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Clinical and functional effectiveness of nuclear magnetic resonance therapy in the comprehensive treatment of the early stages of gonarthrosis

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Abstract. Gonarthrosis (deforming osteoarthritis of the knee joints) is one of the most common degenerative-dystrophic disorders of the musculoskeletal system, which significantly reduces patients' quality of life and leads to persistent impairment of the functional activity of the lower limbs. In the early stages of the disease, the search for effective, non-invasive and scientifically substantiated therapeutic approaches is particularly important, especially those capable of influencing the regeneration of cartilage and bone tissue structures, reducing pain, and slowing the progression of degenerative changes. The aim of this study was to conduct a clinical assessment of the feasibility of using nuclear magnetic resonance as a therapeutic adjuvant in patients with early-stage gonarthrosis and to determine its effect on the dynamics of key clinical indicators. Within the framework of the study, the results of the comprehensive use of nuclear magnetic resonance therapy alone and in combination with basic treatment methods were analysed in 47 outpatients diagnosed with gonarthrosis. The study group included 19 men (40.4%) and 28 women (59.6%). Evaluation was carried out using indicators of pain intensity, range of motion in the knee joint, functional activity, and the overall clinical condition of the patients. It was established that the inclusion of nuclear magnetic resonance therapy in the treatment programme contributed to significant and sustained clinical improvement. After completion of the treatment course, 80.9% of patients demonstrated a marked reduction in pain and improved mobility, 14.9% showed a moderate positive outcome, while the absence of a pronounced effect was recorded in only 4.2% of cases. The practical value of the obtained results lies in the fact that nuclear magnetic resonance therapy may be regarded as an effective, safe and promising method of conservative treatment for patients with degenerative-dystrophic lesions of the knee joints, capable of complementing traditional treatment approaches and enhancing their therapeutic effect

Keywords: osteoarthritis; knee joint; degenerative changes; cartilage tissue; functional status of patients

INTRODUCTION

Osteoarthritis of the knee joint is one of the most common degenerative diseases of the musculoskeletal system, leading to chronic pain, reduced functional activity and significantly reduced quality of life. Despite the availability of various treatment methods, there are very few effective approaches that affect early pathogenetic mechanisms and inhibit the progression of structural changes in joint tissues. This fact necessitates the search for new, safe and scientifically sound therapeutic strategies. Current scientific research is focused on finding physical methods of influence, in particular magnetic resonance technologies, to modify biological processes in cartilage and bone tissues.

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In the period 2017-2024, active research began on the possible use of MBST® nuclear magnetic resonance for therapeutic purposes. In a study by A. Mann *et al*. [1], scientists analysed the effect of low-intensity nuclear magnetic resonance therapy (NMRT) on the regeneration of dorsal root ganglion neurons in culture. The authors investigated whether NMRT is capable of modulating the behaviour of Schwann cells and neurons, in particular their proliferation, gene expression and neurogenesis processes. The results indicated that NMRT stimulates the proliferation of Schwann cells without changing their phenotype and significantly enhanced neuron survival, neurite formation, and differentiation. In addition, the environment obtained from Schwann cells after NMRT itself promoted the growth and survival of neurons. Thus, the study pointed to the potential ability of NMRT to accelerate peripheral nerve regeneration and highlighted the prospects for its further study as an adjunctive non-invasive therapy.

The study by V. Thöni *et al*. [2] presented an experimental analysis of therapeutic nuclear magnetic resonance (tNMR), the essence of which is that the method was divided into three separate components – tNMR itself, sweep field, and radiofrequency mode – to determine their contribution to cellular effects. As a result, it was found that each mode causes specific changes in reactive oxygen species levels, lactate metabolism, and proliferation indices. The authors concluded that tNMR affects processes dependent on proton gradients, indicating a possible enhancement of the proton motive force of cells. A narrative review by M. Žnidarič *et al*. [3] included an analysis of the potential of molecular biophysical stimulation therapy (MBST), in particular NMRT, in the treatment of chronic musculoskeletal disorders. The authors emphasised the fact that traditional treatments for osteoporosis and osteoarthritis have limited effectiveness and are mainly aimed at reducing pain or increasing bone mass. MBST has been shown to have a safe and non-invasive effect on cartilage regeneration, improving bone tissue quality and reducing symptoms in chronic musculoskeletal disorders, including back pain, making it a promising technology for conservative treatment.

