joints, the intensity of pain. In addition, there is a link between disorders in the microcirculation system and venous pressure with the progression of osteoarthritis [16]. Thus, the influence of pathology of peripheral venous blood flow on the development of arthropathy is shown, and this can be due to structural changes in the joints themselves, and arise due to primary circulatory disorders in the extremities (chronic lymphohemostasis, thrombophlebitis, varicose veins). Thus, the combination of DA with peripheral venous disease leads to an aggravation of the clinical picture of the joint syndrome. Accordingly, when correcting the pain syndrome in such patients, it is necessary to take into account both the actual damage to the joint tissues and peripheral vessels. Other researchers have shown disorders of hemocirculation and lymphatic outflow of varying severity in patients with gonarthrosis at an early stage of the disease, so, there were significant violations related to reduced basal blood flow in the knee joint [17].

The analysis of radionuclide indicators of osteoscintigraphy of the knee and ankle joints in patients with DM 1 and 2 type revealed unidirectional changes, namely a probable increase in both average and total activity in the bone structures of the knee and ankle joints, and a marked increase in the percentage of asymmetry of the total activity of both knee and ankle joints, which confirms the presence of an inflammatory process in the structures of the above joints.

In the development of the pathological process in the joints, changes in hemocirculation and lymphatic outflow are important, as they lead to disorders of transudation and synthesis of synovial fluid, and therefore to disorders of the metabolism of articular cartilage. Changes in microcirculation in the knee joint can be considered as indicators of severity and prediction of gonarthrosis. The rate of progression of osteoarthritis of the knee joints depends on the violation of regional blood flow and blood rheology. It is established that more pronounced changes in articular cartilage and bone structures in osteoarthritis are not accompanied by an increase (as in inflammation should be expected), but a decrease in blood flow through the terminal arteries due to vascular tone of the microcirculatory system [3, 17].

According to modern publications [9, 10], radionuclide study of the musculoskeletal system in combination with general clinical and radiological data allows to develop additional objective criteria for the diagnosis and differentiation of various lesions of the musculoskeletal system, including joints in clinically similar variants of them overflow and reduce the number of erroneous conclusions.

Thus, the applied method of radionuclide diagnosis to assess the state of blood flow and the presence of DA of the knee and ankle joints with a single injection of RPH is one of the most informative methods of early diagnosis of this pathology, and venous outflow disorders with unchanged arterial blood flow in patients with type 1 DM may be a differential criterion of DA in patients with type 1 and type 2 DM.

Study limitations. A small cohort of patients (94 patients with DM 2 type and 58 patients with DM 1 type) were included in the study to perform radionuclide diagnostics to assess blood flow status and the presence of diabetes-associated arthropathy, so further

studies on a larger cohort of patients and analysis the influence of concomitant pathology on the detected changes, especially in patients with type 2 DM.

Prospects for further research. The development of algorithms for early diagnosis of diabetes-associated arthropathy is important for the development of methods for timely prevention and pathogenetic treatment of this complication DM in order to improve the quality of life of patients and prevent their early disability.

5. Conclusions

1. When conducting radionuclide studies of hemodynamics in patients with DM 1 type with arthropathy in comparison with patients without joint damage there are no changes in blood flow in vessels of large and medium calibre, as well as arterioles and capillaries of the lower extremities in the presence of severe venous outflow disorders. For patients with type 2 DM with arthropathy, a significant slowing of blood flow in large and medium-sized vessels, as well as arterioles and capillaries, accompanied by venous outflow disorders.

2. The analysis of radionuclide indicators of osteoscintigraphy of the knee and ankle joints in patients with DM 1 and 2 type revealed unidirectional changes, namely a probable increase in both average and total activity in the bone structures of the knee and ankle joints, and a marked increase in the percentage of asymmetry of the total activity of both knee and ankle joints, which confirms the presence of an inflammatory process in the structures of these joints.

3. The applied method of radionuclide diagnostics to assess the state of blood flow and the presence of DA of the knee and ankle joints with a single injection of RPH is an approach to the early diagnosis of this pathology, and impaired venous outflow with constant arterial blood flow in patients with DM 1 type may be a differential criterion of DA in patients with DM 1 and 2 type.

Conflict of interests

The authors declare that they have no conflicts of interest.

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MICROHARDNESS OF FIBERGLASS – REINFORCED PHOTOCOMPOSITE MATERIAL UNDER DIFFERENT CONDITIONS OF LIGHT POLIMERIZATION

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Мета: *у лабораторних умовах вивчити мікротвердість зміцненого скловолокном фотокомпозита за різних режимів світлової дії у різні терміни.*

Матеріали та методи. *Мікротвердість зміцненого скловолокном фотокомпозита everX Posterior, GC, досліджували на 60 зразках за допомогою мікротвердометра ПМТ-3 у термін 1 година, 1 та 7 діб після полімеризації. Зразки циліндричної форми висотою 3 мм 1 групи опромінювали світловим потоком фотополімеризатора за «м'яким стартом», зразки 2 групи полімеризували світлом потоком з постійною високою інтенсивністю 1400 мВт/см^2.*

Результати дослідження. *Через 1 годину мікротвердість на найближчій до світловода поверхні дорівнювала у зразках 1 групи 87,34±1,21 кгс/мм^2, 2 групи – 102,0±0,94 кгс/мм^2 ($p<0,05$), на найвіддаленій – 70,98±1,23 кгс/мм^2 (найнижчий показник) та 90,65±1,12 кгс/мм^2 ($p<0,05$). Через 1 добу на найближчій поверхні мікротвердість зросла у зразках 1 групи до 97,03+1,25 кгс/мм^2, 2 групи – до 114,61±1,13 кгс/мм^2 ($p<0,05$), на найбільш віддаленій – до 75,95±1,11 кгс/мм^2 та 99,83±1,24 кгс/мм^2 ($p<0,05$), відповідно. У 7 діб показники на першій з поверхонь у 1 групі склали 104,64±1,23 кгс/мм^2, у 2 групі – 123,35±1,15 кгс/мм^2 ($p<0,05$), на іншій поверхні – 80,25±1,48 кгс/мм^2 та 107,53±0,92 кгс/мм^2 ($p<0,05$). Зростання мікротвердості на цих поверхнях за увесь термін склало у зразках 1 групи 16,5 % та 11,6 %, 2 групи – 17,3 % та 15,7 %.*

Висновки. *Світловий потік постійної високої інтенсивності забезпечує статистично значуще ($p<0,05$) більш високі показники мікротвердості зміцненого скловолокном фотокомпозита на усіх поверхнях зразків, ніж світловий вплив за «м'яким стартом». Під час прямого відновлення зубів необхідно зменшувати товщину шару фотокомпозита у разі полімеризації за «м'яким стартом»*

Ключові слова: *зміцнений скловолокном фотокомпозит, мікротвердість, полімеризація, світловий потік, інтенсивність, «м'який старт»*