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# STRATEGY OF AN INTERDISCIPLINARY APPROACH IN THE TREATMENT OF PATIENTS WITH HIP OSTEOARTHRITIS

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# INTRODUCTION

**Relevance of the problem.** Osteoarthritis of the hip joint (OA of the HJ) is one of the most common and socially significant forms of joint damage. This disease, which initially manifests as impaired motor activity, subsequently leads to reduced functional outcomes, quality of life, and working capacity of patients. Alongside cardiovascular diseases, osteoarthritis (OA) has become one of the most frequent reasons for seeking medical attention across various specialties. According to a number of authors, 15–20% of the world's population suffers from OA, with the incidence rate increasing by approximately 20% annually. Experts predict that OA will become one of the most widespread causes of disability by 2030 (Sebbag E., et al., 2019). Currently, no unified treatment approach has been developed by OA study groups and societies (OARSI, ESCEO, etc.) (Bruyère O., et al., 2019; Bannuru R.R., et al., 2019).

Joint replacement with an implant does not always lead to positive outcomes. Complications of this surgical procedure range from 2 to 27% of all cases of THA (Roth A., 2014; Song, S.J., 2014; Kremers H.M. et al., 2015; Ward D.T. et al., 2015). The structure of adverse outcomes after hip arthroplasty is heterogeneous (Akhtyamov I.F. et al., 2019; Khatod M. et al., 2014; Siegel G.W. et al., 2015; Mariaux S. et al., 2018). Both local and systemic complications are noted. These may include deep surgical site infection, periprosthetic fracture, prosthesis instability, and wear of its components (Sineokiy A.D. et al., 2019; Thornley P. et al., 2015; Elbuluk A.M. et al., 2019).

To date, therapeutic approaches to the treatment of OA of the HJ have expanded significantly (Alekseeva L.I., 2015; Mazurov V.I., 2017; Lila A.M. et al., 2022). The use of nonsteroidal anti-inflammatory drugs, glucocorticosteroids, structure-modifying agents, PRP therapy, autologous chondrocyte transplantation, local therapeutic techniques and physiotherapy, as well as minimally invasive surgical interventions, gives patients the opportunity to preserve the functionality of their own joint and, in the long term, prevent or significantly delay the need for arthroplasty (Karateev A.E., Lila A.M., 2018).

Currently, in both broad and specialized academic circles, active discussions are underway regarding the improvement of medical care quality for patients with advanced forms of OA requiring hip joint arthroplasty. Therefore, the study of issues related to the treatment of OA of the HJ is a relevant topic of medical scientific research. Questions regarding the cessation of conservative treatment and indications for THA are often contradictory and remain subjects of discussion both among orthopedic traumatologists and among therapeutic specialists (Gromov, K. et al., 2014; Dabare, K. et al., 2017; Halawi M.J. et al., 2019).

Data from many researchers indicate an increase in the number of patients dissatisfied with arthroplasty outcomes, both in the short term (in the presence of complications) and in the long term after surgery, due to the natural wear of the prosthesis (Kaneuji A. et al., 2015; Huynh C. et al., 2018; Moorhouse A., Giddins G., 2018). The results of studying this problem suggest that in some cases hip joint replacement with an implant was performed prematurely and unjustifiably. This situation prompts the need for special scientific research aimed at developing a set of measures to prevent the adverse consequences of hip joint arthroplasty.

Currently, the problem of competent and comprehensive examination, as well as integrated treatment of patients with OA of the HJ, is socially significant; therefore, the development of a strategy for an interdisciplinary approach to the treatment of hip osteoarthritis is highly relevant today.

**Degree of development of the research topic.** Despite multifaceted scientific investigations by domestic and foreign specialists in the creation and implementation of new methods for the comprehensive treatment of hip OA in medical practice, many questions remain without substantiated answers. In providing medical care to patients with OA of the HJ, the scientific justification of methods to improve treatment outcomes often lacks an evidence-based solution.

**Objective of the study.** To improve the outcomes of treatment for patients with hip osteoarthritis through the development and implementation of a strategy for an interdisciplinary approach to medical care for coxarthrosis.

**Research objectives**

1. To analyze the prevalence of degenerative-dystrophic joint diseases in the regions of the Russian Federation and identify features of their statistical accounting.
2. To assess the frequency and structure of complications in patients who have undergone arthroplasty due to hip osteoarthritis.
3. To determine functional outcomes and assess quality of life in the long term after hip arthroplasty performed for idiopathic osteoarthritis.
4. To identify the impact of comorbidity on long-term outcomes of hip arthroplasty in osteoarthritis.
5. To determine the justification for performing hip joint arthroplasty based on retrospective analysis of pathological examination of the resected femoral head.
6. To compare radiological and morphological changes in the joint in experimentally induced osteoarthritis in terms of the rate and nature of intra-articular changes.
7. To analyze the long-term effectiveness of conservative inpatient treatment of hip osteoarthritis.
8. To develop and scientifically substantiate an algorithm that provides a differentiated approach to the comprehensive treatment of patients with hip osteoarthritis. To establish an interdisciplinary arthrology center and evaluate its effectiveness from the standpoint of organization and therapeutic-diagnostic process technologies.
9. To determine ways to improve treatment outcomes for hip osteoarthritis based on the application of an interdisciplinary approach strategy.

**Scientific novelty**

In the course of the dissertation work, for the first time, long-term outcomes of total hip arthroplasty (THA) for idiopathic and post-traumatic osteoarthritis were studied using the Kaplan–Meier survival analysis method. It was determined that sex, age, and comorbidity do not show statistically significant differences in the analysis of 5-year outcomes.

For the first time, a scientifically substantiated, developed, and tested algorithm for a differentiated approach to the comprehensive treatment of patients with hip osteoarthritis was proposed. It integrates conservative and surgical technologies within the framework of an arthrology center. According to the proposed algorithm, long-term outpatient treatment using SYSADOA preparations and scheduled conservative inpatient therapy for hip joint pathology are advisable before making a decision on THA.

It was demonstrated that determining indications for conservative and surgical treatment should be carried out based on a comprehensive interdisciplinary approach with mandatory assessment of both short- and long-term periods. The most significant parameters for evaluating the effectiveness and outcomes of the proposed treatment methods were established.

For the first time, data from postoperative morphological examination of femoral heads were analyzed from the perspective of the justification and timeliness of performing THA.

A prospective study demonstrated, for the first time, the effectiveness of an algorithm based on an interdisciplinary approach to the treatment of patients with hip OA. In the analysis of long-term outcomes of THA, it was found that the frequency of negative results was twice as low in cases where a multidisciplinary treatment strategy utilizing the resources of an arthrology center was applied (19.6% vs. 9.1%, respectively).

An experimental study confirmed that radiological diagnosis of OA is only possible when the pathological process has already become irreversible, whereas cartilage biopsy can detect the disease at an early stage when the changes are reversible.

For the first time in Russia, a scientific and clinical arthrology center has been established, ensuring the practical implementation of an interdisciplinary strategy in the treatment of hip osteoarthritis.

**Theoretical and practical significance of the study**

The theoretical significance of the study lies in the expanded understanding of the patterns of progression in the initial and terminal stages of hip OA.

Practical recommendations have been developed to improve the quality and accessibility of medical care for patients with hip osteoarthritis.

For the first time in Russia, a scientific and clinical arthrology center has been created, uniting the efforts of specialists from different disciplines with the goal of preserving the hip joint for the longest possible time in OA patients.

The use of the developed multidisciplinary treatment algorithm for hip OA in everyday clinical practice—which takes into account both conservative and surgical treatment options, as well as rehabilitation measures and opportunities for outpatient follow-up and monitoring—has improved treatment outcomes by expanding the application of non-surgical methods and postponing the timing of THA.

**Methodology and methods of the study**

The presented dissertation study was conducted in accordance with the principles and standards of evidence-based medicine. Clinical, laboratory, radiological, morphological, and statistical methods were used during the research. The study included patients aged 23 to 88 years who were admitted for the treatment of hip OA, managed either conservatively or by means of endoprosthesis replacement. The study identified factors that may negatively influence the functional outcomes and quality of life in patients with hip OA.

Within a single-center retrospective–prospective cohort study, data from patients aged 18 years and older with hip OA—regardless of its etiology (idiopathic or post-traumatic)—were analyzed. The study included only those patients who received treatment for hip OA at a specific clinic within a defined timeframe. Patients who died during their hospital stay or underwent revision THA were excluded.

Statistical data on patients with hip OA were analyzed based on their treatment settings: surgical and therapeutic inpatient departments and a specialized interdisciplinary arthrology center functioning at North-Western State Medical University named after I.I. Mechnikov (SZGMU).

Criteria were developed to assess the efficiency of the center in terms of organization and technologies used in the therapeutic and diagnostic process.

Separately, a retrospective study was conducted during 2012–2019 comparing non-personalized data on the prevalence of OA across several regions of the Russian Federation. The materials analyzed included data from all constituent entities of the Northwestern Federal District (NWFD), Moscow, and the Russian Federation as a whole.

An experimental study was carried out at the Department of Industrial Ecology, St. Petersburg State Chemical-Pharmaceutical University (SPCPU), Ministry of Health of Russia, observing all safety protocols. The study involved 20 male Wistar rats weighing 180–250 g. The animals were obtained from the Elektrogorsk branch of the Scientific Center for Biomedical Technologies, FMBA of Russia.

**Provisions to be defended:**

1. The prevalence of degenerative-dystrophic joint diseases across the regions of the Russian Federation is heterogeneous. The incidence of osteoarthritis in Saint Petersburg exceeds that in both Moscow and the national average. A distinctive feature of the statistical accounting of osteoarthritis is the absence of information about this disease in the official statistical reporting forms used in outpatient and inpatient healthcare institutions of the Russian Federation.

2. Under the standard approach to arthroplasty in patients with hip osteoarthritis, both intraoperative and postoperative complications are identified. Their frequency (according to the Clavien–Dindo classification) corresponds to the average values for similar surgeries. The rate of surgical site infection does not exceed 5%, including deep infectious complications—1.5%. In the long-term postoperative period, local complications are predominantly associated with wear and loosening of the prosthetic components.

3. In the long-term postoperative period, the number of patients with excellent and good functional outcomes and quality of life decreases by an average of 15% by the end of the fifth year of follow-up compared to baseline.

4. There are no statistically significant differences in quality of life five years after hip arthroplasty between patient groups with low and high comorbidity levels.

5. In the morphological analysis of femoral heads removed during endoprosthesis implantation, a discrepancy between the histological stage of osteoarthritis and the preoperative radiographic interpretation is observed in one-third of cases. Morphological confirmation of stage 1 or 2 OA may indicate that hip arthroplasty was performed prematurely or without sufficient justification.

6. The changes that develop in experimental OA induced in rats through intra-articular injection of monoiodoacetate and synovial fluid from a patient with osteoarthritis may exhibit similar radiological and pathomorphological characteristics, while differing in the speed and nature of intra-articular changes.

7. Over five years, the number of patients with excellent and good functional outcomes after inpatient non-surgical treatment of hip OA decreases by 7%, and after total hip arthroplasty—by 10%. One in four patients who underwent THA for osteoarthritis had previously received inpatient conservative treatment.

8. When implementing a differentiated treatment algorithm for patients with hip OA, it is crucial to ensure close and continuous collaboration among specialists from various medical fields within an interdisciplinary scientific and clinical arthrology center.

9. A key factor in improving treatment outcomes for patients with hip OA is the integration of a multidisciplinary strategy into the treatment process. Currently, this approach can be implemented by a scientific and clinical arthrology center; in practical healthcare, the establishment of regional arthrology centers modeled after dispensaries appears to be a promising direction.

**Main Scientific Results**

This literature review presents an analysis of current trends regarding controversial issues and unresolved challenges in improving treatment outcomes for patients with hip osteoarthritis (HOA), using both conservative and surgical approaches. More than 350 publications by domestic and international authors were analyzed. The often contradictory opinions of researchers are grouped according to the main issues addressed in this work. Particular attention is given to data on the multidisciplinary approach to the treatment of HOA. Potential prospects for improving outcomes in patients with HOA are presented. (1. p. 62; 2. p. 53; 3. p. 118; 5. p. 32; 6. pp. 100, 170, 172; 7, p.34; 9. pp. 31, 38, 40, 49; 12. pp. 34, 52, 151, 152; 14. p. 105; 18. p. 83; 22. pp. 102, 118, 126; 23. pp. 102, 118, 126; 24. p. 44; 26. p. 55)

It was established that the incidence of osteoarthritis in Saint Petersburg is two or more times higher than in Moscow and the Russian Federation as a whole. The overall incidence rate in Saint Petersburg is 7,480.4 per 100,000 adults; in Moscow – 3,725.8; and on average across the Russian Federation – 3,842.2. This discrepancy is most likely due to regional differences in the statistical accounting of this pathology. (15. pp. 91–97)

Intraoperative complications during total hip arthroplasty (THA) due to HOA were observed in a subset of patients. Overall, complications were verified in 8.7% of patients (local – 5.0%, systemic – 3.7%). Postoperative complications occurred in 16.9% of cases (local – 13.8%, systemic – 3.1%), including: postoperative wound hematoma (3.9%), surgical site infection (5.0%), and dislocation of the prosthetic femoral head (2.1%). In the structure of long-term postoperative complications: wear and loosening of prosthetic components occurred in 7.3% of patients; local infectious complications in 7.7%; prosthesis dislocation in 6.7%. (25. p. 123)

The proportion of patients with excellent and good quality of life five years after THA decreases from 99% to 88%, and those with excellent and good functional outcomes from 97% to 86.6%. (4. p. 106; 8. pp. 103–105; 13. pp. 103–106)

In evaluating THA outcomes among patients with comorbidities, differences were observed in the likelihood of achieving excellent and good quality of life by year five. Patients with severe comorbidities (CCI $\geq$ 3) demonstrated an 83% probability, while patients with mild comorbidities (CCI $\leq$ 2) showed an 88% probability. Nevertheless, no statistically significant differences in survival curves were identified between the groups, as confirmed by the log-rank test ($Z = 0.92$, p-value = 0.33). (21. pp. 98, 107, 110; 30. pp. 98, 107, 109)

Radiological preoperative assessment data do not always correspond to the morphological picture. According to pathomorphological studies, stage III HOA was confirmed in only 60% of patients, while in 40%, stage I–II was observed, indirectly confirming the premature and unjustified nature of some THA interventions. (10, 16, 17. pp. 118–127)

In an animal model of induced OA, radiologically diagnosed early stages were confirmed histologically, though the pathological process was found to be irreversible. However, when the OA-inducing factor was withdrawn, the early stages of OA demonstrated a reversible nature. (20. pp. 128–139)

Under inpatient conservative treatment of HOA, excellent and good functional outcomes declined from 57.4% to 50.3% by year five. For THA, this indicator showed a more significant change: from 97% excellent and good results at year one to 86.6% at year five. Non-operative inpatient treatment was recorded in the history of 26.6% of patients hospitalized for THA. (11, 12, 17. p. 150)

The implementation of a comprehensive treatment algorithm for patients with HOA, incorporating both conservative and surgical techniques, demonstrated that excellent and good five-year functional outcomes were achieved in 90.9% of cases. In the group of patients without prior inpatient conservative treatment of HOA, excellent and good outcomes after five years were verified in 80.4% of cases. (27. pp. 129, 152; 28. pp. 129, 153)

The Scientific and Clinical Center for Arthrology (established as part of this dissertation study) has facilitated the practical application of this algorithm by ensuring access to specialists from various disciplines and providing dynamic outpatient follow-up. (19. pp. 155–162; 28. pp. 156–162; 29. pp. 155–161)

The interdisciplinary treatment strategy for HOA has proven effective from both organizational and technological standpoints. Five years after THA, the proportion of patients with satisfactory and unsatisfactory functional outcomes was twice as high among those who were not treated according to the proposed strategy (9.1% vs. 19.6%, respectively). (11. p. 164)

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30. Urazovskaya, I.L. Survival Analysis Results for Assessing the Quality of Life after Knee and Hip Arthroplasty in Osteoarthritis Patients / I.L. Urazovskaya, V.M. Khaidarov, D.Sh. Mansurov, V.D. Savitsky, V.V. Magdalinov, A.N. Tkachenko // VIII International Congress of the Association of Rheumo-Orthopedists: Collection of Abstracts, Moscow: "Scientific Book", 2024. – P. 86–88.

**Validity and Implementation of the Results**

The general findings of the study were evaluated based on an analysis of data from two groups of patients (retrospective and prospective) who underwent total hip arthroplasty (THA) or received a course of inpatient conservative treatment for osteoarthritis. Taking into account the use of modern technological and organizational methods applied in the diagnostic and therapeutic process, as well as statistical processing, the data obtained are considered reliable and the results of the study – substantiated.

The research findings were presented at the following events: the All-Russian Congress with International Participation “Rheumatology Days” (St. Petersburg, 2019, 2023); the 5th, 6th, 8th, 9th, and 10th All-Russian Congresses with International Participation “Medical Care for Injuries and Emergencies in Peacetime and Wartime. Innovations in Organization and Technology” (St. Petersburg, 2020, 2021, 2023, 2024, 2025); the 7th All-Russian Correspondence Scientific and Practical Conference with International Participation “Public Health and Quality of Life” (St. Petersburg, 2020); the All-Russian Therapeutic Congress with International Participation “Botkin Readings” (St. Petersburg, 2020); the 5th, 7th, and 8th International Congresses of the Association of Rheumoorthopedists (Voronezh, 2021, 2023, 2024); the 12th All-Russian Congress of Traumatologists and Orthopedists (St. Petersburg, 2022); the 17th International Scientific Conference on the State and Prospects of Sports Medicine in Elite Sports “SportMed–2022”, the 9th Scientific and Practical Conference, and the 15th International Scientific Conference of Young Scientists (Moscow, 2022); and the 8th Pirogov Forum of Traumatologists and Orthopedists (Kazan, 2023).

The theoretical and practical results of the dissertation are utilized in the clinical practice of several healthcare institutions in St. Petersburg, including: the Department of Traumatology and Orthopedics at the Peter the Great Clinic of the North-Western State Medical University named after I.I. Mechnikov, Ministry of Health of the Russian Federation; the St. Petersburg State Budgetary Healthcare Institution “St. George City Hospital”; the St. Petersburg State Budgetary Healthcare

Institution “City Polyclinic No. 96”; the St. Petersburg State Budgetary Healthcare Institution “Mariinsky Hospital”; as well as in the educational process at the Department of Traumatology, Orthopedics, and Military-Field Surgery of the North-Western State Medical University named after I.I. Mechnikov, Ministry of Health of the Russian Federation.

**Author’s Personal Contribution to the Obtained Results**

The author personally participated in all stages of the study. The research objectives and tasks were formulated by the author, who also conducted an analysis of national and international scientific literature. The author developed and implemented the research program, which included the design of statistical reporting documents, expert evaluation forms, and patient survey questionnaires. The collected and processed materials enabled the generalization and analysis of the study results. The treatment of patients in the prospective group was carried out under the direct supervision of the author.

The author contributed 90% to the collection of statistical data, 85% to the expert evaluation process, 90% to the data processing, and 100% to the synthesis and analysis of the final research results.

**Volume and Structure of the Dissertation**

The present dissertation comprises 211 pages of typeset text and consists of an introduction, eight chapters, a concluding section, conclusions, and practical recommendations. To enhance clarity and visualization, the dissertation includes 27 tables and 33 figures. The bibliography contains 371 references, of which 251 are sources in foreign languages.

# CHAPTER 1. CURRENT PERSPECTIVES ON THE TREATMENT OF HIP OSTEOARTHRITIS (LITERATURE REVIEW)

## 1.1. History of Osteoarthritis Treatment of the Hip Joint

For a long time, osteoarthritis (OA) was regarded as a degenerative-dystrophic disease primarily affecting the cartilage tissue. However, as scientific knowledge about the nature of OA accumulated, it became evident that the disease affects not only the cartilage itself and is not merely a natural degenerative process of joint structures associated with aging (Khitrov N.A., 2011). Evidence emerged pointing to the involvement of subchondral bone, joint capsule, ligaments, periarticular muscles, and even bone marrow, as well as inflammatory changes in the synovial membrane and synovial fluid (Khitrov N.A., 2011; Ayrapetov G.A., Vorotnikov A.A., Vasyukov V.A., 2020; Hediom E., Huselmann H.J., 2002). The critical role of synovial fluid in maintaining the viscoelastic properties of cartilage tissue was also established (Davies D.V., 1946; Hamerman D., Schuster H., 1958). As new insights into the etiopathogenesis of OA emerged, the paradigm of its treatment began to shift.

At the end of the 19th century, the first non-steroidal anti-inflammatory drugs (NSAIDs) were introduced. Once their analgesic and anti-inflammatory effects were confirmed, these drugs began to be widely prescribed for joint diseases (Hess E.V., Herman J.H., 1986; Brandt K.D., Slowman-Kovacs S., 1986; Wright V., 1995). However, in the 1930s, researchers identified adverse effects of NSAIDs, particularly their damaging impact on the gastrointestinal mucosa, leading to erosion and ulcer formation (Karateev A.E., Nasonov E.L., 2016; Shostak N.A. et al., 2020). Furthermore, it was discovered that NSAIDs may contribute to cartilage degradation—thus, while alleviating symptoms, they may actually worsen the disease course and promote its progression (Ostensen M., 1991).