A study by N. Huels *et al*. [4] showed a statistically significant reduction in pain in dogs with osteoarthritis of the elbow joint. Even though this was a veterinary model, the results are important because the pathogenesis of osteoarthritis in animals is similar to that in humans. A scientific review by D. Bichsel *et al.* [5] revealed significant heterogeneity in clinical recommendations for the treatment of hip and knee osteoarthritis, indicating the lack of a universal approach and the need for more standardised evidence-based treatment algorithms. Scientists L.O. Dantas *et al*. [6] summarised the key areas of physical therapy for gonarthrosis, emphasising the importance of exercise, load control and multimodal strategies, the effectiveness of which has been confirmed by clinical data. A study by T. Paolucci *et al*. [7] demonstrated that a new physiotherapy approach leads to a statistically significant reduction in pain and improvement in joint function after just a few weeks of therapy. This discovery is important for the development of effective treatment strategies for this disease. A brief communication by S. Onuora [8] drew attention to the phenomenon of "hyalinisation" as a potential marker of regeneration, opening up new diagnostic guidelines. This phenomenon may become an important tool for monitoring tissue repair processes and evaluating the effectiveness of therapeutic methods. The monograph by K.P.H. Pritzker & H.K. Gahunia [9] presented a summary of the mechanisms of homeostasis, ageing and cartilage degeneration, emphasising the combined role of mechanical stress, inflammatory mediators and cellular metabolism disorders.

Thus, in summary, modern clinical and experimental studies have shown that nuclear magnetic therapy shows promising results in reducing pain, improving joint function, modulating inflammatory mechanisms, and stimulating regenerative processes. The aim of the study was to investigate the clinical and functional efficacy of NMRT in the complex treatment of early stages of gonarthrosis.

MATERIALS AND METHODS

The study was conducted using a combined retrospective-prospective model. Initially, a retrospective analysis of patients' medical records from 2019-2021 was carried out, which made it possible to determine the main clinical characteristics of disease progression and the outcomes of previously applied treatment methods. This was followed by prospective observation of patients who underwent a course of nuclear magnetic resonance therapy, with the aim of assessing the dynamics of clinical status and structural changes in the knee joint. Histological, clinical, radiological, and statistical methods were used in the study. Histological analysis was focused on investigating degenerative-dystrophic changes in the knee joint in rats and assessing morphological signs of the regenerative capacity of cartilage tissue under the influence of nuclear magnetic resonance therapy. The clinical approach involved evaluation of treatment outcomes in patients with early stages of knee osteoarthritis after completion of an NMRT course. Radiological examination made it possible to monitor structural and functional changes in the knee joint at early stages of gonarthrosis during the course of treatment.

During the study, clinical outcomes of the use of NMRT alone and in combination with other treatment methods were analysed in 47 patients diagnosed with gonarthrosis who were receiving outpatient care at the "VinProfiMed" Rehabilitation Centre in Vinnytsia. The group included 19 men (40.4%) and 28 women (59.6%). The mean age of the examined patients was 60.4 years (range 28-77 years). Inclusion criteria were patients diagnosed with deforming osteoarthritis of the knee joints (gonarthrosis) stages I-III. Exclusion criteria included stage IV gonarthrosis, the presence of metal implants, and oncological diseases.