A promising direction in OA treatment became the use of chondroprotective agents—drugs containing natural components of the cartilage extracellular matrix, such as glucosamine salts (sulfate or hydrochloride), chondroitin sulfate, and hyaluronic acid (Zotkin E.G., 2005). The mechanism of action of these drugs was based on the attempt to influence the composition of synovial fluid (Reginster J.Y., Veronese N., 2021).

In 1971, the ability of glucosamine to promote the restoration of glycosaminoglycans—key components of proteoglycans—was discovered (Dydykina I.S. et al., 2020). Since the 1980s, glucosamine and chondroitin sulfate have been used in the treatment of OA and other joint disorders (Alekseeva L.I., Tsvetkova E.S., 2009). Initially, these agents were considered solely as "building materials" for damaged cartilage tissue. For instance, the study by Bassleer C. et al. (1998) demonstrated increased synthesis of type II collagen and proteoglycans by cartilage chondrocytes during OA treatment with glucosamine sulfate (Bassleer C., Rovati L., Franchimont P., 1998). Subsequent studies revealed that the mechanism of action of chondroprotective agents is complex, multifaceted, and encompasses nearly all key aspects of OA pathogenesis, including anti-inflammatory effects, suppression of matrix metalloproteinase expression, antioxidant properties, induction of chondrocyte apoptosis, and others (Anikin S.G., Alekseeva L.I., 2012). A significant advantage of these drugs was their ability not only to alleviate disease symptoms but also to slow its progression with long-term use.

The use of hyaluronic acid in OA treatment marked a major breakthrough in the management of the disease. The history of hyaluronic acid application dates back to 1934, when the first reports appeared describing a polysaccharide with a very high molecular weight. The world’s first therapeutic drug based on hyaluronic acid was developed and applied in Russia by N.F. Gamaleya in 1943 (Gamaleya N.F., 1946). Hyaluronic acid preparations suitable for OA treatment in humans became available in the 1970s (Rydell N.W., Balasz E.A., 1971). In 1974, Peyron J.G. and Balasz E.A. presented results from the administration of 1, 2, and 3 ml of hyaluronic acid (Healon) into 23 knee joints (Peyron J.G., Balasz E.A., 1974). Positive outcomes were achieved in 74% of patients, with the authors considering the optimal treatment regimen to be two injections of 2 ml each. It was later established that hyaluronic acid is a key component of both cartilage and synovial fluid and, in addition to its pronounced lubricating properties, possesses wound-healing, antiseptic, anti-inflammatory, and reparative effects (Breeva N.V., 2020; Weiss C. et al., 1981; Goldenberg V.M., Bucwalter J.A., 2005).

An innovative approach to OA treatment was the use of intra-articular drug injections. Since the mid-1990s, the term "viscosupplementation"—intra-articular injection of hyaluronic acid and its derivatives—has appeared in foreign literature (Marshall K.W., 1998). Indications for the use of hyaluronic acid preparations included the inefficacy of oral OA treatment or the impossibility of surgical intervention (Wright K.E., Maurer S.G., Di Cesare P.E., 2000).

In 2006, a Cochrane systematic review was published on the use of hyaluronic acid and its derivatives for treating knee OA, summarizing data from 76 studies (Bellamy N. et al., 2006). The review revealed efficacy comparable to NSAIDs and a longer-lasting effect compared to corticosteroids, along with a relatively low incidence of adverse events.

However, despite the positive outcomes observed with chondroprotectors, the clinical effectiveness of these agents remained a subject of debate, and criteria for selecting a specific drug were unclear. This highlighted the need to investigate the efficacy of other drugs for OA treatment.

In the 1940s, the first synthetic injectable glucocorticoid hormones were developed, and the first intra-articular injection was administered in the United States in 1950. This method showed good results due to the strong anti-inflammatory effect of the drugs and was used for a long time for the symptomatic treatment of OA (Menkes C.J., 1994; Jones A., Doherty M., 1996). However, it was soon reported that improvements after glucocorticosteroid use were short-lived and, in some cases, disease progression worsened. In addition, there were findings indicating that these hormones could have a destructive effect on cartilage tissue, thereby aggravating the course of osteoarthritis and causing various complications (Uthman I. et al., 2003). It should be noted that some publications refuted these claims. For instance, Pelletier J.P. et al. (1989, 1994) presented studies conducted on animal models of OA and reported that intra-articular administration of low doses of corticosteroids sufficient to suppress catabolism led to normalization of proteoglycan synthesis in cartilage tissue, significantly reduced the frequency and severity of erosive cartilage damage, and limited osteophyte formation (Pelletier J.P., Martel-Pelletier J., 1989; Pelletier J.P. et al., 1994). Nevertheless, the attitude toward glucocorticoid use became much more cautious, and such drugs were mainly prescribed in cases of pronounced synovitis and joint effusion (Gaffney K. et al., 1995).

Despite the widespread use of conservative treatment for coxarthrosis, the effectiveness of the available medications remained insufficient, which led to expanded indications for surgical treatment.

One of the earliest surgical procedures for OA was arthrodesis—an intervention aimed at creating joint immobility to ensure stability. Numerous arthrodesis techniques were proposed, but the core principles across all procedures included denudation of the bone ends and joint immobilization. The advantages of arthrodesis included the elimination of pain and improved joint stability (Niebauer J.J., King D., 1946; Foley W.B., 1949; Abbott L.R.C., Lucas D.B., 1954; Lipscomb P.R., McCaslin Jr. F.E., 1961). In 1956, Watson-Jones R. and Robinson W.C. presented data on 120 patients aged 10 to 70 years who underwent arthrodesis for hip OA with immobilization in a cast for no less than 4 months (Watson-Jones R., Robinson W.C., 1956). Positive outcomes were noted in 94% of patients based on clinical and radiographic findings. In 1961, Axer A. reported on his experience with hip arthrodesis in 19 patients, 16 of whom showed successful outcomes during a follow-up period of 1 to 5 years (Axer A., 1961).

For a long time, joint arthrodesis remained the only effective method for treating OA. However, this procedure was associated with a number of significant drawbacks: the need for prolonged immobilization in a cast, limb shortening, and joint immobility, which was compensated by functional overload of the knee joint and lumbar spine. In addition, patients experienced difficulties with climbing and descending stairs, as well as discomfort while sitting. The appropriateness of arthrodesis became a matter of debate, as the results were often unsatisfactory. Gradually, arthrodesis began to be used only in cases where the primary goal was pain relief rather than restoration of the joint’s function.

Later, a methodology was developed that combined arthrodesis with osteotomy, which proved effective in cases of hip joint (HJ) deformity, as it allowed for decompression and offloading of axial stress from the affected joint. Thus, A.G. Apley and R.A. Denham (1955) performed 33 arthrodeses without osteotomy, of which only 13 yielded satisfactory outcomes, whereas 23 arthrodeses combined with high osteotomy resulted in positive outcomes in 22 cases (Apley A.G., Denham R.A., 1955). At the same time, the advantages of osteotomy included joint preservation, pain reduction, and the postponement of radical surgical intervention, which made these procedures relevant in specific clinical scenarios.

As a joint-unloading surgery for hip OA, fenestration of the tendinous-fascial complex in the region of the greater trochanter was also proposed. This intervention contributed to reduced pressure on the femoral head, improved regional blood supply, and pain relief (Åström J., 1975; Hietala S.O., Åström J., 1977).

The next stage in the development of surgical technologies for hip OA was total hip arthroplasty (THA), which allowed for a stable and long-lasting favorable outcome. The first attempts at hip replacement date back to the 1830s. In the early stages, various foreign (alloarthroplastic) materials were used to fabricate femoral prostheses, including wood, rubber, ivory, latex, and glass (Gluck T., 1890; Judet J., Judet R., 1950; Huggler A.H., 1972). A significant milestone in the history of THA is associated with the names of C.S. Venable, W.G. Stuck, and A. Beach, who in 1937 presented a study noting that a cobalt-chromium-molybdenum alloy (Vitallium®) surpassed other metal prostheses in terms of biocompatibility, corrosion resistance, mechanical properties, and the absence of adverse reactions from periprosthetic tissues (Venable C.S. et al., 1937).

To improve the effectiveness of surgical treatment methods for coxarthrosis, M.N. Smith-Petersen (1939, 1948) proposed the use of a spherical cap made of Vitallium® alloy, which was placed over the affected femoral head. In parallel, O.E. Aufranc developed an acetabular component with a hemispherical shape that more closely resembled the natural anatomy of the acetabulum (Aufranc O.E., 1957). This type of arthroplasty was popular until the 1960s, but was gradually phased out.

A major milestone in the history of THA was the development of cementless technology. In 1938, P. Wiles in London performed the first cementless total hip arthroplasty using stainless steel components; prosthetic stability was achieved through an extramedullary plate with screw fixation passing through the femoral neck (Wiles P., 1958). In 1943, A.T. Moore and H.R. Bohlmann proposed a fenestrated prosthesis that was securely fixed in the intramedullary metaphyseal-diaphyseal space using fins and included perforations in the proximal third that allowed for progressive bone ingrowth (Moore A.T., Bohlmann H.R., 1943).

As THA technology continued to evolve, ultra-short stem prostheses were developed, which were fixed only within the femoral neck and part of the proximal metaphysis. These prostheses were expected to enhance joint stability. In 1946, J. Judet and R. Judet proposed a design for ultra-short stem prostheses made of acrylic glass (Plexiglas®), which were fixed in the femoral neck using a central steel pin (Judet J., Judet R., 1950). However, the initial models of ultra-short or short-stem prostheses did not gain wide acceptance due to their high wear rates. The medical community continued searching for safe, stable, and durable prosthetic designs. In 1966, G.K. McKee and J. Watson-Farrar introduced a total removable prosthesis made of Vitallium®, marking the beginning of cementless total metal-on-metal prostheses (McKee G.K., Watson-Farrar J., 1966; McKee G.K., 1970).

The history of cemented THA began in 1960, when J. Charnley proposed the fixation of the prosthesis using methyl methacrylate as bone cement (Charnley J., 1960). The method introduced by J. Charnley served as a prototype for the development of modern hip prosthesis designs. It is worth noting that bone cement was approved by the FDA in the United States in the early 1970s, after which the cemented THA technique became widely adopted (Huggler A.H., 1972; Gómez-García F., 2021).

In the Soviet Union, the first arthroplasty procedures were performed in 1954 by N.N. Blokhin. In the early 1960s, orthopedic surgeon K.M. Sivash developed a cementless total prosthesis that gained widespread use primarily in Eastern

European countries. Other notable Soviet researchers involved in the development of THA included Ya.L. Tsivyan and A.V. Kaplan (Vishnyakov A.N., 2018).

### 1.2. Outcomes of Total Hip Arthroplasty

The primary criteria for evaluating the outcomes of total hip arthroplasty (THA) are prosthesis survivorship, functional results, and quality of life. Prosthesis survivorship refers to the duration during which the implant ensures adequate joint function. Implants demonstrating a survivorship rate of 95–98% over a 10-year period are considered highly effective. Functional outcomes imply the assessment of the restoration of the affected limb’s function, reflected in the increased range of motion in the replaced joint. Quality of life is defined as an integrated measure of an individual's physical, psychological, emotional, and social functioning, based on their subjective assessments (Novik A.A., Ionova T.I., 2012).

By the 1950s, approximately 30 different designs of hip prostheses had been proposed and used in subsequent years. Compared to conservative treatment or palliative surgeries, THA procedures performed from the 1950s to the 1980s led to improved joint function, increased range of motion, and reduced pain. However, due to the limitations of surgical techniques and the use of foreign materials, the results of these early operations were often unsatisfactory. The main complications at this stage included aseptic loosening of implants, mechanical failure of the prostheses, and metallosis, which led to bone resorption and impaired organ function (Judet J., Judet R., 1950; Mulder J.D., 1951; D'Aubigne R.M., 1954). The Vitallium® prosthesis introduced by M.N. Smith-Petersen often resulted in aseptic necrosis of the femoral head and unstable acetabular fixation, which subsequently led to destruction of the femoral head and neck, as well as increased joint hypermobility (Aufranc O.E., 1957; Ismael A. et al., 2022).

During this period, uncemented prosthesis models that involved only replacement of the femoral head (monopolar prostheses) were most commonly used. However, they had a significant drawback—over time, protrusion of the prosthetic head into the pelvis through the acetabulum occurred (Thompson F.R., 1954; Leinbach I.S., 1969).

As surgeons gained more experience in performing THA and prosthesis models were improved, surgical outcomes began to improve. The range of materials used for implants expanded (metal–polymer, metal–metal, ceramic–polymer, ceramic–ceramic), and total THA technologies began to be actively implemented (Gerard Y., 1978; Garvin K.L. et al., 1991; Grigoris P. et al., 2005). For example, R.A. Lapp and J. Schatzker (1981) reported excellent outcomes of total THA using the uncemented Wagner conical prosthesis in 51 patients ranging in age from 12 to 70 years (Lapp R.A., Schatzker J., 1981). All patients, except one, experienced complete or significant pain relief; stem loosening was observed in only two cases.

At the same time, other researchers noted that total THA was associated with an increased risk of certain complications compared to unilateral procedures. For instance, M.A. Ritte and J.C. Randolph (1976) compared the outcomes of 50 patients who underwent bilateral total hip replacement in a single-stage procedure with those of 50 patients who underwent unilateral total hip replacement. In the total THA group, the duration of surgery and intraoperative blood loss were twice as high as in the unilateral group. In addition, hospital stay was, on average, 7 days longer, and the incidence of phlebitis and ossifying myositis was higher. However, no differences were found in mortality rates, the incidence of infectious complications, or functional outcomes.

J. Parvizi and B.F. Morrey (2000) evaluated the effectiveness of bipolar THA for the treatment of recurrent hip instability in 27 patients following total hip replacement. The mean follow-up period was 5 years. Bipolar arthroplasty prevented recurrent dislocation in 22 cases (81%). At the final follow-up, the hip joint was stable in 25 patients (93%). The authors concluded that bipolar THA may be used to treat recurrent instability of the hip joint in patients when other stabilizing procedures have proven ineffective.

It should be noted that during the 1950s–1980s, a significant number of revision surgeries were performed. G.A. Hunter et al. (1979) analyzed 140 hip revision procedures performed due to aseptic loosening, dislocation, or fracture of the femoral stem or femoral diaphysis (Hunter G.A. et al., 1979) and found a high incidence of postoperative wound infections following revision surgeries, suggesting that infection may have been present at the time of the revision. Other researchers identified infectious complications as the primary cause of unsatisfactory outcomes of THA procedures performed during this period, particularly noting their detrimental impact on functional outcomes and quality of life in elderly patients (Nelson C.L. et al., 1980; Petty W., Goldsmith S., 1980; Linnik S.A. et al., 2021).

At the same time, a retrospective analysis of patients under the age of 30 who underwent THA between 1989 and 2009 showed that the revisions in this group were mainly associated with aseptic loosening of the acetabular component (Daras M., Macaulay W., 2009; Agrawal Y. et al., 2021).

According to W.F. Mulroy and W.H. Harris (1996), the re-revision rate within 15 years among 41 patients who underwent revision arthroplasty was 20% (Mulroy W.F., Harris W.H., 1996).

To improve the outcomes of repeated revision THA, I. Atroshi et al. (2004) proposed combining hip revision with bone grafting, which significantly improved patients' quality of life (Atroshi I. et al., 2004).

A number of publications in the literature report long-term positive outcomes of hip arthroplasty for OA over a 10–15-year postoperative period (Bateman J.E. et al., 1990; Archibeck M.J. et al., 2001). The 10-year survival rate of the prosthesis was 96.4%±2.1% for total hip prostheses, 100% for the femoral component, and 96.4%±2.1% for the acetabular component (Archibeck M.J. et al., 2001).

Of particular interest is the study by C. Götze et al. (2006), which reported the outcomes of 137 THA procedures using a cementless porous metal Lübeck prosthesis with a mean follow-up period of 12.8 years (Götze C. et al., 2006). The cumulative prosthesis survival was 90%±8% for the cups and 86%±5% for the stems at 14.9 years. There were only 4 cases (3%) of prosthesis fracture. Functional outcomes were assessed using the W.H. Harris Hip Score (HHS), with a mean score of 88 (range 34–100). Notably, in patients over 60 years of age, there were no significant differences in quality-of-life scores using the MOS SF-36 questionnaire compared to a healthy population of the same age group, while in patients under 60, physical functioning scores were significantly lower ($p<0.01$), though mental health domains were comparable ($p>0.05$).

In recent years, numerous studies aimed at improving prosthesis designs and surgical techniques have led to significant advances in THA. Under current conditions, THA enables effective restoration of limb function, elimination or reduction of pain, and improvement in quality of life, thereby contributing to the social and occupational rehabilitation of patients with OA (Świtoń A. et al., 2017; Moorhouse A., Giddins G., 2018). While initially considered a rare and high-risk procedure, THA has gradually become one of the most common surgical interventions. In 2007, I.D. Learmonth, C. Young, and C. Rorabeck referred to THA as the "operation of the century" in their publication in *The Lancet*. According to projections, the demand for primary total THA will increase by 174% by 2030 compared to 2005, while the demand for revision hip surgeries will double by 2026 (Kurtz S. et al., 2007; Aliev B.G. et al., 2023).

Currently, the 10-year survival rate after primary total THA is estimated at 95–97%; however, in certain clinical scenarios, survival rates are significantly lower. For instance, among younger patients and those with complex pathology or severe comorbidities, prosthesis survival rates range from 70% to 80% (Bliznyukov V.V. et al., 2014; Podmore B. et al., 2018; Boyer B. et al., 2019; Zeng W.N. et al., 2019).

According to contemporary concepts, particular attention should be paid to PRO (patient-reported outcomes) criteria when evaluating treatment outcomes, as they represent a subjective assessment of health status without interpretation by a physician or any third party (Guidance for Industry, 2006). Using the Oxford Hip Score (OHS), the WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index), and the SF-36 quality-of-life questionnaire, M.G.H.Y. Yeo et al. (2020) found that 93.1% of patients were satisfied with the results two years after

THA (Yeo M.G.H. et al., 2020). Another recent study with a two-year follow-up after THA demonstrated a correlation between pain severity (HOOS/KOOS), activities of daily living (ADL), and health-related quality-of-life indicators (Goodman S.M. et al., 2020). The greatest improvements in quality of life were associated with the highest levels of pain relief and joint function restoration.

In a study by G. Grappiolo et al. (2021) with a mean follow-up of 13.0±6.2 years after THA, significant improvements were recorded in HHS and the Visual Analogue Scale (VAS) from 46.0±16.7 to 80.8±18.8 points and from 4.4±1.5 to 2.1±1.4, respectively ($p<0.001$). Twenty-three patients (40.4%) exhibited a positive Trendelenburg sign, heterotopic ossification was observed in 29 cases (49.1%), and the overall complication rate was 29.8%. Implant survival rates were 98.7±1.3% at 5 years, 92.4±3.3% at 10 years, 82.1±5.7% at 15 years, and 73.4±8.0% at 20–25 years. Implant survival was lower in patients with prior hip surgeries. According to patient surveys, the majority were satisfied with the surgical outcomes (Grappiolo G. et al., 2021).

A study by domestic authors assessing mid- and long-term outcomes of 349 “metal-on-metal” total THA procedures found excellent clinical and functional outcomes in 76.6% of patients and good outcomes in 10.9%, based on the Oxford Hip Score (Shubnyakov I.I. et al., 2017). According to the W.H. Harris scale, 57.9% of patients had excellent results, 15.6% good, 7.8% fair, and 18.7% poor. The majority of patients (77.2%) had an optimal acetabular component position based on radiographic data. There were 16 cases of periprosthetic effusion, 5 cases of pseudotumors, and cobalt and chromium ion concentrations were within normal ranges for all patients. Prosthesis survival was 89% (range 80–97%).

Total THA is now increasingly performed in younger patients. According to X.Y. Mei et al. (2019), in patients under 55 years of age, the mean 5- and 10-year prosthesis survival rates were 98.7% and 94.6%, respectively. Long-term survival rates beyond 10 years varied from 27% to 99.5%. The rates of dislocation, deep infection, and revision for any reason were 2.4%, 1.2%, and 16.3%, respectively. The mean Harris score improved from 43.6 to 91.0 points. The authors concluded that total THA in patients under 55 provides reliable outcomes for up to 10 years postoperatively (Mei X.Y. et al., 2019). In another study involving 260 total THA procedures in patients under 35 years of age with follow-up ranging from 1 to 14 years, excellent and good results were observed in 85.3% of cases, satisfactory in 12.8%, and unsatisfactory in 1.9%, the latter being due to infection and subsequent prosthesis removal (Zagorodny N.V. et al., 2015).

To improve THA outcomes, fast-track recovery protocols are now being used, enabling pain reduction and improved joint function as early as 7 days postoperatively (Fransen B.L. et al., 2018).

It is worth noting that in the available literature, insufficient attention has been paid to the impact of THA on postural balance. In 2019, F. De Lima et al. presented a systematic review of 13 studies examining the effects of primary THA for OA on postural balance compared with preoperative status and/or healthy individuals (de Lima F. et al., 2019). The authors highlighted the inconsistency of findings. While five studies reported advantages of surgical treatment for OA in terms of postural balance, three studies demonstrated better results among healthy individuals. Two studies showed that postural balance may be impaired from 6 months to 3 years postoperatively, and three studies without a healthy control group reported improvements compared to preoperative balance. The reviewers concluded that assessment of changes in postural balance may be useful for evaluating the effectiveness of surgical interventions (de Lima F. et al., 2019).

Thus, in recent years, the technologies and methods of THA have undergone substantial advancements, allowing for excellent and good treatment outcomes in patients with coxarthrosis.

### 1.3. Unresolved Issues in Total Hip Arthroplasty

Despite significant advances in THA, the risk of complications at various postoperative stages persists. These complications can be conditionally classified as general (e.g., thrombosis, infections) and procedure-specific (e.g., instability and failure of prosthetic components, dislocation, periprosthetic fractures of the pelvis and femur) (Enge Júnior D. J. et al., 2020). A prospective study involving 976 patients from 14 medical centers across 7 countries found that more than 10% of patients were dissatisfied with the long-term functional outcomes of THA (Galea V.P. et al., 2020). The spectrum of THA complications is extensive. The Hip Society’s THA Complications Workgroup in the U.S., based on extensive surgical outcome analysis, identified 19 potential complications, including hemorrhage, delayed wound healing, thromboembolism, neurological deficit, vascular dysfunction, prosthetic dislocation/instability, periprosthetic fracture, abductor muscle rupture, periprosthetic joint infection (PJI), heterotopic ossification, bearing surface wear, osteolysis, implant loosening, liner dissociation, implant fracture, reoperation, revision surgery, rehospitalization, and mortality (Healy W. L. et al., 2016; Ismael A. et al., 2022).

Periprosthetic joint infection remains one of the most pressing concerns in THA. Its management often requires repeated surgical interventions and prolonged antibiotic therapy. Infectious complications are associated with low patient satisfaction and high socioeconomic burden (Bozic K. J. et al., 2010). PJI is also linked to increased mortality, particularly in elderly populations (McGarry S.A. et al., 2004).

The incidence of infectious complications following primary THA ranges from 0.3% to 3% (Murylyev V. et al., 2018), with some reports suggesting rates as high as 5–8% (Bozhkova S.A. et al., 2015; Dorofeev Yu.L. et al., 2015; Barrett L., Atkins B., 2014; Hawker G. et al., 2015). Data show that the incidence of infections during hospitalization is about 0.2%, rising to 1.1% within five years postoperatively (Urquhart D.M. et al., 2010).

According to Inabathula A. et al. (2018), the infection rate within 90 days after THA was 2.2%, with the risk of developing PJI being four times higher in patients who did not receive antibiotic prophylaxis. A study by domestic authors analyzing the outcomes of 260 THAs in 221 patients under the age of 35 found poor outcomes in 5 patients (1.9%) due to infection and subsequent prosthesis removal (Zagorodniy N.V. et al., 2015).

Heterotopic ossification is one of the most common long-term complications of THA. Z. Morison et al. (2016) reported a high incidence (43%) of clinically significant heterotopic ossification over a two-year period, with around 40% of cases classified as Brooker class II. Other sources suggest a prevalence of 15–50%, although only 1–5% of patients experience clinical manifestations (Keogh C.F. et al., 2003).

A review by R.D. Jr. Stibolt et al. (2018) included data from 10 studies involving 448 patients undergoing THA for post-traumatic osteoarthritis between 1995 and 2017. Over follow-up periods ranging from 4 to 20 years, the most common postoperative complications were heterotopic ossification (28–63%), implant loosening (1–24%), and infection (0–16%). The minimum 5-year implant survival rate ranged from 70% to 100%, and revision rates varied from 2% to 32%.

C. Bellabarba et al. (2001) found that only 20% of patients who received prophylaxis against heterotopic ossification developed the complication, compared to 50% without prophylaxis. Similar results were reported by other authors, noting that the anterior surgical approach and preoperative prophylaxis were associated with a lower incidence of heterotopic ossification (Newman E.A. et al., 2014; Archdeacon M.T. et al., 2014).

Acetabular or femoral shaft fractures during THA occur in 0.4–5% of cases intraoperatively, more frequently with uncemented fixation (Masterson S. et al., 2012; Tikhilov R.M., Shapovalov V.M., 2008). Implant dislocation is observed in 7.5% of total hip arthroplasties (Kanzoba A.I., 2016).

S.E. Lvov et al. (2013) followed 88 THA patients over 6–7 years and reported unsatisfactory results in 9 cases (10.2%), mainly due to persistent pain and functional impairment, though without signs of PJI or implant instability (Ismael A. et al., 2022).

Chinese researchers retrospectively analyzed clinical data from 354 patients (384 hips) who underwent THA using ribbed femoral stem prostheses (Yang T. et al., 2019). With an average follow-up period of 7.4 years, 2 cases of prosthetic joint infection, 3 cases of prosthesis loosening, and 4 cases of periprosthetic fractures were identified, as well as 48 cases of mild to moderate pain in the hip joint area. In addition, femoral stem subsidence was recorded in 25 cases, and a leg length discrepancy of more than 10 mm was noted in 5 patients.

A retrospective cohort study based on the South China THA database examined long-term outcomes of cemented (n = 164) and cementless (n = 160) THA (Liu T. et al., 2019). The median follow-up was 73.3 months, ranging from 11.6 to 89.2 months. The revision rate in the cementless group was 7.5% compared to 1.8% in the cemented group ($p = 0.015$); prosthesis loosening occurred in 17.5% vs. 8.5%, respectively ($p = 0.016$); and the incidence of periprosthetic fractures was 11.9% vs. 4.9%, respectively ($p = 0.021$).

Currently, metal-on-metal (MoM) bearing surfaces are widely used, especially in young and active patients. According to some reports, the wear rate of MoM implants is 60 times lower than that of metal-on-polyethylene implants (Cuckler J.M., 2005). However, the literature reports specific complications associated with MoM bearing surfaces, collectively referred to as "adverse reactions to metal debris," which include metallosis, pseudotumors, and aseptic lymphocytic vasculitis (Drummond J. et al., 2015). Timely diagnosis of these conditions is often hampered by their frequently asymptomatic nature, despite their locally destructive effects on adjacent muscles and bone.

In the United Kingdom, an analysis of 660 THA cases using MoM prostheses identified 17 patients (3.4%) with adverse reactions to metal debris who required revision surgery (Langton D.J. et al., 2010). These patients showed significantly elevated levels of metal ions (cobalt and chromium) in the blood and synovial fluid; histopathological examination revealed extensive histiocytic and lymphocytic infiltration with areas of tissue necrosis, and 16 patients experienced groin pain between 2 and 25 months postoperatively.

A study conducted jointly by researchers from the USA, Italy, and Finland included a total of 158 patients, with a mean time to symptom evaluation of 7.6 years (range: 3.4–11.4 years). The proportion of patients with moderate to severe adverse reactions to metal debris was 14.7–15.6% in the case of surface arthroplasty (hip resurfacing) and 32.7–36.7% in total hip arthroplasty (Laaksonen I. et al., 2021).

A single-center retrospective study conducted in France with a follow-up period of at least 17 years included 115 hip joints (Erivan R. et al., 2019). Implant survival until revision for any reason was 86.10% (95% CI, 79.8–92.4%), and survival until revision for aseptic loosening was 92.6% (95% CI, 87.7–97.6%). In half of the specimens obtained during revision surgery, a macrophage reaction and nonspecific inflammatory infiltrate were observed.

A. Reito et al. (2013) reported unsatisfactory overall survival of metal-on-metal hip prostheses in patients under the age of 40, despite good functional outcomes (Reito A. et al., 2013). In a domestic study with a 12-year follow-up of 64 patients who underwent THA with metal-on-metal bearing surfaces, an unsatisfactory result was recorded in 13 cases (3.1%) (Lyubchak V.V. et al., 2019). Patients complained of persistent pain in the hip and groin, varying degrees of motion limitation in the operated hip joint, limping, and difficulties with self-care. Revision surgery was required in 7 cases, with pseudotumor diagnosed in 5 patients.

Some authors report unsatisfactory outcomes with hydroxyapatite-coated prostheses associated with osteolysis, polyethylene liner wear, and aseptic loosening. For example, in a South Korean study, the results of 66 consecutive uncemented primary acetabular arthroplasties using hydroxyapatite-coated metal-on-polyethylene cups were retrospectively analyzed (Han C.D. et al., 2015). In 39 cases (59.1%), prosthesis failure was attributed to progressive acetabular osteolysis or aseptic loosening of the cup. Acetabular osteolysis was observed in 47 hips (71.2%), and 33 hips (50.0%) required revision due to cup loosening. The survival rate of the acetabular cup was 46.3% at 15 years and 34.8% at 20 years. The authors concluded that THA with hydroxyapatite-coated acetabular cups demonstrated unsatisfactory long-term survival due to progressive osteolysis. Similar findings were reported in studies conducted in Poland (Blacha J., 2004), Sweden (Lazarinis S. et al., 2010), Finland (Eskelinen A. et al., 2006), and Japan (Nakashima Y. et al., 2013).

A group of Austrian researchers found that, among 49 patients two years after THA with a short uncemented metaphyseal-anchored femoral stem, 5 patients (10%) exhibited increased vertical stem migration (1.5 mm/2a), which serves as a predictor of late aseptic loosening of the prosthesis (Kaipel M. et al., 2015).

In the study by K. Goto et al. (2019), unsatisfactory long-term outcomes of THA using bioactive bone cement containing apatite–wollastonite glass ceramic powder and bisphenol-A-glycidyl methacrylate resin were demonstrated (Goto K. et al., 2019; Aliev B.G. et al., 2021). The mean follow-up period was 17.6 years. Among 20 patients, radiographic analysis showed aseptic loosening of the prosthesis in 4 cases, on average 7.8 years postoperatively (range: 1.5–20.7 years). The survival rates ranged from 84.4–94.7% at 10 years and 62.8–84.4% at 20 years; the average linear wear rate was 0.068 mm per year. The authors noted the brittleness and unsatisfactory performance characteristics of this type of bone cement.

The literature provides conflicting data on comparative outcomes of THA performed via anterior versus posterior approaches. For instance, a recent study by K. Moerenhout et al. (2020) found no difference in complication rates between anterior and posterior approaches in THA, whereas according to L.E. Miller et al. (2018), the anterior approach was associated with a lower risk of reoperation, prosthetic dislocation, and infection, but a higher risk of nerve injury compared to the posterior approach.

Interesting findings were obtained from an analysis of the Swedish Hip Arthroplasty Register. An evaluation of over 90,000 THA procedures showed that the effect of surgical approach on the risk of revision depends on the type of implant used (Lindgren V. et al., 2012). For the Lubinus SPII and Spectron EF Primary prostheses, the anterolateral transgluteal approach was associated with an increased risk of revision due to aseptic loosening, but a reduced risk of revision due to dislocation. In contrast, for the Exeter Polished prosthesis, the surgical approach did not influence the outcome. At the same time, the risk of infectious complications was not affected by the type of approach.

Pulmonary complications following THA are rare but pose a serious risk to the patient. A large-scale study in the United States examined the incidence of pulmonary complications following THA and knee arthroplasty from 2004 to 2014 (Malcolm T.L. et al., 2020). Among 2,679,351 patients who underwent elective primary THA, 1.42% developed early postoperative bronchopulmonary complications such as pneumonia, respiratory failure, pulmonary embolism (PE), or aspiration. The highest risk of pulmonary complications was observed in patients with a history of significant weight loss, fluid and electrolyte imbalances, congestive heart failure, prior paralysis, and HIV infection. Perioperative pulmonary complications were associated with prolonged hospital stays, increased healthcare costs, and elevated mortality.

Neurological complications are another cause of unsatisfactory THA outcomes, significantly affecting surgical results and patient quality of life. According to a review conducted by Korean researchers, the incidence of neurological complications after primary THA ranges from 0.7% to 3.5%, but may rise to 7.6% after revision THA (Yang I.H., 2014). The sciatic and peroneal nerves are most frequently affected; femoral nerve injury occurs in 0.1–0.2% of cases, while obturator nerve injury is even rarer.

Thromboembolic complications following THA are a major concern due to their impact on hospital stay length, surgical outcomes, mortality risk, and additional healthcare costs estimated at USD 15,000–30,000 per episode (Shahi A. et al., 2017; Warren J.A. et al., 2019). A.B. Pedersen et al. (2014) analyzed data from the Danish Hip Arthroplasty Register from 1997 to 2011 and found a 90-day venous thromboembolism (VTE) incidence rate of 1.3%, with no significant change over time (Pedersen A.B. et al., 2014). J.M. Januel et al. (2018) assessed VTE incidence before discharge in five countries (Canada, France, New Zealand, Switzerland, and the state of California, USA) between 2006 and 2010 and reported a VTE incidence ranging from 0.16% to 1.41% (Januel J.M. et al., 2018). Warren J.A. et al. (2020), using data from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) from 2008 to 2016, found an average 30-day VTE incidence of 0.6%, including deep vein thrombosis (DVT) in 0.4% of cases and pulmonary embolism in 0.3% of patients (Warren J.A. et al., 2020).

At the same time, according to data from Korea's National Health Insurance (NHI), the 90-day VTE incidence after THA was 3.9% (DVT – 2.7%, PE – 1.5%), which was higher than in other studies (Lee S. et al., 2016). This may be due to the low rate of VTE prophylaxis, which is administered in only 37.3% of cases.

The mortality rate after THA is estimated at 0.2–4.5% (Dorofeev Yu.L. et al., 2015; Gandhi R. et al., 2009). The most common causes of death include PE, acute coronary syndrome, and sepsis. It should be noted that the risk of poor outcomes, including mortality, is increased in patients with significant comorbidities, particularly among the elderly and senile population (Ivanov L.V. et al., 2019; Tsed A.N., Dulaev A.K., 2018; Shilnikov V.A. et al., 2018; Mimura T. et al., 2014; Roger C. et al., 2019).

In 2021, A.J. Silman and colleagues conducted a study that demonstrated a strong correlation between the American Society of Anesthesiologists (ASA) physical status classification and patient mortality following endotracheal bronchoscopy (Silman A.J. et al., 2021). This large-scale study analyzed data from six national registries (Australia, Finland, the Netherlands, New Zealand, Norway, and Sweden) and one U.S. healthcare organization registry, totaling 418,916 THA procedures. Overall, the one-year mortality rate was 0.93% (95% CI: 0.87–1.01) and increased from 0.2% for ASA Class I to 8.9% for ASA Class IV.

According to data from the Danish Hip Arthroplasty Register, which included 99,962 patients from 1996 to 2013, the 90-day absolute mortality risk after THA decreased from 0.70 (CI: 0.57–0.85) to 0.45 (CI: 0.38–0.54) (Glassou E.N. et al., 2017). However, the mortality risk was associated with the severity of comorbidities and did not show a declining trend over the study period.

A study conducted in Spain revealed that while in 2001, 81% of THA patients had a Charlson Comorbidity Index (CCI) of 0, 18.4% had a CCI of 1–2, and 0.6% had a CCI above 2, by 2008 the proportions with 1–2 and >2 points had increased to 20.4% and 1.1%, respectively ($p<0.001$) (Jimenez-García R. et al., 2011). These findings suggest that the modern trend toward worsening patient health profiles and an aging population may lead to poorer THA outcomes in the future.

M. Fuchs et al. (2017) analyzed outcomes of cemented (n=70) and uncemented THA (n=91) in patients over 65 years old (Fuchs M. et al., 2017). Both groups exhibited a high complication rate of approximately 19%. General complications, including thromboembolic and cardiopulmonary events, were most common (12.8% in the cemented group vs. 10.8% in the uncemented group). In the cemented THA group, there were four deaths due to thromboembolic complications (a mortality rate of 5.7%), while no deaths occurred in the uncemented THA group. The rate of surgery-specific complications was 7.8% in the uncemented group and 5.7% in the cemented group.

Thus, although poor THA outcomes are currently observed in a relatively small number of cases, the range and frequency of complications following THA remain highly variable.

### 1.4 Causes of Revision Surgery and Outcomes of Reimplantation

The progressive increase in the number of total hip arthroplasties (THA) observed in recent years inevitably leads to a rise in the number of patients requiring revision surgery. According to an analysis of the endoprosthesis register at the Vreden Russian Research Institute of Traumatology and Orthopaedics (RRITO) from 2014 to 2018, the proportion of revision hip arthroplasties increased 1.7-fold and currently accounts for 18.9% of all THA procedures (Shubnyakov I.I. et al., 2019). Within the structure of revision surgeries, the share of early revisions has grown: 32.9% of revisions are performed within 5 years after the primary THA, with the average time to revision being 7.9 years (Tikhilov R.M. et al., 2014; Shubnyakov I.I. et al., 2019).

In the United States, 50,220 revision THAs were performed in 2014, and projections estimate a 43–70% increase in their incidence by 2030 (Schwartz A.M. et al., 2020). According to S.D. Ulrich et al. (2008), the increasing frequency of revision THA in recent years is associated with greater patient activity levels, younger age at the time of surgery, and increasing life expectancy (Ulrich S.D. et al., 2008). Data from the National Joint Registry for England, Wales and Northern Ireland report a 10-year revision rate of 3.13% for cemented THA and 3.98% for uncemented THA (National Joint Registry for England, Wales and Northern Ireland, 2014).

The proportion of various causes of revision THA varies significantly. The main reasons for revision surgery include aseptic loosening of prosthesis components (25–50.3%), periprosthetic joint infection (6–27.6%), recurrent dislocations (6.2–21.8%), periprosthetic fractures (8–11%), polyethylene wear and osteolysis (4–9.0%) (Kaminsky A.V., Marchenkova L.O., Pozdnyakov A.V., 2015; Bozhkova S.A., 2016; Shubnyakov I.I. et al., 2019; Chang J.S., Haddad F.S., 2020; Kelmer G. et al., 2021). Additionally, in THA with large-diameter metal-on-metal bearings, pathological changes in the surrounding soft tissues due to wear debris may serve as indications for revision (Danilyak V.V. et al., 2015). A population-based study conducted in Spain showed that dislocations were responsible for 22.5% of revisions after total THA, mechanical loosening for 19.7%, and infections for 14.8% of cases (Villanueva-Martínez M. et al., 2012).

According to the National Joint Registry for England, Wales, Northern Ireland, and the Isle of Man, more than 1,000 revision surgeries are performed annually due to periprosthetic hip joint infection. The revision rate due to prosthetic joint infection is 0.4 cases per 100 procedures following primary THA and 1.6 cases per 100 procedures following revision THA (Lenguerrand E. et al., 2017). From 2005 to 2013, the incidence of revision surgeries due to periprosthetic infection within three months of primary THA increased 2.3-fold, and after revision surgery — 3-fold.

S.D. Ulrich et al. (2008) analyzed 237 revision THAs. The overall mean time to revision was 83 months (range 0–360 months). The indications for revision were aseptic loosening in 123 cases (51.9%), instability in 40 cases (16.9%), and infection in 37 cases (5.5%). Notably, 118 out of 237 (50%) revisions were performed within 5 years of the primary procedure, with instability (33%) and deep periprosthetic infection (24%) being the main causes of unsatisfactory outcomes following primary THA. The authors emphasize that the success of primary THA depends largely on meticulous attention to the technical aspects of the procedure—particularly the correct positioning of prosthetic components—as well as on effective infection prevention strategies (Ulrich S.D. et al., 2008; Ismael A. et al., 2022).

According to a study conducted in Sweden and Norway, reverse hybrid prostheses are associated with a higher incidence of early revision due to femoral periprosthetic fractures in patients aged 55 years and older compared to cemented THA. The adjusted relative risk of revision in these patients was 3.1 (CI: 2.2–4.5, $p<0.001$) (Wangen H. et al., 2017). The higher rate of early revisions after reverse hybrid THA contributes to lower 10-year prosthesis survival, which was 92% compared to 94% for cemented fixation.

High long-term revision rates after THA were reported by Z. Morison et al. in 2016 and by Berry D.J. and Halasy M. in an earlier study (2002)—30% and 32%, respectively (Morison Z. et al., 2016; Berry D.J., Halasy M., 2002). The primary causes of the high revision rates included periprosthetic osteolysis, wear of polyethylene liners, and aseptic loosening of the prosthesis. In both studies, the vast majority of patients (96%) received uncemented prosthetic fixation. The authors suggested that the choice of bearing materials may significantly affect surgical outcomes. Notably, accelerated polyethylene wear is a particularly relevant issue for young and active patients (Ryabova M.N., 2016). According to D.J. Berry and M. Halasy, the use of first- and second-generation uncemented acetabular cups is associated with higher polyethylene wear rates and, consequently, increased revision frequency (Berry D.J., Halasy M., 2002).

At the same time, studies by F.Y. Chiu et al. (2015) and L. Zhang et al. (2011), in which metal and ceramic were used as prosthetic materials, reported low revision rates—5% and 2%, respectively (Chiu F.Y. et al., 2015; Zhang L. et al., 2011). The authors suggested that the use of these materials may reduce the risk of periacetabular osteolysis and lower the need for revision. However, limitations of these studies include short follow-up periods (mean durations of 120 and 64 months, respectively), small sample sizes (56 and 53 patients, respectively), and the absence of a control group.

In a study by A. Reito et al. (2013), among 74 THA procedures using metal-on-metal bearing surfaces performed in patients under the age of 40, a total of 8 revisions (10.8%) were carried out, 7 of which were due to adverse reactions to metal debris (Reito A. et al., 2013).