The study was conducted in accordance with international ethical standards. The provisions of the Declaration of Helsinki and the recommendations of the European Commission were observed. Approval from the local ethics committee was obtained prior to the start of the study in accordance with Protocol No. 7 dated 16 September 2021. All participating patients signed informed consent forms for participation in the study and for the processing of their medical data. Potential participants were invited from the patient database of the "VinProfiMed" Medical and Rehabilitation Centre or applied independently. A clinical examination by an orthopaedic trauma specialist was performed, eligibility according to inclusion and exclusion criteria was verified, and medical history was collected (duration of symptoms, previous therapeutic interventions,

comorbidities). Before the initiation of therapy, each patient underwent clinical pain assessment (Visual Analogue Scale, VAS); evaluation of joint function (Lequesne Index or WOMAC, if available); psycho-emotional screening (HADS or PHQ-9, if indicated); knee joint radiography in standard projections to determine disease stage; MRI or ultrasound where indicated to clarify the condition of cartilage, menisci, and periarticular structures; and laboratory tests (complete blood count, C-reactive protein, biochemistry) when clinically required.

These data were used as baseline values for subsequent comparisons. The next stage involved assignment of the therapeutic programme and group allocation. Allocation of patients to the "cartilage" or "bone" NMRT programme was based on clinical and instrumental findings (predominantly cartilage pathology or signs of bone involvement/aseptic necrosis) and individual indications. Subsequently, the treatment protocol (intervention) was determined. The cartilage programme consisted of daily NMRT sessions lasting 60 minutes for seven consecutive days (one course) and was applied to 40 patients. The bone programme consisted of daily NMRT sessions lasting 60 minutes for nine days and was applied to six patients. One patient sequentially completed both programmes, first the cartilage programme and then the bone programme.

During each session, vital signs (blood pressure, heart rate), patients' subjective sensations, and any adverse events or discomfort were recorded. Concomitant (combined) therapy was provided. Thirteen patients received intra-articular injections of hyaluronic acid (the interval between the last injection and the start/end of NMRT was documented); one patient received cell-based therapy, and one patient underwent spa and health resort treatment. All these interventions were documented and taken into account in the analysis as potential covariates. Assessment of effectiveness was repeated immediately after completion of the course and at follow-up examinations at 3 and 6 months. At each stage, clinical scales (VAS, Lequesne/WOMAC), physical examination (presence of swelling, range of motion), and radiological or instrumental methods – when planning long-term follow-up (MRI/ultrasound) – were used to evaluate structural changes.

Treatment was carried out using the certified MBST® system, which generates low-intensity magnetic fields with resonant characteristics adapted for therapeutic effects on cartilage and bone tissue. Ultrasound examinations were performed using expert-class devices, and radiographic examinations were carried out on digital X-ray systems in accordance with medical equipment standards. Statistical analysis was conducted using descriptive statistics; depending on the type of data, the t-test, Mann-Whitney U test, χ^2 test, or their non-parametric equivalents were applied. A p value of < 0.05 was considered statistically significant. Medical data were stored in the centre's secure electronic registry with restricted access and in paper form (patients' medical records). Anonymised datasets with assigned patient codes were used for analysis. Study limitations included a small sample size, variability in the intensity of concomitant treatment in some patients, the absence of randomisation, and the lack of a control group, which may affect the interpretation of causal relationships.

RESULTS AND DISCUSSION

Osteoarthritis is among the most prevalent disorders of the musculoskeletal system and is accompanied by the development of chronic pain syndrome, leading to disability, significantly impairing patients' quality of life and constituting a serious public health problem. For a long time, this pathology was regarded exclusively as a consequence of natural ageing processes; consequently, treatment was predominantly symptomatic, while preventive approaches remained largely overlooked. Research by I. Mařík *et al*. [12] demonstrated that resonant vibration of the molecular structures of cartilage and bone tissue stimulates the proliferation of chondroblasts and osteoblasts, activates the synthetic function of chondrocytes, and reduces proteoglycan degradation. Energy accumulated by cells under the influence of external factors modifies cellular metabolism by enhancing protein expression, ion transport, and the activation of signalling cascades [2].