It should be noted that the outcomes of revision hip arthroplasty are variable. For example, A.E. Loskutov et al. (2018) followed 583 patients over a period of 1 to 16 years, during which 621 revision THAs were performed. The indications included aseptic loosening of the acetabular (n=14, 36.8%) or femoral components (n=6, 15.8%), debridement for superficial infection (n=13, 34.2%), dislocation of the prosthetic head (n=4, 10.5%), and infectious complications (n=1, 2.6%). Excellent and good outcomes were observed in 425 patients (79.6%), while 100 patients (18.7%) had satisfactory outcomes. Unsatisfactory results were noted in 9 cases (1.7%) and were associated with prosthesis removal due to infectious complications. It is worth noting that infectious complications remain the predominant cause of repeated revisions, accounting for more than half of all cases (Shubnyakov I.I. et al., 2019).

C.M. Haydon et al. (2004) evaluated the outcomes of 129 cemented revision THAs (Haydon C.M. et al., 2004). The mean W.H. Harris hip score increased from 52 points preoperatively to 71 points at final follow-up ($p<0.001$), and the 10-year prosthesis survival rate was 71%. Interestingly, patients over 60 years of age showed better prosthesis survival and experienced less pain compared to younger patients. Radiographic analysis revealed stable prosthesis fixation in most cases. A decline in the quality and quantity of femoral bone adjacent to the prosthesis was associated with an increased rate of re-revision due to aseptic loosening.

M. El-Husseiny et al. (2019) reported favorable long-term outcomes in 75 revision procedures utilizing a tripolar hip prosthesis (El-Husseiny M. et al., 2019). The 10-year survival rate was 89.4%, and the 20-year survival rate was 82.5%. There were 5 cases (4.4%) of deep periprosthetic infection, 2 cases (1.8%) of pelvic ring disruption with pain syndrome, and another 2 patients (1.8%) experienced femoral periprosthetic fractures without dislocation.

Y. Tyson et al. (2019) compared outcomes of revision surgeries using cementless (n=1668) and cemented (n=1328) THA stems based on data from the Swedish Hip Arthroplasty Register (Tyson Y. et al., 2019). The 10-year survival rate was 85% (95% CI 83–87) for cementless and 88% (CI 86–90) for cemented revision stems. The adjusted relative risk of re-revision for the cementless fixation during the first postoperative year was 1.3 (CI 1.0–1.6), and from the second year onward—1.1 (CI 0.8–1.4). Differences in the causes of re-revision were noted: infection and dislocation were more common with cementless fixation, while aseptic loosening was more frequent in cemented revisions.

Positive outcomes of revision THA are presented in the study by A.A. Korytkin et al. (2019). According to a review of 10 studies, the use of 3D printing in the manufacture of hip and knee revision implants was associated with improved clinical and radiographic outcomes (Zhang R. et al., 2021).

At the same time, several studies indicate that the outcomes of revision arthroplasty are generally inferior to those of primary THA. J.F. Konopka et al. (2018) report that revision procedures are associated with a lower gain in QALY (quality-adjusted life years) compared to primary arthroplasty (Konopka J.F. et al., 2018). A similar opinion is expressed by A.E. Postler et al. (2017), who compared the outcomes of primary and revision THA in 124 patients (Postler A.E. et al., 2017). To evaluate surgical outcomes, the authors used the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the UCLA activity score, and the EuroQol quality-of-life questionnaire. Six months after revision THA, the mean overall WOMAC score improved by 22.1 points, the UCLA score by 0.6 points, and the EuroQol Index by 0.2 points, whereas after primary THA, the corresponding improvements were 41.4 points, 1.1 points, and 0.3 points, respectively. On average, 3.6 years after revision and 2.3 years after primary THA, patients who underwent revision arthroplasty showed significantly lower overall improvement and final scores compared to those who had primary surgery (Aliev B.G. et al., 2023).

S.N. Leonova et al. (2019) investigated revision outcomes in 62 patients with deep periprosthetic infection of the hip and knee joints (Leonova S.N. et al., 2019). In this cohort, revision arthroplasty was effective in only 68.7% of cases. Analyzing the causes of unsatisfactory outcomes, the authors concluded that one-stage revision often involved an inappropriate choice of revision technique. In contrast, for two-stage revision arthroplasty, factors influencing the surgical outcome included allergies to antibacterial drugs, multiple prior surgeries on the affected joint, and extensive bone defects at the prosthesis site. According to some reports, the risk of recurrent purulent infection following two-stage revision for periprosthetic infection of the hip may reach 9.8% (Ermakov A.M. et al., 2018).

C. Kenney et al. (2019), in a systematic review of the literature, analyzed the causes of unsatisfactory outcomes in 9,952 revision THA procedures (Kenney C. et al., 2019). The leading cause of revision failure was aseptic loosening of the prosthesis (23.2%), followed by instability (22.4%) and infection (22.1%). The frequency of repeat revisions was significantly higher among patients with obesity and individuals under the age of 55.

Some researchers have examined the frequency and outcomes of revision THA depending on the surgical approach used. According to W. Hoskins et al. (2020), the overall revision rate does not significantly depend on the surgical approach; however, the anterior approach was associated with a slightly higher frequency of early revisions due to periprosthetic fracture and femoral loosening compared to posterior and lateral approaches, while also showing a lower rate of dislocation and infection. A recent publication by Hasler J. et al. presented the results of revision THA via the anterior approach in 63 patients (Hasler J. et al., 2020). With a mean follow-up period of 18 months, the overall complication and reoperation rates were 14.3% and 12.7%, respectively. The mean Harris Hip Score one year after surgery was 91 points (range 74–100).

Thus, revision THA may be performed for various reasons, and decisions in each specific case are made individually based on the clinical situation. Literature analysis indicates that the effectiveness of re-arthroplasty may vary, and predicting the outcome of the surgery remains challenging (Vorokov A.A. et al., 2020).

### 1.5 Modern Conservative Methods for the Treatment of Hip Osteoarthritis

Joint arthroplasty is currently not the only available treatment option for osteoarthritis (OA). A large-scale study conducted in Spain involving 15,105 OA patients assessed the lifetime risk of knee and hip joint replacement, which was found to be 30% and 14%, respectively (Burn E. et al., 2019). The lifetime risk of joint replacement was influenced by factors such as age under 60 at the time of diagnosis, male sex, and elevated body mass index. Thus, a significant proportion of patients may be managed using conservative methods, while total joint arthroplasty is recommended only at the advanced stage of OA (Bruyère O. et al., 2019; Bannuru R.R. et al., 2019).

To date, there is no universally accepted treatment algorithm for OA, as numerous recommendations from various scientific medical societies often contain conflicting data and fail to consider several important therapeutic factors, such as comorbidities and the generalization of the disease process (Lila A.M. et al., 2019, 2022). Nevertheless, there is a consensus among experts that the cornerstone of OA management is the combination of non-pharmacological and pharmacological methods.

Non-pharmacological treatments include educating and increasing patients' awareness of OA to enable self-management of the disease; weight normalization in patients with a body mass index ≥25 kg/m²; regular therapeutic exercise; physiotherapy; orthopedic correction of joint axis deviations (e.g., the use of orthoses, arch supports, orthopedic shoes, and insoles); and assistive devices for joint unloading in advanced stages of the disease (such as canes, crutches, walkers, etc.) (Alekseeva L.I., Naumov A.V., 2017; Rausch Osthoff A.K. et al., 2018; Daste C. et al., 2021; Pavlova O.Yu. et al., 2022). It is worth noting that the level of evidence supporting non-pharmacological OA treatments is high (Lila A.M. et al., 2019). According to G.R. Abusueva et al. (2020), the strongest evidence exists for physical exercises combined with traditional health gymnastics and acupuncture, as well as peloid therapy, balneotherapy, low-frequency electrotherapy, ultrasound therapy, and infrared laser therapy.

Pharmacological therapy for OA is prescribed in a stepwise fashion (Drapkina O.M. et al., 2018). The basic agents are Symptomatic Slow-Acting Drugs in Osteoarthritis (SYSADOA) — chondroitin sulfate (CS) and crystalline glucosamine sulfate (GS), which have a positive effect on inflammation and metabolic processes in cartilage tissue and chondrocytes (Alekseeva L.I., Lila A.M., 2021). SYSADOA should be administered early in the disease course and for an extended period. Numerous studies have demonstrated the high efficacy of these agents in reducing pain and joint symptoms, as well as in restoring joint function (Maiko O.Yu., Bagirova G.G., 2009; Henrotin Y. et al., 2012; Denisov L.N. et al., 2018). Long-term use of CS and GS has been shown to slow OA progression due to their structure-modifying effect on cartilage and to reduce the need for total joint replacement (Gregori D. et al., 2018). SYSADOA are characterized by a favorable safety profile — the incidence of adverse effects is comparable to that of placebo (Belyaeva I.B. et al., 2018). Moreover, the use of CS and GS may reduce the need for NSAIDs or allow their complete discontinuation, thereby minimizing the risk of gastrointestinal side effects.

At the same time, a specific characteristic of CS and GS is their delayed onset of action, which typically occurs 2–4 weeks after the start of therapy (Kraus V.B. et al., 2015). Patients should be informed of this to maintain treatment adherence. Although the onset of action of chondroprotective agents is slower than that of NSAIDs, their therapeutic effect may persist for 4–8 weeks or longer (Tikhonov D.A., Krylova I.N., 2018). Parenteral forms of SYSADOA, such as intramuscular injections, increase drug bioavailability, provide a faster analgesic effect, and may be used in patients with low adherence to oral medication (Belyaeva I.B. et al., 2021). CS and GS may also be used in combination (Martel-Pelletier J. et al., 2015; Lomonte A.B.V. et al., 2021), although some studies with 6-month follow-up have shown no significant advantage of this therapy over placebo (Clegg D.O. et al., 2006; Roman-Blas J.A. et al., 2017).

It is known that CS and GS exhibit dose-dependent effects on inflammation and angiogenesis. According to current data, chondroitin doses below 800 mg/day and glucosamine doses below 1500 mg/day are considered subtherapeutic (Wandel S. et al., 2010).

As an alternative to CS and GS, unsaponifiable extracts of avocado and soybean (piaskledin) are considered; however, the level of evidence supporting their use is lower (Zborovskaya I.A. et al., 2019).

Another potential treatment option for OA is diacerein, an acetylated derivative of rhein that inhibits the synthesis and activity of interleukin-1 (Uryasev O.M., Zaigrova N.K., 2016). The drug has been shown to positively affect pain and joint function, as well as to help prevent cartilage degradation.

Paracetamol is currently not recommended for long-term OA therapy due to its adverse effects on the gastrointestinal tract and relatively weak analgesic efficacy. It may be prescribed in short courses to reduce the severity of pain at a dose not exceeding 3 g/day, as an adjunct to SYSADOA therapy (Lila A.M. et al., 2022).

If clinical symptoms of OA persist despite SYSADOA therapy, the use of topical NSAIDs may be considered to alleviate pain and improve joint function. A systematic review of 25 articles and meta-analysis of 19 studies demonstrated that topical NSAIDs do not increase the incidence of gastrointestinal or cardiovascular adverse events compared to placebo; however, a higher frequency of dermatological side effects was observed (Honvo G. et al., 2019). At the initial stage of OA treatment, topical NSAIDs should be regarded as first-line agents for patients over 75 years of age and those with significant comorbidities involving the gastrointestinal or cardiovascular systems (Lila A.M. et al., 2022).

If OA symptoms persist despite treatment with SYSADOA and topical NSAIDs, the use of non-selective NSAIDs or selective cyclooxygenase-2 (COX-2) inhibitors should be considered. However, the issue of using these drugs in patients at increased risk of gastrointestinal and cardiac complications, as well as in elderly patients with pronounced comorbidities, remains relevant (Coxib and traditional NSAID Trialists' (CNT) Collaboration et al., 2013; Alekseeva L.I., Naumov A.V., 2017). In patients with gastrointestinal pathology, selective NSAIDs should be prescribed in combination with proton pump inhibitors (Rational Use of Nonsteroidal Anti-Inflammatory Drugs. Clinical Guidelines, 2018; Bruyère O. et al., 2019). It should be especially noted that NSAIDs are contraindicated in patients with a glomerular filtration rate below 30 ml/min due to an increased risk of acute renal failure (Belyaeva I.B. et al., 2018).

According to a Cochrane review of 76 randomized clinical trials involving 58,451 OA patients comparing various NSAIDs with placebo, the most effective in terms of pain relief and joint function improvement was the non-selective COX-1 and COX-2 inhibitor diclofenac at a dose of 150 mg/day (da Costa B.R. et al., 2017). Among selective COX-2 inhibitors, celecoxib and etoricoxib are widely used in our country (Anikin S.G., Alekseeva L.I., 2020). It has been shown that compared to non-selective NSAIDs, celecoxib is associated with the lowest risk of gastrointestinal damage, and etoricoxib is less likely to cause dyspepsia and asymptomatic ulcerative lesions—though this does not apply to gastrointestinal bleeding, including in the distal gastrointestinal tract (Rational Use of Nonsteroidal Anti-Inflammatory Drugs. Clinical Guidelines, 2018).

If non-selective or selective NSAIDs are ineffective or contraindicated, intra-articular administration of glucocorticosteroids (GCS) and hyaluronic acid preparations may be considered. Despite the pronounced anti-inflammatory effect of GCS, their action is short-lived and tends to decrease over time. According to a Cochrane review of 27 studies involving 1,767 patients, the most noticeable effect of intra-articular GCS administration compared to placebo was observed 1–2 weeks after injection; however, by 6 weeks the effect was unclear, and by 6 months it was nullified (Jüni P. et al., 2015). The advisability of using GCS is often questioned due to their low level of evidence and the high risk of potential side effects (Zotkin E.G., Dydykina I.S., 2019). The frequency of GCS injections should not exceed 2–3 times per year (Drapkina O.M. et al., 2018). The main risks of frequent intra-articular glucocorticoid injections include infections and accelerated degradation of hyaline cartilage (Jüni P. et al., 2015).

Hyaluronic acid (HA) preparations are widely used in the treatment of OA. In addition to their anti-inflammatory and analgesic effects, they exhibit structure-modifying properties and can delay the need for joint arthroplasty (Varonko I.A., 2018; Bannuru R.R. et al., 2019). Unlike GCS, intra-articular administration of HA provides longer-lasting improvement—up to 8–12 months (Bellamy N. et al., 2006; Jüni P. et al., 2015). Evidence suggests that the efficacy of HA preparations depends on their molecular weight: high molecular weight agents provide a more prolonged analgesic effect and sustained improvement in joint function (Varonko I.A., 2018). According to current guidelines, no more than 2–3 injections into the same joint per year are allowed (Russian Clinical Guidelines. Rheumatology, 2019). It should be noted that HA preparations are generally well tolerated by patients and rarely cause adverse events, the most serious of which are pseudoseptic and septic arthritis (Zborovskaya I.A. et al., 2019).

L. Kandel et al. (2020) presented preliminary results of a double-blind clinical trial on the efficacy of high molecular weight HA preparations conjugated with plasma fibrinogen in 67 OA patients. The study demonstrated a favorable safety profile and efficacy in reducing pain intensity for at least 6 months after the final injection.

In recent years, intra-articular injections of platelet-rich plasma (PRP) have shown promise in OA treatment. The beneficial effects of PRP are attributed to the regenerative and anti-inflammatory action of various growth factors contained in platelets and released upon their degradation (Xie X. et al., 2014). A systematic review of 14 randomized controlled trials involving 1,423 OA patients revealed the advantages of PRP injections in reducing pain and improving joint function at 3, 6, and 12 months after treatment, compared to placebo (saline solution), GCS, HA, and ozone therapy (Shen L. et al., 2017).

Some international guidelines consider the use of opioids and duloxetine in cases where intra-articular administration of GCS and HA proves ineffective

(Bruyère O. et al., 2019; Bannuru R.R. et al., 2019). However, studies have shown that the analgesic effect of tramadol only marginally exceeds that of NSAIDs, while it is less well tolerated and associated with an increased risk of gastro- and enteropathies (Schaefert R. et al., 2015; Fuggle N. et al., 2019). Therefore, tramadol should only be prescribed in short courses when all other analgesics have proven ineffective (Lila A.M. et al., 2019).

Duloxetine, an antidepressant, may be used in chronic pain syndrome when prior adequate analgesic therapy has failed and the patient exhibits features of central sensitization (Citrome L., Weiss-Citrome A., 2012; Kawarai Y. et al., 2020; Blikman T. et al., 2022). In some cases, the neuropathic component of chronic pain is managed with pregabalin and gabapentin in clinical practice in Russia (Zborovskaya I.A. et al., 2019).

The use of strontium ranelate in OA treatment has been discussed in the literature. Its efficacy is thought to stem from pathogenetic effects on subchondral bone metabolism and osteosynthesis, along with antiresorptive properties (Dubikov A.I., 2013). Alternative treatments for OA also include complex bioregulatory agents of natural origin, which are presumed to possess anti-inflammatory, immunomodulatory, and antimicrobial properties (Zotkin E.G., Davydkina I.S., 2019). Studies by C. Lozada et al. (2014, 2017) demonstrated better clinical outcomes with the use of *Zeel T* and *Traumeel S* compared to placebo. However, these drugs have not found wide clinical use due to the lack of robust evidence.

A promising future direction in the treatment of hip OA may lie in cellular technologies, in particular, intra-articular administration of stem cells or growth factors, which can stimulate reparative processes in damaged articular cartilage. However, these approaches remain in the pilot study phase (Sarana A.M. et al., 2021).

Thus, to date, a vast body of data has accumulated on the potential for both pharmacological and non-pharmacological OA treatment. Numerous studies have reported on the efficacy and safety of each pharmacological agent. Nevertheless, a recent publication by Gwynne-Jones J.H. et al. (2020) presented the results of an observational cohort study assessing the long-term outcomes of conservative treatment in 337 patients with OA. Over a 7-year follow-up period, only 7% of patients with HOA did not require surgical intervention and were able to continue conservative management, while in patients with knee OA this figure reached 55.9% ($p<0.001$). These findings highlight the ongoing challenge of choosing an appropriate treatment strategy for patients with HOA.

### 1.6 Modern Joint-Preserving Surgeries in Hip Osteoarthritis

Joint-preserving surgical interventions at early stages of OA often make it possible to slow the progression of the disease associated with joint surface destruction and degenerative changes in periarticular tissues. Such procedures help restore the mechanical axis of the limb, offload the pathologically altered joint segment, restore the limb's weight-bearing function, and postpone or even avoid joint replacement (Solomin L.N., 2015; Paley D. et al., 2015; Yadav A.K. et al., 2020). The goal of hip joint-preserving surgery is to correct bony deformities and chondrolabral injuries, as well as to restore joint anatomy and function (Madan S.S., Chilbule S.K., 2017; Meier M.K. et al., 2022).

In recent years, joint replacement (JR) has almost completely displaced joint-preserving surgeries from routine clinical practice. As a result, there is a relatively small number of publications on this topic in the scientific literature. However, accumulating evidence on unsatisfactory outcomes and complications of JR, the increasing number of revision procedures, the economic burden of the operation, and the not always favorable results of conservative treatment have led to a gradual resurgence in the use of joint-preserving surgeries by trauma and orthopedic surgeons (Riddle D.L. et al., 2014; Vorokov A.A. et al., 2020). In the long term (7–33 years), the vast majority of patients who underwent joint-preserving procedures on major joints of the lower extremities demonstrated positive outcomes in the form of pain relief or reduction in its intensity, improved joint function, and enhanced quality of life (Nazarov E.A. et al., 2018).

One of the most common joint-preserving procedures is osteotomy, which is performed to correct deformities of the bone surfaces forming the joint (McKinley T.O., 2003; Baindurashvili A.G. et al., 2016; Baskov V.E. et al., 2017; Clinical Guidelines: Coxarthrosis, 2021). The high functional load on the articular cartilage in patients with OA contributes to the progression of degenerative-dystrophic processes in the cartilage, subchondral bone, and joint capsule, while concomitant deformity of the lower limb axis further exacerbates these changes (Thorp L.E. et al., 2007). Performing corrective osteotomy of the pelvis and proximal femur at early stages of OA allows for restoration of the lower limb axis and redistribution of static and dynamic load across different weight-bearing zones of the joint, thereby preventing or slowing the progression of the degenerative-dystrophic process (Troelsen A. et al., 2008; Paley D. et al., 2015; Akgul T. et al., 2016; Khan O.H. et al., 2017). During osteotomy, the pathologically altered bones are surgically cut and then repositioned into the correct anatomical alignment.

Proximal femoral osteotomy is often performed as a preparatory stage prior to hip joint replacement (JR). This approach postpones JR to an older age, making it possible to rely on a single joint replacement procedure, considering the natural decline in physical activity with age (Oleynik A.E., 2014; Amstutz H.C., Le Duff M.J., 2017; Zeng Y. et al., 2021). According to the literature, the time interval from osteotomy to subsequent total hip arthroplasty (THA) ranges from 8.7 to 19.7 years, with an average of 12.5 ± 1.9 years (Zhumabekov S.B. et al., 2021).

An analysis of 118 cases of femoral corrective osteotomies with follow-up periods ranging from 14 to 37 years after surgery demonstrated sustained positive outcomes in most patients, including satisfactory functional adaptation in terms of self-care and mobility, despite the advanced stage of the disease and the long postoperative interval (Parshikov M.V. et al., 2019).

S. Ohsawa (2017) reported satisfactory long-term outcomes of valgus osteotomy in end-stage hip OA. The study followed 82 hip joints in 75 patients with a mean follow-up period of 298 months. THA was eventually performed on 32 joints at an average of 185 months post-osteotomy, while in 60% of cases, joint replacement was not required over the 20-year follow-up period.

An important aspect of successful surgical management of OA is the restoration of blood supply to pathologically altered areas of the subchondral bone and stimulation of osteogenesis and chondrogenesis (Volokitina E.A., 2003). In this context, revascularizing femoral osteotomies are of particular importance. According to E.A. Nazarov (2018), during revascularization of the femoral neck and head, imaging studies revealed channels in these structures into which a vascular bundle was implanted. This technique contributed to the restoration of vascularization and ensured long-term viability of the bone.

The possibility of joint-preserving surgery should be considered primarily in young, physically active patients, in whom the outcomes of JR are often less favorable compared to those in older individuals (Kubo Y. et al., 2017). According to R. Tanaka et al. (2019), in young patients with secondary OA, an average of 9.4 years after intertrochanteric rotational osteotomy, the mean score on the Merle d'Aubigné and Postel (MDPS) hip function scale improved from 10.3 to 14.2 points, and the OA grade remained the same or improved in 91% of cases.

V.V. Guryev et al. (2011) demonstrated favorable long-term outcomes of a minimally invasive double incomplete revascularizing intertrochanteric osteotomy in young and middle-aged patients with early-stage OA. Within 3–4 years, among patients who underwent only conservative treatment, unsatisfactory outcomes were observed in 39–86% of cases, whereas among those who underwent the proposed surgical treatment, this figure was only 6.5–9.6%.

Another surgical technique is arthrodesis, which involves the rigid fixation of bones in the joint area using metal staples or screws (Sirikonda S.P. et al., 2008). It should be noted that today arthrodesis of major joints is more of a "last resort surgery" and is applied when conservative therapy is ineffective or other surgical methods cannot be used (Zagorodniy N.V., 2016). The results of arthrodesis and subsequent arthroplasty are controversial. S. Jain and P.V. Giannoudis (2013) conducted a systematic review to evaluate the outcomes of hip joint arthrodesis followed by total JR. Evaluation of 249 hip joints across eight studies revealed varying fusion rates (37.5%–100%) and patient satisfaction levels (69%–100%). Pain in adjacent joints was typically reported in the lower back (up to 75%) and ipsilateral knee (up to 57%), with complications recorded in 8.4% of cases. An analysis of 11 studies on conversion arthroplasty involving 579 patients revealed inconsistent outcomes in terms of pain relief, with complications occurring in 54% of cases, most commonly due to mechanical failure, deep infection, and nerve palsy.

Among joint-preserving surgeries is decompression-drainage tunneling (osteoperforation) of the articular ends of the hip joint – a surgical procedure in which additional openings are formed in the femoral neck and head. This method helps reduce intraosseous pressure, restore microcirculation in the subchondral zone, and stimulate reparative processes (Rechkin M.Yu., 2000). Tunneling is advisable in cases of a stable joint and preserved alignment of the lower limb. According to S.A. Grinev (2019), tunneling of the hip joint is associated with good clinical and functional outcomes, allows for rapid reduction of pain, and significantly reduces the need for JR.

Currently, arthroscopic techniques are used to treat various hip joint pathologies (Ross J.R. et al., 2017; Yakupova E.R., 2020). A clear advantage of hip arthroscopy is its minimally invasive nature and the possibility for visual assessment of intra-articular structures, particularly in determining the degree and type of cartilage damage, which can influence patient management strategies (Jamil M., 2018). The objectives of arthroscopic procedures on the hip joint may include joint revision, decompression, sanitation, and debridement. Short-term clinical and functional outcomes of arthroscopic procedures are generally favorable (Milyukov A.Yu., 2006). Arthroscopic treatment with surface alignment yields good results in patients with early-stage OA combined with femoroacetabular impingement or soft tissue damage in the joint area (Volokitina E.A. et al., 2020; Gerasimov S.A. et al., 2020; Morattel B., Bonin N., 2021).

The first mention of hip arthroscopy also dates back to 1931, but its widespread use began in the 1980s (Bedi A. et al., 2015). Initially, arthroscopic instruments developed for the knee and shoulder joints were inadequate for deep access to the hip joint (Kandil A., Safran M.R., 2016). However, over time, specific instruments and improved approaches for hip arthroscopy were developed.

Initially, hip arthroscopy was used to identify the cause of pain in the joint projection area that could not be diagnosed by other means. Arthroscopic procedures were also employed to remove osteochondral fragments, perform debridement and drainage in cases of purulent arthritis, and treat hip joint diseases in children (Ross J.R. et al., 2017). Today, hip arthroscopy is utilized for diagnosing and treating a wide range of pathologies – articular cartilage injuries, chondromalacia, traumatic lesions of the acetabular bone, synovial chondromatosis, septic arthritis, synovitis, avascular necrosis of the femoral head, bone tumors, and others (Yakupova E.R., 2020; Jamil M. et al., 2018; Freeman K.L. et al., 2021).

De Sa D. et al. (2014) conducted a review of 14 studies on the outcomes of hip joint endoscopy in patients with synovial chondromatosis (involving 197 patients). These authors concluded that arthroscopic removal of osteochondral fragments in combination with synovectomy is a safe and effective method. The average recurrence rate was 7.1%, compared to up to 22% for open surgical approaches, while the rate of minor complications (such as neurapraxia) was only 1%.

Hip arthroscopy has proven to be highly effective as a minimally invasive diagnostic and therapeutic method for various pathological conditions in young patients (Murzich A.E., 2019), which is of practical importance given the recent trend toward the “rejuvenation” of hip joint diseases.

Hip arthroscopic surgery is also gaining increasing importance as an auxiliary diagnostic and therapeutic tool in combination with open femoral and/or periacetabular osteotomy in cases of complex hip joint deformities (Lynch T.S. et al., 2013).

However, hip arthroscopy is performed less frequently than knee or shoulder arthroscopy, due to the deep location of intra-articular structures, the complexity of the technique, and the need for specialized arthroscopic instruments (Ross J.R. et al., 2017).

The study by A.J.R. Palmer et al. (2019) demonstrated the advantages of arthroscopic treatment of symptomatic femoroacetabular impingement syndrome of the hip joint compared to physiotherapy. In the assessment of hip joint function in daily activities, the average scores in the hip arthroscopy group were 10.0 points higher (ranging from 6.4 to 13.6) than in the physiotherapy group ($p<0.001$). No serious adverse events were reported in either group. Similar findings were obtained in a multicenter randomized controlled trial published by D.R. Griffin et al. in *The Lancet* in 2018, which compared arthroscopic surgery and conservative treatment for femoroacetabular impingement syndrome.

The frequency of subsequent THA following hip arthroscopy is about 5%, with all conversions to THA occurring within four years after arthroscopy (Bedard N.A. et al., 2016). At the same time, according to M. Drobniewski et al. (2019), hip arthroscopy in patients with joint space narrowing does not yield favorable outcomes.

Of particular importance among joint-preserving surgeries are chondroplasty techniques, which are performed arthroscopically and aim to restore cartilage defects (Gilfanov S.I. et al., 2017; Mardones R., Larrain C., 2015).

Thus, joint-preserving surgeries have once again come into the focus of trauma and orthopedic specialists in the treatment of patients with HOA of the hip joint. However, in many cases, such interventions remain palliative in nature.

### 1.7 Approaches to Improving the Outcomes of Hip Osteoarthritis Treatment

In accordance with the modern concept of patient-centered medicine, the treatment of hip osteoarthritis (HOA) must be personalized, taking into account the patient’s age, disease stage, regenerative capacity of the synovial environment, and the type and severity of biomechanical impairments of the affected joint (Olyunin Yu.A., 2016). High efficacy may be achieved through comprehensive conservative therapy, which can be administered independently or following palliative or radical surgical interventions (Volokitina E.A. et al., 2020).

Non-pharmacological interventions targeting the musculoskeletal system help to offload the affected joint and restore the range of motion. The prescription of basic chondroprotective therapy contributes to the normalization of the viscoelastic properties of cartilage and the structure of the subchondral bone, promotes the disappearance of degenerative cysts, and may slow disease progression.

The use of joint-preserving procedures in combination with pharmacological and physiotherapeutic anti-inflammatory treatments improves the trophism of the subchondral bone, eliminates synovial hypoxia and synovitis, and alleviates pain.

In cases where comprehensive conservative treatment and joint-preserving interventions yield unsatisfactory results, total hip replacement (THR) should be considered. A cost-effectiveness analysis of THR has shown that the procedure is economically justified only in patients with end-stage osteoarthritis (Kamaruzaman H. et al., 2017).

One of the key factors influencing the outcomes of surgical treatment of HOA is the experience of the surgical team. The optimal THR volume for a surgical team is 100 procedures per year, with surgeon case volume being the most significant determinant of surgical success (Solomon D.H. et al., 2002). A study conducted in the United Kingdom analyzing 281,360 hip replacement procedures revealed that performing fewer than 50 operations per year results in a 2.5–6-fold increase in mortality and a 1.5-fold increase in the number of revision surgeries (Judge A. et al., 2006).

As previously mentioned, patient selection for surgical intervention remains a pressing issue, necessitating clarification of the indications and contraindications for THR. In particular, management strategy selection can be challenging in patients presenting with clinical symptoms of osteoarthritis in the absence of clear radiographic signs. D. Zarringam et al. (2019) examined prognostic factors influencing the decision to perform hip and knee arthroplasty in patients with radiographic OA graded 0–2. It was found that the decision to proceed with THR was primarily based on male sex, older age, and a high total score on the WOMAC scale.

According to A.E. Weber et al. (2015), a strategy to improve surgical outcomes for hip joint interventions includes increasing surgeon experience, refining patient selection criteria, thorough preoperative planning, and appropriate postoperative rehabilitation.

An important aspect of successful OA treatment is enhancing patient awareness of their condition and treatment options, which improves patient adherence to medical recommendations (Vina E.R. et al., 2016). Patients must be clearly informed about the benefits and risks of surgical intervention, so that decisions are made consciously, within a “patient-physician” partnership framework (de Jesus C. et al., 2017).

At the same time, as emphasized by A. Cronström et al. (2019), patients must be more clearly and comprehensively informed about conservative treatment options for OA, including non-pharmacological methods. For example, a survey of patients who participated for six weeks in the digital Joint Academy program revealed that some respondents reconsidered their readiness for THR after observing clinical improvements from conservative therapy. Patients noted that they were initially ready for surgery simply due to a lack of awareness about alternative treatment options. Increasing patient knowledge in such cases may help reduce the need for surgical intervention.

However, it should be noted that conservative treatment of elderly and senile patients is often limited by pronounced comorbidities, the tendency of practicing physicians toward polypharmacy, the high risk of adverse drug reactions, and difficulties in adherence to treatment regimens due to cognitive impairments (Shukurova S.M. et al., 2016). In such cases, total hip replacement appears to be a rational choice. Given the reduced physical activity of older patients, long-term favorable outcomes of surgery and lower prosthesis wear can be expected compared to younger patients (Austin D.C. et al., 2020). According to S.T. Kunkel et al.

(2018), total hip replacement is a more cost-effective option than conservative treatment in patients over the age of 80.

One of the causes of revision hip surgery is inaccurate implant positioning. In this regard, modern computer-assisted surgical techniques enable more accurate positioning of prostheses during surgery (Petursson G. et al., 2018). Specialized equipment improves the spatial orientation accuracy of prosthetic components in all planes. Computer navigation is particularly effective in treating patients with severe musculoskeletal deformities. The use of computer navigation has been shown to significantly improve prosthesis survival rates compared to conventional hip arthroplasty methods (Baier C. et al., 2017).

Various strategies for improving THR outcomes are discussed in the scientific literature. For example, B. Bouyer et al. (2016) suggest using the acetabular index as a predictor of severity and progression of HOA when estimating the risk of joint replacement. Burn E. et al. (2019) propose considering individual patient characteristics when assessing the risk of joint replacement, emphasizing body mass index, where an increase from 25 to 35 kg/m² is associated with a rise in joint replacement risk from 24% to 32%. Von Lewinski G. (2020) proposes the use of custom-made acetabular implants for treating severe hip joint damage, but emphasizes the high cost of such treatment and the need for extensive surgical planning.

As the literature review suggests, there is no universally accepted approach to the treatment of idiopathic hip osteoarthritis. When choosing one treatment method, many authors do not consider alternative medical care options for HOA. Overall, most researchers agree that the early stages of HOA should be treated conservatively, while the late stages require surgical intervention. However, the timing of the introduction of surgical methods remains the most debated issue. Many authors consider THR to be a last resort, mainly for elderly patients or in cases where conservative treatment fails.

In general, the most optimal strategy for managing patients with HOA appears to be a comprehensive treatment approach involving modern conservative and surgical methods. In many cases, these allow for an impact on various pathogenetic mechanisms, thereby not only improving the clinical and functional condition of patients, but also slowing disease progression.

# CHAPTER 2. GENERAL CHARACTERISTICS OF CLINICAL CASES AND RESEARCH METHODS

## 2.1. General Characteristics of Clinical Cases

To achieve the objectives set in this study, data from several patient groups were analyzed.

A retrospective study of the prevalence of osteoarthritis was conducted across several federal subjects of the Russian Federation from 2012 to 2019. Data on the frequency of osteoarthritis among the population aged over 18 years were collected in the regions of the Northwestern Federal District (NWFD). Non-personalized data were presented as the number of patients per 100,000 population in the region. Separate analyses were conducted for Saint Petersburg, Moscow, and the Russian Federation as a whole.

At the Peter the Great Hospital, which serves as the clinical base of the Department of Traumatology, Orthopedics, and Military Field Surgery of the North-Western State Medical University named after I.I. Mechnikov (hereinafter referred to as “the clinic”), a total of 965 patients aged 21 to 89 years (mean age 59.4 ± 13.0 years) underwent total hip arthroplasty (THA) for idiopathic osteoarthritis between 2012 and 2019 inclusive. Two patients (0.21%) died in the early postoperative period. The remaining 963 patients, who successfully underwent surgery and were discharged from the clinic, formed the basis of this study. According to age at the time of surgery, the patients were divided into three groups (Table 2.1).

Table 2.1 – Distribution of Patients Who Underwent THA for Osteoarthritis According to Age (Retrospective Group)

| Study Group | Patient Age (years) | Number of Cases (%) |
|---|---|---|
| Young | 18–44 | 189 (19.6) |
| Middle-aged | 45–64 | 433 (45.0) |
| Elderly | 65 and older | 341 (35.4) |
| Total | | 963 (100) |

As shown in Table 2.1, the majority of the cases—622 (64.6%)—were among individuals of working age. Long-term treatment outcomes were assessed within a follow-up period of up to 5 years.

During the same period, 277 patients aged 30 to 88 years (mean age 61.1±12.6 years) received inpatient conservative treatment at the clinic. According to the age at the time of hospitalization, the patients were divided into 3 groups (Table 2.2).

Table 2.2 – Distribution of patients who received inpatient conservative treatment for hip osteoarthritis (HOA) by age group

| Study Group | Patient Age (years) | Number of Cases (%) |
|---|---|---|
| young | 18–44 | 32 (11.6) |
| middle-aged | 45–64 | 132 (47.7) |
| elderly | 65 and over | 113 (40.8) |
| Total | | 277 (100) |

As can be seen from the data presented in Table 2.2, as in the cases of hip joint arthroplasty, the majority of observations—164 (59.2%)—were patients under the age of 65, i.e., of working age. Long-term treatment outcomes were assessed over a period of at least 5 years.

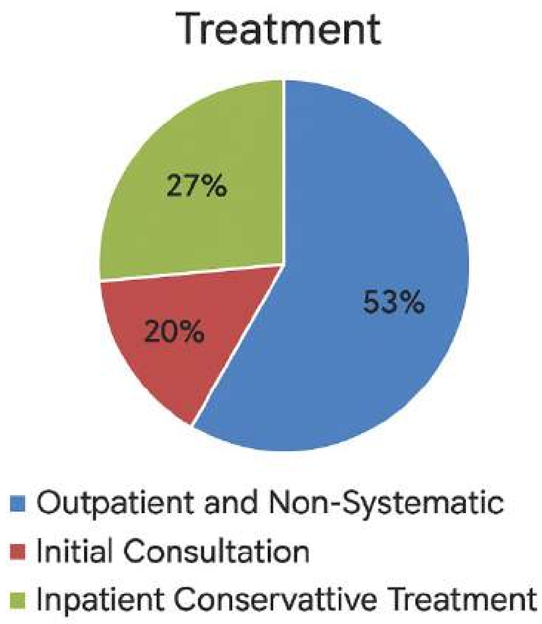



Figure 2.1. Anamnestic data on pre-arthroplasty treatment of patients with hip osteoarthritis (HOA).

Before hospitalization for hip joint arthroplasty, 515 patients (53.5%) had undergone outpatient treatment, which was not always systematic. Notably, 192 patients (19.9%), nearly every fifth individual, were hospitalized immediately after their first visit to a polyclinic specialist. Inpatient conservative treatment for hip osteoarthritis was reported in the medical history of only 256 patients (26.6%).

There were no significant differences between the two study groups (non-surgical treatment of HOA and hip arthroplasty) in terms of age and gender characteristics.

In 2022, a total of 116 patients underwent THA in the clinic (Table 2.3). The majority—78 (67.2%)—belonged to the working-age population. Samples for intravital pathomorphological examination were collected by random sampling from 30 of these patients, aged 27 to 79 years (18 women and 12 men).

Table 2.3 – Distribution of patients who underwent THA for osteoarthritis, by age (prospective group)

| Study Group | Patient Age (years) | Number of Cases (%) |
|---|---|---|
| young | 18–44 | 17 (14,6) |
| middle-aged | 45–64 | 61 (52,6) |
| elderly | 65 and over | 38 (32,8) |
| Total | | 116 (100) |

Thus, the dissertation study analyzed data from several groups of patients (Table 2.4), with a sufficient number of observations to consider the sample representative and the results reliable.

Table 2.4 – Information on the main clinical observation groups analyzed in the study in accordance with its objectives

| № | Clinical Observation Groups | Research Objectives | Number of Observations |
|---|---|---|---|
| 1 | Non-personalized data on the prevalence of osteoarthritis in subjects of the Russian | Analysis of the prevalence of osteoarthritis. | Population of the Russian |

| | | | |
|---|---|---|---|
| | Federation (NWFD, Moscow) and the Russian Federation as a whole | | Federation over 18 years of age |
| 2 | Patients with OA who underwent inpatient conservative treatment at the clinic from 2012 to 2019 | Analysis of functional outcomes and quality of life in patients. | 277 |
| 3 | Patients with OA who underwent primary total THA at the clinic from 2012 to 2019 | Study of long-term functional outcomes and quality of life. | 963 |
| 4 | Patients with OA who underwent THA at the clinic (prospective study group) | Total number of patients<br><br>Histological examination of the resected femoral head | 116<br><br>30 |

## 2.2 Methods of Experimental Research

The objectives of the dissertation research were addressed by studying data from several groups of experimental animals and groups of patients with idiopathic and post-traumatic osteoarthritis.

The objects of the study included: monoiodoacetate preparation, 0.9% NaCl solution, biological fluids (plasma) of patients, biopsy (autopsy) material from animals, and medical records of patients (retrospective and prospective analysis).

The subject of the study was the results of clinical and laboratory tests and autopsies of laboratory animals in a model of knee joint osteoarthritis, as well as the results of retrospective and prospective analyses of data from patients with hip osteoarthritis.

The experiment was conducted at the Department of Industrial Ecology of the Saint Petersburg State Chemical and Pharmaceutical University of the Ministry of Health of the Russian Federation, in compliance with all safety measures. All procedures involving animals were performed in accordance with the principles of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986), Directive 2010/63/EU of the European Parliament and of the Council of the European Union of 22.09.2010 on the protection of animals used for scientific purposes, Recommendation of the Board of the Eurasian Economic Commission dated November 14, 2023, No. 33 “On the Guidance for Working with Laboratory (Experimental) Animals in Preclinical (Non-Clinical) Studies,” and the Universal Declaration of Animal Rights (adopted by the International League of Animal Rights on September 23, 1977, in London and proclaimed on October 15, 1978, at UNESCO headquarters in Paris). The research was approved by the Bioethics Committee of the Saint Petersburg State Chemical and Pharmaceutical University of the Ministry of Health of Russia (Protocol No. Rats-SA-15.01.2024).

The animals participating in the experiment were sorted by age and sex and kept on a standard diet in a standard vivarium under continuous clinical and veterinary supervision. Each day they were provided with an equal amount of food and water and housed individually in cages at a temperature of 19–23°C, relative humidity of 60–80%, and a light period of at least 12 hours, which complies with the requirements for testing medicinal products (Durnev A.D. et al., 2012).