NMRT is based on the principles of diagnostic magnetic resonance imaging and relies on the phenomenon of nuclear magnetic resonance. Under the influence of a static magnetic field, hydrogen protons in the body align parallel to the field lines, forming a net magnetic moment. A radiofrequency pulse delivered at the appropriate precessional frequency via a coil induces their transition to a higher energy level, after which, during relaxation, the absorbed energy is emitted. The energy transferred to tissues exerts a therapeutic effect [13]. Exposure parameters (field strength, resonant frequency, and procedure duration) are selected individually, taking into account the localisation and stage of the degenerative–dystrophic process. The settings are recorded on chip cards, from which the information is automatically read by the device control unit [14]. To facilitate a clearer understanding of the physical principles and therapeutic potential of the method, its main mechanisms of action are summarised (Table 1).

Table 1. Main mechanisms of action and parameters of NMRT

Component	Description/Characteristics	Therapeutic significance
Physical principle	The phenomenon of nuclear magnetic resonance: precession of hydrogen protons in an external magnetic field and resonant absorption of energy.	Mobilisation of intracellular processes, restoration of energy balance.
Primary fields	Static (0.4-2.35 mT); alternating electromagnetic (17-100 kHz); sinusoidal alternating (stabilising).	Creation of resonance conditions, stimulation of cellular metabolism.
Equipment	Twelve independently controlled coils, orthogonal configuration, local coil for the affected joint.	Formation of a three-dimensional therapeutic field.
Biological effect	Stimulation of chondroblast and osteoblast proliferation; activation of the synthetic function of chondrocytes; reduction of proteoglycan degradation; modulation of ionic transport across membranes.	Restoration of cartilage tissue, reduction of inflammation and pain syndrome.

Table 1. Continued

Component	Description/Characteristics	Therapeutic significance
Safety	Induction 10,000 times lower than that used in diagnostic MRI.	Absence of harmful effects, possibility of repeated treatment courses.

Source: compiled based on I. Mařík *et al.* [12]

The study analysed the effectiveness of NMRT in 47 patients with gonarthrosis who were receiving outpatient treatment at the "VinProfiMed" Rehabilitation Centre in the city of Vinnytsia. The study group was characterised by a wide spectrum of clinical forms of the disease (Fig. 1).

In order to expand and strengthen the analytical nature of the results, patients were divided into subgroups according to age, gender, disease stage, and NMRT programme (Table 2). This division allows for a more accurate assessment of the differentiated effect of therapy and identification of the characteristics of response to treatment in different categories of patients.

This distribution and its analysis demonstrated a tendency toward an increased effect in younger patients, women, and in the early stages of the disease; the combination of NMRT with additional treatment methods shows a synergistic positive effect. Immediately after completing the course of treatment, most patients noted positive changes (Table 3). According to the survey, 38 patients (80.9%) noted a significant reduction or complete disappearance of pain in the affected joint. Seven patients (14.9%) reported moderate improvement, and two patients (4.2%) did not experience significant changes.

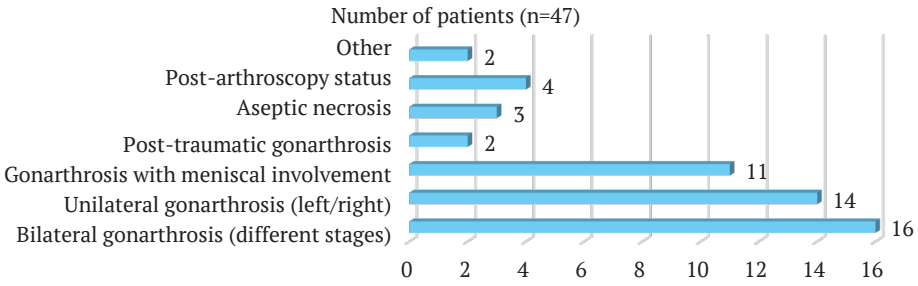

Figure 1. Distribution of patients by diagnosis
Source: compiled by the authors based on the results of a clinical study

Table 2. Distribution of patients into subgroups by age, gender, disease stage, and NMRT programme

Subgroup	Number of patients	Significant improvement, %	Moderate improvement, %	No change, %
Age ⩽50 years	18	88	11	1
Age >50 years	29	76	17	7
Women	25	84	12	4
Men	22	77	18	5
Stage I-II	21	90	10	0
Stage III	26	73	15	12
NMRT standard programme	30	80	15	5
NMRT programme + additional treatment	17	82	12	6

Source: compiled by the authors based on the results of a clinical study

Table 3. Clinical results of treatment

Result	Number of patients (n=47)	Percentage (%)
Significant improvement	38	80.90
Moderate improvement	7	14.90
No change	2	4.20

Source: compiled by the authors based on the results of a clinical study

Among the main complaints reported by the patients were pain (constant and movement-related), restricted mobility in the affected joint(s), and swelling. After completion of the NMRT course, the majority of patients noted a reduction in pain intensity, improved mobility, and resolution of swelling. Patients who received additional treatment (intra-articular administration of hyaluronic acid) demonstrated a relatively more pronounced and rapid positive effect, which can be explained by the synergistic action of different therapeutic modalities. In patients with aseptic necrosis and osteoporosis who received a bone-targeted programme, subjective improvement was also observed, indicating a positive effect of NMRT not only on cartilage but also on bone tissue.

Analysis of the questionnaire-based assessment methods showed that, after completing the NMRT course, patients experienced a statistically significant reduction in pain intensity and an improvement in joint functional status. The dynamics according to the VAS and Lequesne indices were positive and indicated a substantial decrease in pain severity and mobility limitation, thereby confirming the clinical effectiveness of the therapy. Follow-up examinations at 3 and 6 months after the NMRT course demonstrated the persistence of the therapeutic effect: pain intensity remained reduced at a level of 2.8-3.2 points, while anxiety and depression scores according to the HADS scale remained at 7.0-7.5 and 6.0-6.7, respectively (Table 4).

Table 4. Dynamics of clinical indicators in patients at 3 and 6 months after the NMRT course

Indicator	Before treatment (M ± SD)	After 3 months (M ± SD)	After 6 months (M ± SD)	p-value
VAS (pain)	6.8-7.2	3.0-3.4	2.8-3.2	<0.05
HADS – anxiety	9.0-10.2	7.2-7.5	7.0-7.3	<0.05
HADS – depression	8.2-9.1	6.5-6.9	6.0-6.7	<0.05
Lequesne index (function)	8.5-9.3	5.0-5.4	4.8-5.1	<0.05

Source: compiled by the authors based on the results of a clinical study

This fact indicates the long-term positive effect of NMRT on the physical and psycho-emotional state of patients. The changes detected were statistically significant ($p < 0.05$), which is consistent with the data presented in Table 5.

Table 5. Clinical and psycho-emotional outcomes of treatment in patients with gonarthrosis (n = 47)

Indicator	Before treatment (mean ± SD)	After the NMRT course (mean ± SD)	Change	p-value
VAS (pain)	6.8 ± 1.2	3.4 ± 1.0	↓ 3.4	<0.05
Lequesne index (function)	11.2 ± 2.1	7.1 ± 1.9	↓ 4.1	<0.05
HADS – anxiety	10.1 ± 3.4	7.2 ± 2.8	↓ 2.9	<0.05
HADS – depression	9.3 ± 3.1	6.5 ± 2.5	↓ 2.8	<0.05
PHQ-9	12.4 ± 4.2	8.1 ± 3.7	↓ 4.3	<0.05

Note: the arrow '↓' indicates a decrease in values, which indicates improvement; $p<0.05$ – statistically significant dynamics
Source: compiled by the authors based on the results of a clinical study