The experiment was conducted on 20 Wistar rats weighing 180–250 g. The animals were obtained from the “Elektrogorsk” branch of the Federal State Budgetary Institution of Science – National Research Center for Biomedical Technologies of the Federal Medical-Biological Agency of Russia. All animals used in the study were standardized by age and sex. The animals were fed with a complete feed “LBK-120” for rats and mice, manufactured by Tosnensky Compound Feed Plant JSC, with ad libitum access to food and water. Animals were kept in standard vivarium conditions under constant clinical and veterinary supervision, with daily provision of a consistent amount of food and water. They were housed individually in cages at a stable temperature of 19–23°C and relative humidity of 60±10%, with a light cycle of no less than 12 hours per day.

The laboratory animals were randomly assigned into 4 groups of 5 animals each (Groups K, S, M, and MS) (Table 2.5).

Table 2.5 – Distribution of animals involved in the experiment

| Animal type | Study Groups | | | | |
|---|---|---|---|---|---|
| | Control (K) group | S | M | MS | Total |
| Rats | 5 | 5 | 5 | 5 | 20 |

In the control group (Group K), animals received intra-articular injections of sterile 0.9% sodium chloride solution (NaCl) in a volume of 10 µL into both knee joints.

In Group S, 10 µL of synovial fluid obtained from a patient with stage III osteoarthritis of the knee during an arthroscopic procedure was injected into the right knee joint. The left knee joint received 10 µL of sterile 0.9% NaCl.

In Group M, animals were injected with 10 µL of monoiodoacetate (MIA) solution at a dose of 2 mg per 10 µL into the right knee joint, and 10 µL of 0.9% NaCl into the left. The MIA solution was prepared on the day of injection by weighing 30 mg of sodium monoiodoacetate (Sigma) and dissolving it in 150 µL of sterile saline. The solution was filtered through a 0.22 µm membrane filter and used within 24 hours. The experiment was conducted at the Department of Industrial Ecology, St. Petersburg State Chemical-Pharmaceutical University of the Ministry of Health of the Russian Federation, in compliance with all safety measures.

In Group MS, 10 µL of MIA solution (2 mg/10 µL) was injected into the right knee joint and 10 µL of synovial fluid into the left.

To assess the rate and nature of morphological changes in joints and tissues, X-ray examinations of the knee joint were followed by histopathomorphological studies. Animals were euthanized one at a time from each group on day 10 of the experiment, and two animals per group on days 25 and 46 after a single administration of the substances. Euthanasia was performed using the inhalation anesthetic Isoflurane. Cotton balls soaked in Isoflurane were placed in a desiccator.

All manipulations were performed in a fume hood to ensure safety and compliance with narcotic handling regulations.

After euthanasia, the rats were placed supine with 0° hip flexion, abduction, internal and external rotation. Both limbs were secured to the table with tape. Anteroposterior radiographs of the knee and hip joints were taken using a DS. Xray 5010t/5080t portable veterinary X-ray machine. Lateral images were also obtained at 45° flexion and abduction, with 0° internal and external rotation. Radiological studies were performed on days 10, 25, and 46 (groups [K, M, S, MS] and control group [K, M, S, MS] respectively). The radiographic images were classified according to the Kellgren–Lawrence (KL) system as follows: Grade 0: none – no radiographic features of OA; Grade 1: doubtful – possible joint space narrowing (JSN) and osteophyte; Grade 2: minimal – definite osteophyte and possible JSN; Grade 3: moderate – multiple osteophytes, definite JSN, sclerosis, possible bone deformity; Grade 4: severe – large osteophytes, marked JSN, severe sclerosis, definite bone deformity.

For histological examination, macropreparations of the knee joint were collected from each animal. The limb was transected proximally at the mid-femoral level and distally at the mid-tibial and fibular level. Soft tissues and skin were removed, and the samples were fixed in 10% neutral buffered formalin (BioVitrum, Russia) in a 1:20 ratio for 72 hours. Histological sample preparation followed standard protocols, including decalcification using “Softidec” solution (BioVitrum, Russia) at a 1:50 ratio for 7 days with daily fluid changes. The endpoint of decalcification was determined by bending and puncturing the tissue with a fine needle—decalcification was considered complete if the tissue bent easily and the needle passed through the bone without resistance. Samples were rinsed under tap water for 30 minutes. Standard histological processing, embedding, and sectioning at 3–5 μm thickness were carried out, and the slides were stained with hematoxylin and eosin.

## 2.3. Methods of Investigation

All patients with hip osteoarthritis (HOA) who were hospitalized for inpatient treatment (surgical or conservative) in the Department of Traumatology and Orthopedics of the Petrovsky Hospital underwent a standard examination in accordance with the clinic's established protocol.

### 2.3.1. Laboratory Methods of Investigation

As part of this dissertation study, laboratory analysis of biological fluids in patients with hip osteoarthritis was performed at the Central Clinical Diagnostic Laboratory of the North-Western State Medical University named after I.I. Mechnikov (Table 2.6).

Table 2.6 – Laboratory tests in patients hospitalized for treatment of HOA

| Analyzed Medium | Analysis Parameters | Research Method |
|---|---|---|
| Blood | - Complete blood count<br><br>- Coagulogram (blood clotting time, fibrinogen level combined with fibrinolytic activity, prothrombin activity, plasma recalcification time) | Hematology analyzer DxH 800 (USA)<br>Hemostasis analyzer STA Compact (France) |
| | Biochemical analysis (glucose, urea, total protein, bilirubin, ALT, AST, amylase, alkaline phosphatase, creatinine, electrolytes: $K^+$, $Na^+$) | Biochemical analyzer COBAS INTEGRA 400+ by ROCHE (Austria, Switzerland)<br>Analyzer KONELAB 20 (Finland) |
| | - Blood loss volume | Gravimetric method to determine blood volume using intraoperative surgical aspirator (Lebedeva M.N. et al., 2015) |
| Biological fluids or tissues from the infection focus | Identification of microorganisms and their antibiotic sensitivity | Growth on nutrient media, microscopy |
| Urine | Urine microscopy,<br>Urine biochemical analysis | Urine microscopy analyzer IRIS IQ 200 Elite (Japan)химический<br>Urine chemical analyzer Aution Max 4030 (Japan) |

*2.3.2. Instrumental Research Methods*

Instrumental examinations were performed in patients scheduled for surgical treatment—hip joint arthroplasty (Table 2.7).

Table 2.7 – Instrumental examinations in patients hospitalized with a diagnosis of hip osteoarthritis

a

| Object of the study | Type of study | Research method |
|---|---|---|
| Bones and joints, thoracic cage | Radiography | Radiography system Ysio Max<br>Manufacturer: Siemens<br>Country of origin: Germany |
| Bones, joints, soft tissues | MRI, CT | CT SOMATOM Force<br>Manufacturer: Siemens<br>Country of origin: Germany<br><br>MRI Siemens Symphony 1.5 T with Tim – high-performance full-body scanner<br>Manufacturer: Siemens<br>Country of origin: Germany |
| Heart | Resting ECG in 12 leads. Functional stress tests if indicated | Electrocardiograph Fukuda FX-8222 – 6-channel ECG<br>Manufacturer: Fukuda<br>Country of origin: Japan |
| Blood vessels | Duplex scanning of lower limb veins | Vivid E95<br>Manufacturer: General Electric<br>Country of origin: Israel |
| Abdominal organs, joints, blood vessels of the lower limbs, neoplasms, soft tissues, surgical area | Ultrasound | MyLab™Gamma<br>Manufacturer: Aokai Medical Equipment<br>Country of origin: China |
| Hollow organs | EGD (before THA) | Olympus Video Gastroscope GIF-Q165<br>Manufacturer: Olympus Corporation<br>Country of origin: Japan |

Radiological examination made it possible to determine the stage of hip osteoarthritis, the nature of the relationship between the articular surfaces of the femoral head and the acetabulum, as well as the presence and size of osteophytes, and the degree and localization of osteosclerosis.

Table 2.8 – Updated Physical Status Classification of a Patient by the American Society of Anesthesiologists (ASA), 2020 (cited from Levin I.Ya., Koryachkin V.A., 2021).

| Class | Definition | Adults |
|---|---|---|
| ASA I | Normal healthy patient | Healthy, non-smoking patient with no or minimal alcohol use |
| ASA II | Patient with mild systemic disease | Mild systemic disease without significant functional limitations. The patient smokes and consumes alcohol moderately. Obesity (BMI >30)<br>Well-controlled diabetes / hypertension |
| ASA III | Patient with severe systemic disease | Significant functional limitations; one or more moderate to severe diseases. Uncontrolled diabetes or hypertension, chronic obstructive pulmonary disease (COPD), morbid obesity (BMI ≥40 kg/m²), history of myocardial infarction, stroke, transient ischemic attack, or coronary stenting (>3 months ago) |
| ASA IV | Patient with severe systemic disease that is a constant threat to life | Recent (<3 months) myocardial infarction, stroke, transient ischemic attack, or coronary stenting, ongoing cardiac ischemia or severe valvular dysfunction, shock, sepsis, disseminated intravascular coagulation syndrome, respiratory distress syndrome, or end-stage renal failure with irregular dialysis |

When assessing the severity of comorbid conditions in patients with hip osteoarthritis (HOA), the anesthesiologist-intensivist relied on data obtained during the preoperative examination. Low-level comorbidity was diagnosed in patients with ASA I and ASA II. Patients with ASA III and ASA IV demonstrated a high frequency of concomitant diseases.

Additionally, to determine the comorbidity index, the Charlson Comorbidity Index (CCI) was used (Charlson M.E. et al., 1987). This tool enabled the prediction of a patient's quality of life.

1 point: myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease (stroke or transient ischemic attack), chronic pulmonary disease, connective tissue diseases, peptic ulcer disease, mild or moderate chronic liver disease, diabetes without complications.

2 points: diabetes with end-organ damage, hemiplegia, chronic renal failure, any

malignancy (except minor), leukemia, lymphoma.
3 points: moderate or severe liver failure.
6 points: metastatic cancer, AIDS.

In addition, patient age was taken into account: 1 point is added for every decade over the age of 40. For example, a 50-year-old patient receives 1 point, at 60 years — 2 points, and so on.

Prognostic value:

Total CCI score correlates with mortality risk: 0 points – 12% risk of mortality; 1–2 points – 26%; 3–4 points – 52%; 5 or more points – 85%.

The index is based on assigning a certain number of points to various chronic diseases depending on their impact on the patient's prognosis. The sum of points reflects the overall level of comorbidity. A low level of comorbidity was verified with a CCI of 0–2. A high level of comorbidity was diagnosed in cases with a CCI of 3 or more.

### *2.3.3 Methods for Evaluating Treatment Outcomes in Hip Osteoarthritis*

The assessment of functional outcomes following total hip arthroplasty (THA) and conservative treatment of hip osteoarthritis was performed using the W.H. Harris Hip Score (1969, 1987), which was specifically developed for evaluating hip joint function.

Patient quality of life was evaluated based on the categories defined in the "International Classification of Functioning, Disability and Health" (ICF) developed by the WHO in 2001 and modified by A.A. Kharitonov in 2012. To analyze quality-of-life indicators in patients who underwent THA, taking into account their individual limitations, a scoring system was used, the results of which were subsequently coded (Table 2.9).

Table 2.9 – Coding of the severity of activity limitations (in %) depending on their characteristics

| Points | Barriers | Limitation indicators (%) |
|---|---|---|
| 0 | No | 0-4 |
| 1 | Mild | 5-24 |

| | | |
|---|---|---|
| 2 | Moderate | 25-49 |
| 3 | Severe | 50-95 |
| 4 | Complete | 96-100 |

As part of the study, vital functions were identified and selected to interpret their impact on all patients with hip osteoarthritis (HOA) participating in the study, taking into account the classification according to the ICF (see Table 2.10).

Table 2.10 – List of assessed limitations of vital

| Vital Functions | Indicators of limitations in functioning and health |
|---|---|
| Pain sensation | b280.0.1 |
| Joint mobility functions | b710.0.1 |
| Joint stability functions | b715.0.1 |
| Mobility of the skeletal system | b720.0.1 |
| Structure of the pelvic region | s 740.0.1 |
| Structure of the lower limb | s 750.0.1 |
| Carrying out single tasks | d 210.0.1 |
| Carrying out complex tasks | d 220.0.1.2.3 |
| Carrying out daily routine | d 230.0.1 |
| Changing body position | d 410.0.1 |
| Maintaining body position | d 415.0.1 |
| Body movement | d 420.0.1 |
| Lifting and carrying objects | d 430.0.1 |
| Moving objects with legs | d 435.0.1 |
| Walking | d 450.0.1.2 |
| Moving with assistive devices | d 465.0.1.2 |
| Caring for body parts | d 520.0.1 |
| Physiological functions | d 530.0.1.2 |
| Dressing | d 540.0.1.2 |
| Performing household tasks | d 640.0.1.2 |

Each of the 20 indicators was scored if confirmed. The total score was calculated as the sum of individual points.

A score of 16–20 points was rated as “excellent,” 11–15 points – “good,” 6–10 points – “satisfactory,” and 0–5 points – “unsatisfactory.”

*Classification of Surgical Complications*

In the study of surgical complications in patients with hip osteoarthritis (HOA), the Clavien–Dindo classification of surgical complications was used. This is a widely recognized system for standardizing the assessment of postoperative complications. The classification was first proposed in 1992 and refined in 2004. It enables an objective evaluation of complication severity and their impact on treatment outcomes, as well as comparison of results across different surgical procedures.

According to the Clavien–Dindo classification (Dindo D. et al., 2004), complications are divided into the following grades:

Grade I: Any deviation from the normal postoperative course without the need for pharmacological or surgical intervention. This category also includes treatment of wound infections.

Grade II: Complications requiring pharmacological treatment (including antibiotics, blood transfusion, and parenteral nutrition).

Grade III: Complications requiring surgical, endoscopic, or radiological intervention.

Grade IV: Life-threatening complications.

Grade V: Death.

### *2.3.4 Morphological Research Methods*

At the Department of Traumatology and Orthopedics of North-Western State Medical University named after I.I. Mechnikov, 116 total hip replacement (THR) surgeries were performed for patients with osteoarthritis between January 1, 2022 and December 25, 2022. Using random sampling, material was collected for morphological examination from 30 patients aged 38 to 78 years (18 women and 12 men).

After surgery, femoral head fragments were fixed in 10% buffered formalin for 24 hours. Then, bone samples were cut using a saw set.

Histological specimens were prepared using a standard protocol for bone tissue, including decalcification (Sarkisov D.S., Perov Yu.L., 1996), carried out using the following method: bone fragments were decalcified in an electrolyte decalcifying solution (Biovitrum, Russia) at a volume ratio of 1:50 for 8 hours, with periodic assessment of decalcification progress using a needle. After decalcification, samples were rinsed under running water for 60 minutes. Histological processing, embedding, and microtomy (section thickness of 5 μm) were performed according to standard protocols. Staining was done using general-purpose dyes—hematoxylin and eosin—as well as Safranin O.

For the preparation of plastinated histotopograms of the femoral head and the entire hip joint (autopsy material), the epoxy plastination method was applied (Starchik D.A., 2015; Sora M.C. et al., 2019). After freezing the specimens to -80°C, they were sectioned using a Kolbe K430 band saw (Germany) in frontal and horizontal planes, with slice thickness ranging from 2 to 3 mm. The sections were then dehydrated in a 3:2 mixture of acetone and hexane at -25°C for three weeks, with the solvent replaced twice. This was followed by degreasing in the same solution at room temperature for two weeks with one solvent change.

Table 2.11 – Pathomorphological Classification of OOCHAS

<table>
<tr><th>Stage</th><th>Substage</th><th>Associated Criteria</th></tr>
<tr><td>Stage 0. Articular surface intact, cartilage intact</td><td>-</td><td>Intact, uninvolved cartilage</td></tr>
<tr><td rowspan="2">Stage 1. Articular surface is intact</td><td>1.0. Cellular elements intact</td><td>Cartilage matrix: superficial zone intact, edema and/or fibrillation</td></tr>
<tr><td>1.5. Cellular elements damaged</td><td>Cellular elements: active proliferation, hypertrophy</td></tr>
<tr><td rowspan="4">Stage 2. Superficial tears/damage</td><td>2.0. Fibrillation in the superficial zone</td><td>As above</td></tr>
<tr><td rowspan="3">2.5. Surface wear with loss of cartilage matrix</td><td>+ Irregularity in the superficial zone</td></tr>
<tr><td>± Depletion of cartilage matrix (safranin O or toluidine blue staining) in the upper 1/3 of cartilage (middle zone)</td></tr>
<tr><td>± Disruption of chondrocyte column orientation</td></tr>
</table>

| | | |
|---|---|---|
| Stage 3. Vertical fissures | 3.0. Simple cracks | As above |
| | 3.5. Branched cracks | ± Depletion of cartilage matrix (safranin O or toluidine blue staining) in the lower 2/3 of cartilage (deep zone) |
| | | ± New collagen formation (polarized light microscopy, picrosirius red staining) |
| Stage 4. Erosions | • 4.0. Delamination of the superficial zone | Cartilage matrix impoverishment, cyst formation in cartilage matrix |
| | • 4.5. Extensive damage to the middle zone | |
| Stage 5. Exposure of subchondral bone | • 5.0. Subchondral bone intact | Articular surface consists of sclerotic bone and/or initial osteophyte formation, fibrous fibrocartilage |
| | • 5.5. Initial formation of osteophytes | |
| Stage 6. Joint deformation | • 6.0. Osteophytes in the marginal zones of the joint | Subchondral bone remodeling. Deformation with enlargement of articular surface contour (due to osteophyte formation) |
| | • 6.5. Osteophytes in both marginal and central zones of the joint | Microfractures and remodeling areas |

In the Biodur Plastination Kettle vacuum chamber (Germany), the saw cuts were impregnated with a mixture of ED-20 epoxy resin and TETA hardener in a ratio of 20:1, with a gradual pressure reduction to 2 kPa using a Hydromech AVPR-16D (Russia) rotary vane vacuum pump. Impregnation was completed once the release of bubbles from the intermediate solvent ceased.

The cuts were embedded in flat polymethyl methacrylate chambers using a mixture of ED-20 epoxy resin and TETA hardener in a ratio of 10:1. After the resin had fully cured, the sections were removed from the chambers and scanned using an Epson V33 office scanner at a resolution of 600 dpi.

Using the same methodology, total pelvic sections through the hip joint at the level of the acetabulum were prepared from cadaveric material obtained from three men aged 57 to 72 years and two women aged 69 and 76 years, who had been diagnosed with stage II or III hip osteoarthritis during their lifetime and had died from causes unrelated to musculoskeletal diseases.

To assess damage to the articular surface and subchondral bone, the Osteoarthritis Research Society International (OARSI) Cartilage Histopathology Assessment System (OOCHAS) was used (Table 2.11) (Custers, R.J. et al., 2007).

*2.3.5 Statistical Research Methods*

The STATISTICA 10 software package was used for data processing. Statistical analysis included calculation of the arithmetic mean, standard deviation, standard error of the mean, and the 95% confidence interval for each studied indicator ($p = 0.05$). To determine the significance of the identified differences, Student's t-test and confidence probability tests were used. A difference was considered statistically significant if $p < 0.05$ (Glantz S., 1998).

Text formatting, tables, and charts were created using Microsoft Word 2010 and Microsoft Excel 2010 (Microsoft, USA).

The R programming language (https://cran.r-project.org) was used for data processing and graph construction (Andersen P.K., Niels A., 2014; Jawad Z. et al., 2019). To estimate the probability of symptom resolution by a specific observation time, the non-parametric Kaplan–Meier method was applied. This method allowed for comparing the impact of various factors on the maintenance of a positive quality of life (QoL) dynamic. In addition, the log-rank test was used.

The probability of maintaining a satisfactory QoL rating (or, in the terminology of the method, “survival”) at a specific observation time t (year of follow-up) was estimated using the Kaplan–Meier method. This method involves determining the survival function S(t)—the probability of a satisfactory QoL rating at time t—and plotting a survival curve, which enables forecasting the probability of maintaining a satisfactory QoL rating at a given time point. To compare survival probabilities between different groups (e.g., male vs. female patients), the log-rank test was used (Kaplan E.L., Meier P., 1956).

# CHAPTER 3. PREVALENCE OF OSTEOARTHRITIS AND FEATURES OF ITS STATISTICAL RECORDING

Pathologies and injuries of the musculoskeletal system are among the leading causes of disability and incapacitation worldwide (Sebbag E. et al., 2019). Within the structure of musculoskeletal diseases, osteoarthritis holds a leading position, being a major cause of severe pain and impairments in static-dynamic function (Alekseeva L.I. et al., 2015; Cross M. et al., 2014; Martel-Pelletier J. et al., 2016). According to expert forecasts, osteoarthritis will become the primary cause of disability by 2030 (Palazzo C. et al., 2014).

Over the past decade, there have been significant changes in the understanding of the processes underlying the development of osteoarthritis. The notion that this pathological condition develops exclusively in the elderly and as a result of a long-standing pathological process affecting the articular cartilage is now outdated (Karateev A.E., Lila M.A., 2018). Today, osteoarthritis is defined as a chronic, heterogeneous, progressive joint disease characterized by the degradation of the cartilage extracellular matrix, accompanied by remodeling of joint tissues and manifested by pain, development of marginal osteophytes, impaired functional activity, and reduced quality of life (Mazurov V.I. et al., 2016).

The pathogenesis of osteoarthritis also takes into account the role of mechanical stress, impaired reparative processes and remodeling of the subchondral bone, as well as increased production of proinflammatory cytokines (Shostak N.A. et al., 2019).

The results have been published (Mazurov V.I. et al., 2021). Overall, the dynamics of musculoskeletal system diseases in the Russian Federation remain at a high level and have shown no tendency to decrease in recent years (Fig. 3.1).

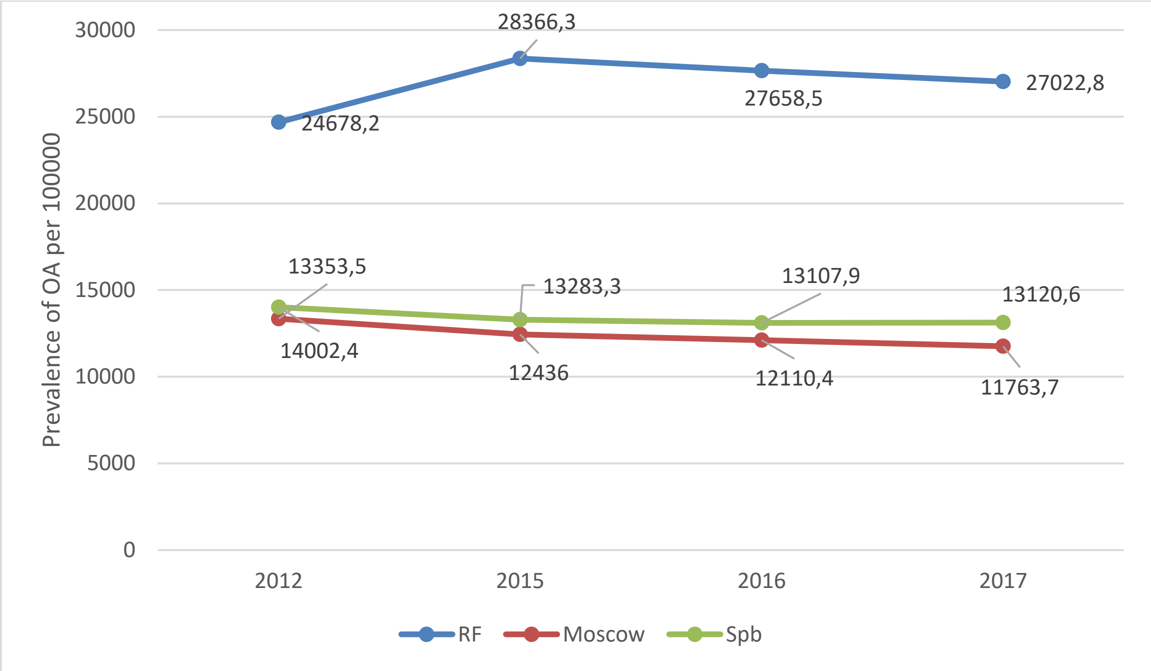



Fig. 3.1. Prevalence of musculoskeletal diseases per 100,000 population in the Russian Federation, with separate data highlighted for Moscow and St. Petersburg (according to data from the Ministry of Health of the Russian Federation, 2018).

As shown by the data presented in Fig. 3.1, the prevalence rates of musculoskeletal diseases in the Russian Federation as a whole and separately in Moscow are almost identical. The rates for St. Petersburg are above the national average, which may be due not only to a higher incidence of musculoskeletal diseases but also to issues related to the statistical recording of this group of diseases. The significance of osteoarthritis, as the most common disease of the musculoskeletal system, is underestimated in the healthcare systems of many countries, including the Russian Federation. This is mainly because of the low mortality rates associated with degenerative-dystrophic joint diseases. At the same time, the relevance of establishing a registry for patients with OA is increasing, primarily due to the expected rise in life expectancy, the irreversibility of joint changes, and the importance of early diagnosis for initiating therapy to delay early disability (Branco J.C. et al., 2016; WHO, 2019). Between 2012 and 2019, a retrospective study was conducted comparing data on the prevalence of osteoarthritis per 100,000 population in several regions of the Russian Federation. Materials covering all subjects of the Northwestern Federal District

(NWFD) were analyzed. Separate data concerning Moscow, St. Petersburg, and the Russian Federation as a whole were also studied. The results of the study were published (Mazurov V.I. et al., 2021).

Table 3.1. Dynamics of OA prevalence in the regions of the Northwestern Federal District in 2012–2019 (per 100,000 population)

| Region | Observation Years | | | | | |
|---|---|---|---|---|---|---|
| | 2012 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Northwestern Federal District | 4474,9 | 5257,2 | 5060,4 | 6174,2 | 5173,7 | 5126,3 |
| Saint Petersburg | 6545 | 7933,3 | 7373,3 | 7528,2 | 7416,5 | 7151,1 |
| Arkhangelsk Region | 3487,5 | 4132,3 | 4195,2 | 4321,3 | 4511,1 | 4693,2 |
| Vologda Region | 2149,8 | 2461,5 | 2756,5 | 2802,6 | 2953,6 | 3096,5 |
| Kaliningrad Region | 2954,5 | 3211,7 | 2656,7 | 3173,6 | 3359,2 | 2957,5 |
| Leningrad Region | 2144,2 | 2149,1 | 2278,4 | 2504,9 | 2574,2 | 2618,9 |
| Murmansk Region | 4383,8 | 4895,3 | 4860,6 | 4885,8 | 4843,2 | 5931,1 |
| Novgorod Region | 3915,7 | 3757,1 | 3595,2 | 3234,2 | 3302 | 3483,3 |
| Nenets Autonomous Okrug | 5234,2 | 5257 | 5218,8 | 4846,6 | 4842,8 | 5375,5 |
| Pskov Region | 2994,3 | 3409,4 | 4348,6 | 4259,5 | 4346,2 | 4443,6 |
| Republic of Karelia | 4872,5 | 5197,9 | 4800,1 | 4665,2 | 4439,5 | 4376,6 |
| Republic of Komi | 4448,1 | 5484,1 | 5293,3 | 5246,6 | 5086,5 | 4843,3 |

When analyzing data on the prevalence of OA in the regions of the Northwestern Federal District (Table 3.1), it was found that the prevalence of OA among residents of Saint Petersburg significantly exceeds both the indicators for other regions of the Northwestern Federal District and the district average. This trend was observed throughout the entire study period.

The highest rates of OA (per 100,000 population) were recorded among residents of Saint Petersburg, the Republic of Komi, and Murmansk Region, while the lowest rates were observed in Leningrad and Kaliningrad Regions.

Particular attention should be paid to the differences in OA prevalence between Saint Petersburg and Leningrad Region. According to the data presented in Table 3.1, the prevalence of OA in Saint Petersburg is, on average, three times higher than in the neighboring Leningrad Region. A similar pattern is seen when comparing the prevalence of OA in Saint Petersburg with that in Moscow and with the national average for the Russian Federation (Fig. 3.2).

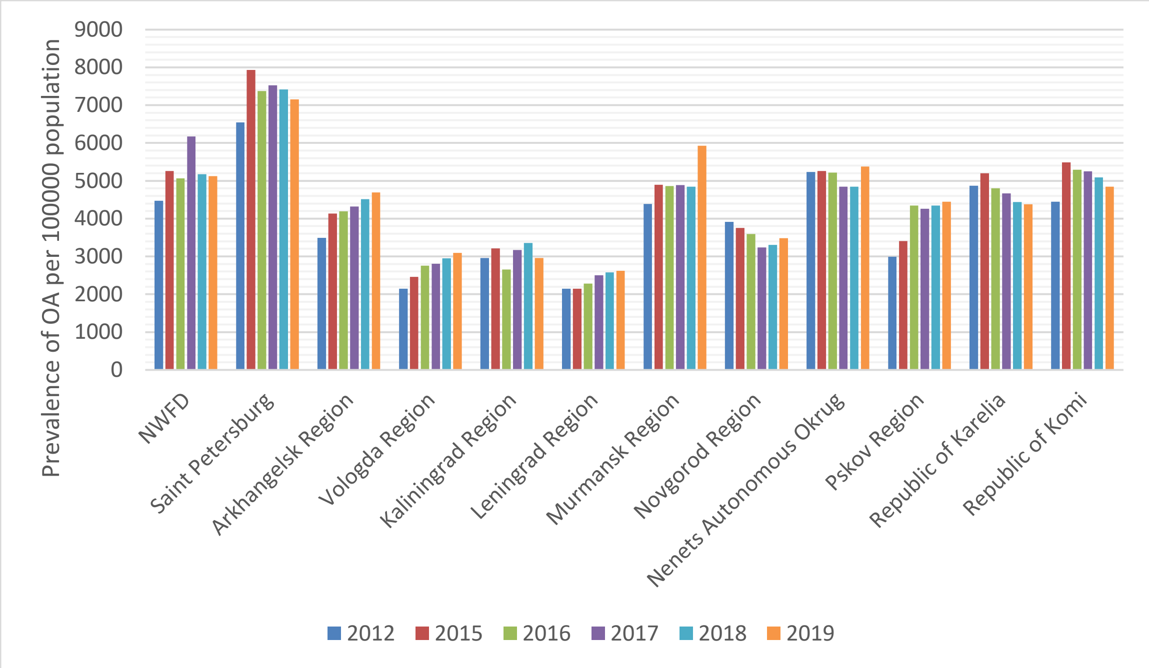



Fig. 3.2. Overall incidence of osteoarthritis per 100,000 adult population in the constituent entities of the Northwestern Federal District.

The incidence of osteoarthritis in Saint Petersburg from 2012 to 2019 exceeded that in Moscow and the Russian Federation overall by twofold or more (Fig. 3.3). The average overall incidence of osteoarthritis was 7,480.4 per 100,000 adult population in Saint Petersburg, compared to 3,725.8 in Moscow and 3,842.2 across Russia over the five-year period from 2015 to 2019 inclusive (Mazurov V.I. et al., 2021).

The trend of a high prevalence of OA among residents of Saint Petersburg persisted in comparison with the rates in Moscow and across Russia throughout the entire study period. These differences are likely attributable to the absence of officially approved forms of statistical reporting in outpatient and inpatient healthcare facilities across the regions, as well as to differences in the procedures for detecting this pathology among patients hospitalized in non-rheumatologic departments. The prolonged course of OA in patients without pronounced clinical symptoms emphasizes the particular importance of early preclinical diagnosis and the selection of appropriate therapy.

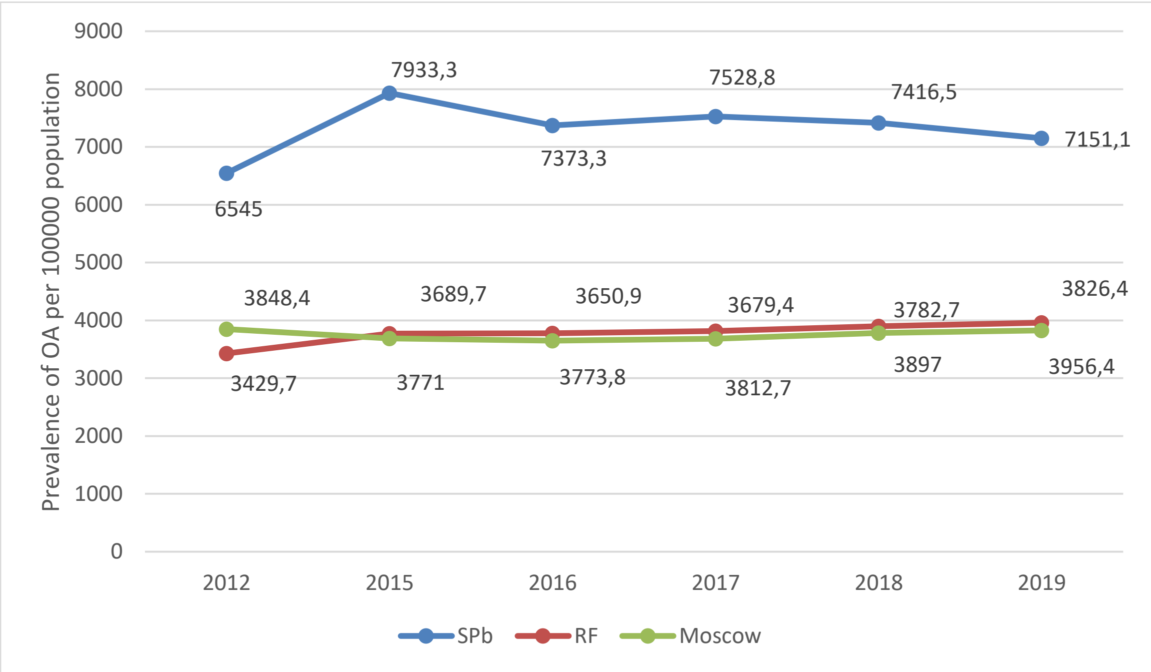



Fig. 3.3. Prevalence of osteoarthritis (per 100,000 population) in Moscow, Saint Petersburg, and the Russian Federation overall.

Osteoarthritis is the most common joint disease, affecting over 10% of the global population (Grotle M. et al., 2008; Hoy D. et al., 2014). In the Russian Federation, according to official statistics, the number of patients with OA is approximately 4 million; however, many authors consider this figure to be underestimated. Actual numbers exceed this figure by four times or more, amounting to approximately 16 million people (Balabanova R.M., Erdesh Sh.F., 2015). In the United States, about 52 million patients with OA have been registered, among whom 964,000 underwent inpatient treatment (Folomeeva O.M. et al., 2008; Pfuntner A. et al., 2013; Arthritis-Related Statistics, 2016). An epidemiological study by E.A. Galushko et al. (2009) showed that in Russia, OA of the knee and hip joints is diagnosed in 13% of the population over 18 years of age (Galushko E.A. et al., 2009). According to the Framingham study, radiological signs of OA in patients over

70 years of age were observed in more than 90% of cases, although clinical manifestations occurred much less frequently (Zhang Y. et al., 2002).

In the medium term, osteoarthritis may become the leading cause of temporary disability and permanent impairment. In the Russian Federation, inpatient conservative treatment of OA is funded by mandatory medical insurance funds only to a minimal extent, which makes hospitalization of such patients extremely unprofitable for healthcare institutions. As a result, patients are hospitalized under a different primary diagnosis, which is legitimate but prevents their inclusion in statistical records (Mazurov V.I. et al., 2021).

In the reporting forms used in outpatient and inpatient healthcare institutions in the Russian Federation, data on OA are not specifically recorded. Data collection is generally carried out manually. The need to establish a systematic record of OA patients in outpatient and inpatient healthcare settings is becoming increasingly relevant, primarily due to the expected rise in life expectancy (Khaidarov V.M. et al., 2020; Urazovskaya I.L. et al., 2024).

Thus, the incidence of osteoarthritis in the Russian Federation remains high overall and shows no stable trend toward decline. The increase in incidence is also associated with the growing life expectancy. The fact that OA patients are treated by specialists of different profiles (orthopedists, rheumatologists, physiotherapists, rehabilitation specialists, etc.) and receive care in institutions of varying levels of accreditation results in the absence of a unified and generally accepted treatment strategy for patients with hip osteoarthritis to date. In the following chapters of this dissertation, treatment approaches to hip osteoarthritis from the perspectives of an orthopedic traumatologist and a therapist, as well as the results of these approaches, are discussed.

# CHAPTER 4. OUTCOMES OF HIP JOINT ARTHROPLASTY IN OSTEOARTHRITIS

As previously mentioned in Chapter 2 (Table 2.1), the retrospective study group included 963 patients with idiopathic or post-traumatic hip osteoarthritis (HOA) who underwent primary total hip arthroplasty and were discharged from the Department of Traumatology and Orthopedics of the North-Western State Medical University named after I.I. Mechnikov between 2012 and 2019 (inclusive). Data on the sex distribution and age of this patient group are presented in Table 4.1.

Table 4.1 – Distribution of patients who underwent primary total hip arthroplasty for osteoarthritis, by age and sex

| Age groups, years | Number of patients (%) | | | | | |
|---|---|---|---|---|---|---|
| | Men | | Women | | Total | |
| | Abs. | % | Abs. | % | Abs. | % |
| 18– 44 | 76 | 7,9 | 44 | 4,7 | 120 | 12,6 |
| 45-– 64 | 189 | 19,6 | 216 | 22,3 | 405 | 41,9 |
| 65 and older | 133 | 13,8 | 305 | 31,7 | 438 | 45,5 |
| Total | 398 | 41,3 | 565 | 58,7 | 963 | 100 |

Among the patients of the younger age group, men predominated — 76 (7.9%), while women accounted for 44 (4.7%). Among the patients of middle and older age groups, women prevailed — 216 (22.3%) compared to 189 (19.6%) men. The male-to-female ratio in the elderly group was 1:3 (13.8% and 31.7%, respectively) (Table 4.1).

## 4.1. Early Outcomes of Hip Arthroplasty

When assessing intraoperative and early postoperative complications among patients who underwent arthroplasty, complications were identified in 131 (13.6%) out of 963 patients (Table 4.2).

Cardiovascular complications were recorded in 15 patients (1.6%). Fracture of the greater trochanter occurred in 9 cases (1.0%), and injury to major blood vessels during surgery was also noted in 9 patients (1.0%). Postoperative hematoma was diagnosed in 38 cases (3.9%), and surgical site infection was detected in 48 patients (5.0%) (Table 4.2).

Table 4.2 – Complications Identified During Hip Arthroplasty

| Types of complications | Number of observations | |
|---|---|---|
| | Abs. | (%) |
| Intraoperative | 84 | 8,7 |
| Local | 48 | 5,0 |
| Fracture of the greater trochanter | 9 | 1,0 |
| Bleeding from major vessels | 9 | 1,0 |
| Injury to nerve trunks | 6 | 0,6 |
| Fracture of the femoral shaft | 7 | 0,7 |
| Acetabular injury | 6 | 0,6 |
| Other | 11 | 1,1 |
| General | 36 | 3,7 |
| Cardiovascular complications | 15 | 1,6 |
| Respiratory complications | 8 | 0,8 |
| Central nervous system complications | 6 | 0,6 |
| Other | 7 | 0,7 |
| Postoperative complications | 163 | 16,9 |
| Local | 133 | 13,8 |
| Endoprosthesis dislocation, aseptic loosening | 20 | 2,1 |
| Hematoma | 38 | 3,9 |
| Superficial surgical site infection (SSI) | 34 | 3,5 |
| Lymphorrhea | 27 | 2,8 |
| Deep surgical site infection (within 12 months) | 14 | 1,5 |
| General | 30 | 3,1 |
| Cardiovascular complications | 13 | 1,4 |
| Respiratory complications | 7 | 0,7 |
| Central nervous system complications | 3 | 0,3 |
| Other | 7 | 0,7 |
| Total number of complications | 247 | 25,6 |
| Total number of patients with complications | 131* | 13,6 |
| Total number of patients | 963 | 100 |

* 61 patients had two or more complications.

The relatively high frequency of complications can be explained by the fact that not only those recorded in the discharge summary were taken into account, but also those verified solely in daily medical notes (such as a single episode of elevated blood pressure; lymphorrhea or a hematoma of the surgical wound evacuated during dressing changes, etc.). According to the Clavien-Dindo classification (2004), the majority of these complications (139 out of 247, or 56.3%) were classified as type I–II complications, which did not affect the overall treatment outcome (Zamyatina K.N. et al., 2021).

Table 4.3 – Comorbidities in Different Age Groups Identified in Patients Who Underwent THA (n = 963)

| Comorbidity | Age groups, years | | | Total |
|---|---|---|---|---|
| | 18–44 | 45–64 | 65 and older | |
| **Cardiovascular diseases** | | | | |
| Hypertension | 31 (16.4) | 234 (54.0) | 258 (75.7) | 523 (54.3) |
| Ischemic heart disease (IHD) | 12 (6.3) | 43 (9.9) | 54 (15.8) | 109 (11.3) |
| Myocardial infarction | 2 (1.0) | 4 (0.9) | 7 (2.0) | 13 (1.3) |
| Chronic heart failure | 5 (2.6) | 21 (4.8) | 20 (5.8) | 46 (4.7) |
| Dyslipoproteinemia | 62 (32.8) | 135 (31.2) | 259 (75.9) | 456 (47.3) |
| Cerebrovascular diseases | 7 (3.7) | 18 (4.2) | 22 (6.4) | 47 (4.8) |
| **Obesity** | 21 (11.1) | 56 (13.0) | 98 (28.7) | 175 (18.2) |
| **Type 2 diabetes mellitus** | 19 (10.0) | 57 (13.1) | 102 (29.9) | 178 (18.4) |
| **Hypothyroidism** | 15 (7.9) | 42 (9.7) | 85 (24.9) | 142 (14.7) |
| **Gastrointestinal diseases** | | | | |
| Peptic ulcer disease | 19 (10.0) | 34 (7.8) | 88 (25.8) | 141 (14.6) |
| Gastritis | 10 (5.2) | 20 (4.6) | 69 (20.2) | 99 (10.2) |
| Chronic liver diseases (mild to moderate) | 9 (4.7) | 32 (7.4) | 34 (9.9) | 75 (7.7) |
| **Chronic lung diseases** | | | | |
| Chronic obstructive pulmonary disease (COPD) | 21 (11.1) | 72 (16.6) | 79 (23.1) | 162 (16.8) |
| Bronchial asthma | 18 (9.5) | 49 (11.3) | 58 (17.0) | 125 (12.9) |
| Malignant neoplasms | 9 (4.7) | 12 (2.7) | 18 (5.2) | 39 (4.0) |
| **Chronic kidney disease** | 2 (1.0) | 3 (0.7) | 6 (1.75) | 11 (1.1) |
| **Gout** | 11 (5.8) | 31 (7.6) | 35 (10.2) | 77 (7.9) |
| **Neuropsychiatric disorders** | | | | |
| Sleep disorders | 19 (10.0) | 47 (10.9) | 50 (14.6) | 116 (12.0) |
| Sleep apnea | 11 (5.8) | 27 (6.2) | 25 (7.3) | 63 (6.5) |
| Depression | 23 (12.2) | 47 (10.9) | 85 (24.9) | 155 (16.0) |
| **Total patients** | 189 | 433 | 341 | 963 |

As can be seen from the data presented in Table 4.3, in young and middle-aged patients, the structure of comorbidities was predominantly represented by arterial hypertension (16.4%), dyslipoproteinemia (32.8%), hypothyroidism (7.9%), type 2 diabetes mellitus (10.0%), gastrointestinal diseases (19.9%), sleep disorders (10%), and depression (12.2%).