Thus, it has been demonstrated that a course of NMRT has a positive effect not only on pain and joint function, but also on the psycho-emotional state of patients. According to Table 2, there was a significant reduction in pain intensity as measured by the VAS and an improvement in function (Lequesne index); a decrease in levels of anxiety and depression according to HADS and in depressive symptoms according to PHQ-9; a synergistic positive effect of NMRT on both the physical and psycho-emotional state of patients is clearly evident. Consequently, the obtained results indicate a comprehensive positive impact of NMRT, which includes not only a reduction in pain intensity and improvement in functional activity, but also a decrease in the psycho-emotional burden that accompanies the course of gonarthrosis. A substantial limitation in clinical practice is the absence of objective *in vivo* methods for measuring bone strength, osteoid quality, and cartilage integrity. This complicates the assessment of therapeutic effectiveness and leads to the predominant use of indirect or subjective criteria, which always carries the risk of a "placebo effect". In this context, observations on the use of NMRT are of particular value.

As a result of the discussion, experimental studies have demonstrated the effect of NMRT on the proliferation and viability of chondrocytes and osteoblasts, accompanied by cartilage tissue regeneration and stimulation of bone formation. Clinical observations have confirmed a reduction in pain intensity in osteoarthritis and a decrease in fracture incidence in osteoporosis. Despite extensive experience with its use, this method has not yet been widely implemented in standard medical practice. Thus, the presented clinical observation, together with the results of numerous experimental and clinical studies, confirms the significant potential of NMRT in the treatment of osteoarthritis and osteoporosis. However, the results of certain experimental and preclinical studies do not provide sufficient grounds to recommend NMR as an effective treatment for post-traumatic osteoarthritis at the current stage of research development, as the data demonstrated only moderate and heterogeneous changes in the expression of individual microRNAs, which cannot form a clear mechanistic vector capable of ensuring cartilage tissue regeneration. It should also be noted that the identified molecular changes were not confirmed by corresponding clinical outcomes: the studies did not demonstrate a significant reduction in pain, improvement in function, or structural restoration of cartilage according to imaging criteria. Thus, this indicates that NMRT currently lacks a sufficient evidence base to be recommended as an effective treatment for post-traumatic osteoarthritis.

In the study by B. Steinecker-Frohnwieser *et al.* [15], the cellular effects of NMRT in osteoarthritis were investigated. The authors analysed the microRNA (miR) profile in healthy chondrocytes and in cells from patients with osteoarthritis after exposure to NMRT. It was shown that the therapy prevents a decrease in the levels of miR-106a, miR-27a, miR-34b, miR-365a, and miR-424, which play a key role in the regulation of cellular metabolism. Table 6 presented summarised data on the clinical effects of NMRT obtained from previous studies, demonstrating the main directions of the therapeutic impact of the method. The authors' research results are consistent with these trends

Table 6. Clinical effects of NMRT in gonarthrosis

Indicator	Study results	Clinical significance
Pain syndrome	Reduction in pain intensity according to the VAS by an average of 35-60% after a course of 5-10 sessions.	Relief of symptoms and an increase in the level of daily activity.
Joint functional status	Improvement on the WOMAC and Lequesne scales by 25-40%.	Increase in range of motion and improvement in gait.
Quality of life	Positive dynamics according to the EQ-5D and SF-36 questionnaires.	Psycho-emotional improvement and reduction in fatigue.
Inflammatory activity	Reduction of local swelling and a decrease in C-reactive protein concentration in some patients.	Modulation of the inflammatory process.
Cartilage tissue	In some patients, an increase in cartilage thickness (according to MRI and ultrasound) was observed after 2-3 courses of therapy.	Signs of chondroprotection and potential regeneration.
Need for NSAIDs	Reduction or complete discontinuation of NSAID use in 40-60% of patients after the course.	Lower risk of medication-related complications.
Tolerability and safety	No serious adverse effects were recorded; mild sensations of warmth or tingling in the treatment area were occasionally noted.	Possibility of safe use in the majority of patients.

Source: compiled based on H. Jansen *et al*. [16]

The obtained data indicated that NMRT exerts a multifactorial effect on cartilage and bone tissue cells by activating regenerative processes, modulating epigenetic and signalling mechanisms, and reducing inflammatory activity. At the same time, the problem of studying cellular changes under the influence of NMRT remains open and requires further in-depth investigation. The results were consistent with the conclusions of J. Tong *et al*. [17], who, in a scientific review, reported a significant reduction in pain, decreased stiffness, and improved physical function in patients with osteoarthritis. Similar to the study by G. L. Bagnato *et al*. [18], the present research demonstrated that combining NMRT with additional treatment methods produced a synergistic effect, whereby patients receiving hyaluronic acid injections showed more rapid and pronounced improvement. These findings underlined the importance of a combined approach in rehabilitation and are consistent with previous randomised controlled trials. In addition, S. E. Hashemi *et al*. [19] presented a study in which pulsed electromagnetic fields combined with physiotherapy significantly improved outcomes in patients with knee osteoarthritis, further emphasising the importance of individualising NMRT parameters, as applied in the present study. The meta-analysis by X. Yang *et al*. [20] confirmed the effectiveness of pulsed electromagnetic fields in improving pain, stiffness, function, and quality of life, which corresponds with the present findings regarding the duration of effect and the positive psycho-emotional impact of NMRT. These data allow the conclusion that the present results are consistent with existing evidence and expand upon it by providing detailed clinical observation of treatment effects lasting up to six months.

Separate reports addressed the long-term use of NMRT. In particular, D. Krpan & W. Kullich [21] described a clinical case of a dog with severe chronic osteoarthritis and hip dysplasia that underwent annual NMRT courses over a period of nine years. Sustained preservation of high motor activity and the absence of pain were observed, which the authors attributed to long-term application of the method. Thus, published data on the effectiveness of NMRT in osteoarthritis remain heterogeneous: some studies demonstrate clear clinical benefits, whereas others indicate the need for further research. A review of the literature nevertheless confirmed the clinical effectiveness of NMRT in the treatment of osteoarthritis. The review by J.K. Schmidt *et al.* [22] summarised trial results and confirmed the effectiveness of this technology in patients with various forms of osteoarthritis. The authors reported reduced inflammation, normalisation of cellular metabolism, and increased expression of extracellular matrix proteins. They also highlighted consistency in treatment duration (one hour per session) despite differences in the number of sessions (five to ten). All seven studies included in the review demonstrated a significant positive clinical effect. In six studies, reductions in pain, improvements in joint function, and enhanced quality of life were reported, while one study demonstrated improvement in the structural characteristics of articular cartilage according to ultrasound findings. Thus, NMRT contributes to a reduction in subjective symptom severity and positively affects objective markers of cartilage tissue regeneration. NMRT is an effective treatment method for osteoarthritis that provides a rapid clinical effect even in the presence of pronounced structural joint changes, which justifies its recommendation for use in later stages of the disease.

Thus, the results of the present study confirmed the conclusions of most previous authors while also extending them, demonstrating the promise of NMRT in the comprehensive treatment of patients with various clinical forms of gonarthrosis. Considering the favourable results of clinical and experimental studies, as well as its high safety profile, NMRT may be regarded as an innovative approach to the treatment of degenerative-dystrophic joint disorders. The method has potential as an adjunct to traditional pharmacological and physiotherapeutic interventions. At the same time, most existing studies have methodological limitations, including short follow-up periods, the absence of unified standards for the physical parameters of

electromagnetic fields, and small sample sizes. Data on the cellular mechanisms of action of NMRT remain limited.

CONCLUSIONS

Analysis of contemporary publications has demonstrated variability in the results of studies on the clinical effectiveness of NMRT in osteoarthritis, with a substantial proportion of research reporting a positive impact of this method on disease progression. Individual clinical observations and experimental studies have indicated the ability of NMRT to maintain the viability of cartilage and bone cells, reduce pain manifestations, and improve joint functional activity. In a clinical and experimental study, it was found that the use of NMRT in patients with early stages of gonarthrosis was associated with a pronounced positive clinical effect. The dynamics of patients' condition indicated improvement in functional parameters and a reduction in pain intensity in 80.9% of patients after completion of the treatment course; moderate improvement was observed in 14.9% of participants, while the absence of a therapeutic response was recorded in only 4.2% of cases, confirming the high effectiveness of the method.

Statistical analysis demonstrated that the effectiveness of NMRT therapy was significantly associated with baseline symptom severity and individual clinical characteristics of patients. The most pronounced changes were observed in patients with a shorter duration of symptoms and minimal structural abnormalities according to imaging findings. It was also confirmed that the therapeutic effect persisted for at least six months after completion of treatment, indicating a potentially prolonged action of the method. The study showed that NMRT can be effectively combined with traditional physiotherapy and pharmacological treatments, enhancing the overall effectiveness of comprehensive therapy.

The obtained data indicated that the inclusion of NMRT in rehabilitation programmes may reduce the need for analgesic medications and improve patients' quality of life. High safety, relative ease of application, and the absence of adverse effects make NMRT a promising non-invasive therapeutic technology capable of reducing the need for injection-based or surgical interventions. Thus, the conducted study confirmed the feasibility and clinical effectiveness of nuclear magnetic resonance therapy in the treatment of early stages of gonarthrosis. The results provided a scientifically substantiated basis for the further expansion of NMRT application in clinical practice and create a foundation for future randomised studies. Further research in this area should focus on determining optimal NMRT exposure parameters (frequency, duration, and individualisation of treatment courses) appropriate for specific patient profiles. In addition, it is important to investigate the relationships between biomechanical, morphological, and molecular changes in cartilage tissue under the influence of NMRT.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Клініко-функціональна ефективність ядерної магнітно-резонансної терапії у комплексному лікуванні початкових стадій гонартрозу

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Анотація. Гонартроз (деформуючий остеоартроз колінних суглобів) є одним із найпоширеніших дегенеративно-дистрофічних захворювань опорно-рухового апарату, що суттєво знижує якість життя пацієнтів та призводить до стійкого порушення функціональної активності нижніх кінцівок. На початкових стадіях перебігу патології особливо важливим є пошук ефективних, неінвазивних та науково обґрунтованих терапевтичних підходів, здатних впливати на регенерацію структур хрящової та кісткової тканин, зменшувати больовий синдром і сповільнювати прогресування дегенеративних змін. Метою даної статті було проведення клінічної оцінки доцільності застосування ядерно-магнітного резонансу як терапевтичного ад'юванта у пацієнтів із початковими стадіями гонартрозу та визначити його вплив на динаміку основних клінічних показників. У межах дослідження проаналізовано результати комплексного застосування ядерної магнітно-резонансної терапії окремо та у поєднанні з базовими методами лікування у 47 амбулаторних пацієнтів із діагнозом гонартроз. До дослідницької групи увійшли 19 (40,4 %) чоловіків та 28 (59,6 %) жінок. Оцінювання проводилося за показниками інтенсивності болю, обсягу рухів у колінному суглобі, функціональної активності, а також загального клінічного стану пацієнтів. Встановлено, що включення ядерної магнітно-резонансної терапії до програми лікування сприяло значному та стійкому клінічному покращенню. Після проходження курсу у 80,9 % пацієнтів відзначено виражене зменшення больового синдрому та покращення рухливості, у 14,9 % – помірний позитивний результат, тоді як відсутність вираженого ефекту зафіксовано лише у 4,2 % випадків. Практична цінність одержаних результатів полягає у тому, що ядерна магнітно-резонансна терапія може розглядатися як ефективний, безпечний та перспективний метод консервативного лікування пацієнтів із дегенеративно-дистрофічними ураженнями колінних суглобів, здатний доповнювати традиційні підходи лікування та посилювати їх терапевтичний ефект

Ключові слова: остеоартроз; колінний суглоб; дегенеративні зміни; хрящова тканина; функціональний стан пацієнтів