Disability, mostly due to general diseases, was established in 460 (47.8%) patients, i.e., almost half of the cases. The intensity of the pain syndrome directly correlated with the development of mobility restrictions, decreased work capacity, and, as a result, the assignment of a disability group. These changes led to increased anxiety, sleep disorders predominantly manifesting as insomnia, and depression. Patients who maintained physical activity, engaged in physiotherapy exercises, and regularly performed rehabilitation activities reported a significantly longer period without joint pain or characterized the pain as insignificant.

An age-related increase in the comorbidity index was primarily associated with a higher prevalence of cardiovascular diseases (75.7%) among older patients. Against the background of pain syndrome therapy with various groups of analgesics, predominantly NSAIDs, combined with antiplatelet therapy, there was a significant increase in the frequency of acute cardiovascular events: acute myocardial infarction (from 1% to 2%) and worsening of chronic heart failure (from 2.6% to 5.8%), with an associated increase in mortality compared to patients with low comorbidity indices.

High comorbidity was also accompanied by an increased number of prescribed medications, leading to polypharmacy. Additionally, elderly and senile patients undergoing long-term NSAID therapy experienced exacerbations of gastrointestinal diseases, predominantly gastritis (from 5.2% to 20.2%) and peptic ulcer disease (from 10% to 25.8%), despite the use of proton pump inhibitors. Frequent exacerbations of gastrointestinal pathology resulted in impaired digestion and absorption, with complaints of dysphagia, dyspepsia, and impaired intestinal motility, predominantly constipation. This was accompanied by weight loss and signs of sarcopenia, worsening the course of both osteoarthritis and comorbid conditions.

Type 2 diabetes mellitus and hypothyroidism were found with varying frequencies in different comorbidity groups, being more prevalent in the low comorbidity group. Hypothyroidism was often diagnosed as subclinical hypothyroidism associated with autoimmune thyroiditis. With age, the incidence of hypothyroidism decreased, while the prevalence of type 2 diabetes mellitus increased. Type 2 diabetes mellitus was significantly more common in patients with obesity, metabolic syndrome, cardiovascular diseases, and chronic kidney disease. The incidence of pulmonary diseases did not differ significantly between low and high comorbidity groups, although it exceeded that of the general population according to statistical data.

Thus, a high comorbidity index in patients with hip osteoarthritis was significantly associated with increased mortality from cardiovascular diseases, especially among patients with type 2 diabetes mellitus, obesity, and metabolic syndrome. The presence of pain syndrome and limited mobility led to an increased need for analgesics, primarily NSAIDs. With aging, the number of comorbidities and the need for a wide range of medications increased, further complicating the course of osteoarthritis due to polypharmacy.

Among patients hospitalized for hip arthroplasty, 88.8% (855 patients) were diagnosed with multiple comorbidities. Cardiovascular pathology was identified in 65% (626 patients).

Patients with low comorbidity (LC) — 286 individuals (29.7%) (CCI: 0–2). Patients with high comorbidity (HC) — 677 individuals (70.3%) (CCI: 3 or more).

During THA, implants of different fixation types (cemented, cementless, and hybrid) were used (Table 4.4).

Table 4.4 – Types of Fixation Used for Total Hip Arthroplasty Implants

| Type of Fixation | Number of Observations abs. (%) |
|---|---|
| Cementless | 438 (45,5) |
| Cemented, including | 525 (54,5) |
| • Acetabular component only | 124 (12,9) |
| • Femoral component only | 87 (9,0) |
| • Both acetabular and femoral components | 314 (32,6) |
| Total | 963 (100) |

According to the data presented in Table 4.4, bone cement was used for implant component fixation in 525 cases (54.5%).

Table 4.5 – Types of Anesthetic Management Used During Total Hip Arthroplasty

| Anesthetic management | Число наблюдений (%) |
|---|---|
| spinal anesthesia | 789 (81,9) |
| endotracheal anesthesia | 61 (6,3) |
| combined anesthesia | 65 (6,7) |
| concurrent anesthesia | 48 (5,1) |
| Total | 963 (100) |

In the majority of cases (81.9%), spinal anesthesia was used (Table 4.5). The early results of THA were taken into account when assessing the functional outcomes and quality of life (QoL) of the patients, serving as the baseline for evaluating further dynamics.

4.2 Long-term outcomes of hip joint replacement with an implant in osteoarthritis

Throughout the entire follow-up period after discharge, the patients remained under observation.

The data on patients who maintained contact during the entire observation period, considering their comorbidity, are presented in Table 4.6.

Table 4.6 – Information on patients under follow-up considering comorbidity and the duration after THA

| Years of follow-up | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Number of patients (%) | 963 (100) | 831 (86,3) | 798 (82,9) | 765 (79,4) | 742 (77,1) | 726 (75,4) |
| - with low comorbidity (LC) (%) | 286 (29,7) | 189 (19,6) | 162 (16,8) | 154 (16,0) | 149 (15,5) | 145 (15,1) |
| - with high comorbidity (HC) (%) | 677 (70,3) | 642 (66,7) | 636 (66,1) | 611 (63,4) | 593 (61,6) | 581 (60,3) |

70.3% of 960 patients had high comorbidity (CCI: 3 or higher), and 29.7% (286 patients) had low comorbidity (CCI: 0–2). By the end of the 6-year follow-up period, data on the condition of 75.4% (726 patients) were collected. Data on complications that occurred during the follow-up period are presented in Table 4.7.

Table 4.7 – Complications of THA within 5 Years after Surgery (n=726)

| Type of Complication | Число наблюдений (%) |
|---|---|
| wear and loosening of implant components | 53 (7,3) |

| | |
|---|---|
| infectious complications | 56 (7,7) |
| superficial infection<br>deep infection | 38 (5,2)<br>18 (2,5) |
| dislocation of the implanted joint with loss of stability | 49 (6,7) |
| implant fracture | 8 (1,1) |
| periprosthetic ossification | 28 (3,9) |
| periprosthetic fracture | 19 (2,6) |
| Total complications | 213 (29,3) |

According to the data presented in Table 4.7, the most common complications were infectious complications – 56 cases (7.7%). The method of survival analysis in Russia is considered innovative. Its effectiveness has been analyzed and the results published in scientific journals (Aliyev B.G. et al., 2022; Tkachenko A.N. et al., 2023). The study determined the probability of maintaining high and excellent quality of life (QoL) over a certain follow-up period. The effectiveness of THA was clinically evaluated using the W.H. Harris scale (1969, 1987), the results of which are presented in Table 4.8.

Table 4.8 – Functional outcomes over 5 years of follow-up in patients who underwent total hip arthroplasty (THA)

| Years of follow-up | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Functional results<br>- excellent and good (%) | 934 (97,0) | 793 (95,4) | 729 (91,4) | 602 (90,4) | 645 (87,0) | 629 (86,6) |
| - fair and poor (%) | 29(3,0) | 38(4,6) | 69 (8,5) | 64 (8,6) | 97(13,0) | 97 (13,4) |
| Number of patients (%) | 963 (100) | 831 (100) | 798 (100) | 766 (100) | 742 (100) | 726 (100) |

According to the data presented in Table 4.8, the dynamics of positive functional outcomes over the five-year follow-up period show a distinct downward trend: from 98.4% in the early postoperative period to 84.5% by the beginning of the sixth year. The actual follow-up time for patients (taking into account censored observations) was considered in the calculations. Survival analysis methods make it possible to include all such clinical observations. Although statistical survival analysis methods are applied to censored data, their use to describe the postoperative course dynamics in traumatology and orthopedics studies is not yet considered widespread (Khaidarov V.M. et al., 2020; Urazovskaya I.L. et al., 2024). The aim of this stage of the dissertation was to study the patterns of the long-term postoperative course (results published in open access – Aliev B.G. et al., 2022; Tkachenko A.N. et al., 2020; Tkachenko A.N. et al., 2023). The probability of the event of interest occurring at any time point during follow-up can be assessed using survival probability curves or by applying specific functions for each year of observation. For example, by the beginning of the sixth year of follow-up, the estimated probability of maintaining a satisfactory quality of life (QoL) rating, with a 95% confidence interval, decreased from 99% (in the first postoperative year) to 87%, amounting to 0.875 (0.823; 0.911).

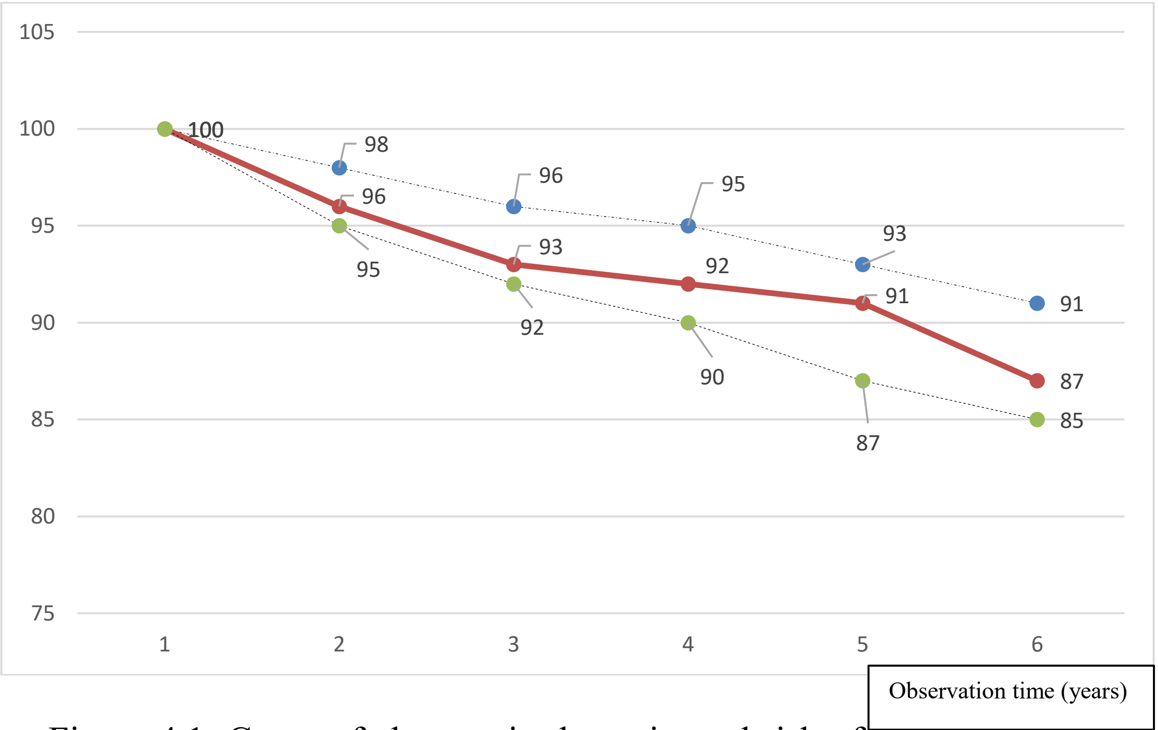



Figure 4.1. Curve of changes in the estimated risk of maintaining excellent and good quality of life outcomes with a 95% confidence interval.

Figure 4.1 shows the survival curve estimating the probability of maintaining a satisfactory quality of life (QoL) assessment with a 95% confidence interval.

In order to investigate the impact of certain parameters on the deterioration of QoL, factors such as age, gender, body mass index (BMI), and anesthetic risk as an integrated indicator of comorbidity severity were analyzed separately.

Figure 4.2 presents the survival curves for maintaining excellent and good quality of life (QoL) in patients who underwent THA, depending on gender.

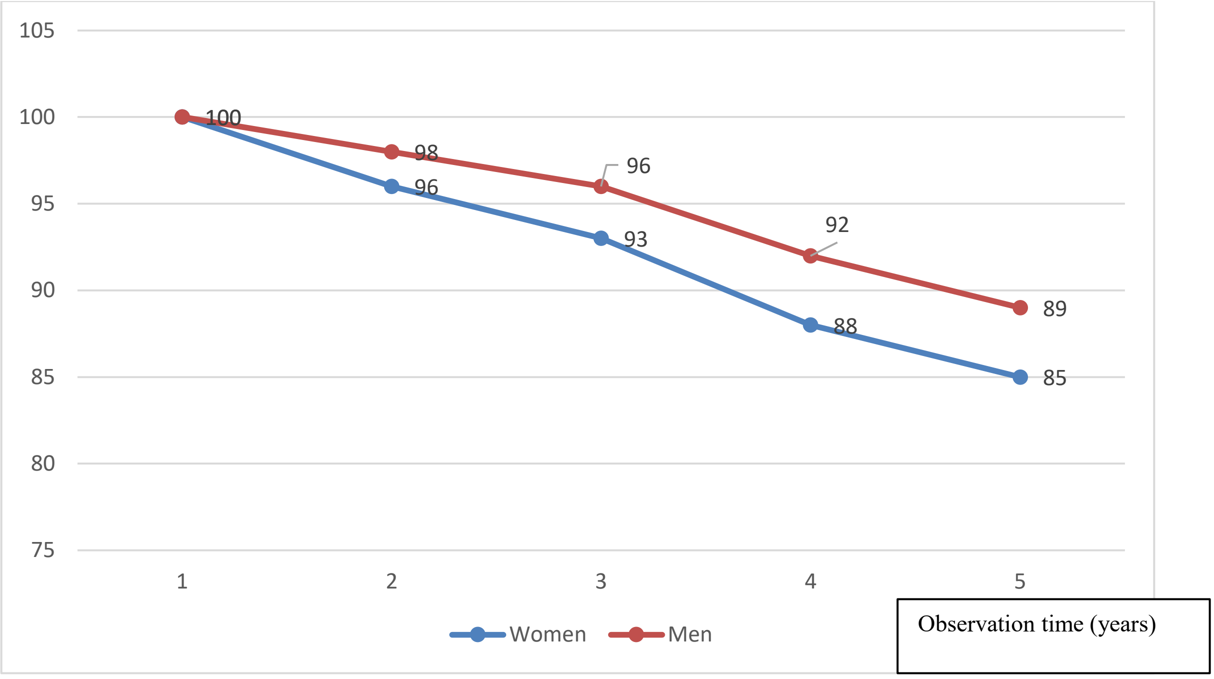



Figure 4.2. Risk assessment curve for maintaining excellent and good quality of life outcomes depending on gender, with a 95% confidence interval (women; men).

As shown by the results of the log-rank test, the test statistic ($Z = -0.2714$) and the p-value ($p = 0.7273$) indicate that there are no statistically significant differences between the survival (maintenance) curves for satisfactory quality of life (QoL) assessment among patient groups of different sexes. The log-rank test is used solely to verify the statistical significance of differences and does not provide an estimate of the magnitude of the difference between groups. The graph in Figure 4.2 illustrates the differences between the two survival (maintenance) curves for satisfactory QoL assessment after surgery depending on gender. According to the data presented in Figure 4.2, up to the 5th year, the QoL of both male and female patients does not differ significantly. However, by the 5th and especially the 6th year of observation, a trend emerges indicating that the probability of maintaining a satisfactory QoL assessment in female patients decreases to 0.85 (0.79; 0.88), compared to 0.89 (0.83; 0.93) in male patients. (Khaydarov V.M. et al., 2020; Urazovskaya I.L. et al., 2024).

As for patient age (Figure 4.3), by the 6th year of follow-up, the following trend is observed: the best outcomes are noted in young patients (up to 44 years of age), with the probability of maintaining a satisfactory QoL assessment reaching 0.91 (0.85; 0.93); slightly worse outcomes are seen in the middle-aged group (45 to 64 years inclusive) – 0.88 (0.77; 0.91); excellent and good QoL outcomes in patients aged 65 years and older amount to 0.84 (0.77; 0.88).

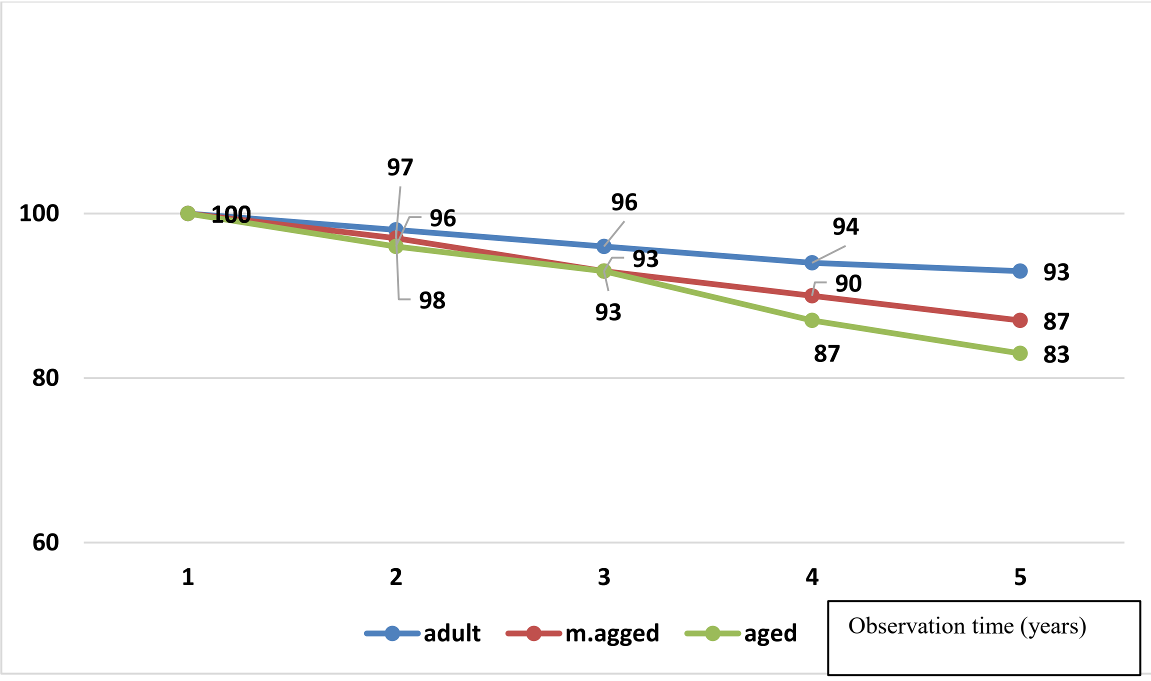



Fig. 4.3. Risk curve for maintaining excellent and good quality of life outcomes depending on patients' age, with a 95% confidence interval (adult – from 19 to 44 years; middle-aged – from 45 to 64 years; aged – 65 years and older).

The log-rank test indicates no statistically significant differences between the survival curves of these age groups (Chi-square = 2.9166 and p-value = 0.2733). However, a clear trend is observed, which requires further investigation.

The integral indicator characterizing the severity of comorbid pathology was considered the physical status grade of patients who underwent THA according to the updated classification of the American Society of Anesthesiologists (ASA) (Levin Ya.I., Koryachkin V.A., 2021). The observation group with low comorbidity included patients classified as ASA I and ASA II, while patients with ASA III–IV were assigned to the group with significant comorbidity (see Table 2.6).

As shown in Fig. 4.4, the long-term outcomes of total hip arthroplasty (THA) in patients with ASA I–II (less severe comorbid pathology) are slightly better. The probability of maintaining excellent and good QoL by the end of the 5th year of follow-up was 0.87 (0.82; 0.93). Among clinical observations with ASA III–IV, this indicator was slightly lower — 0.855 (0.83; 0.89).

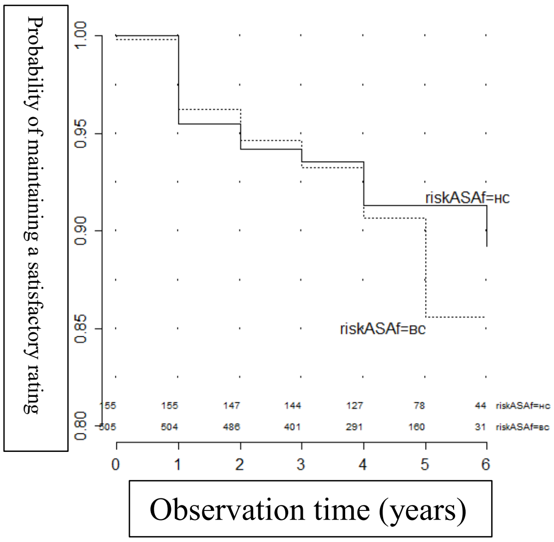



Figure 4.4. Survival curve for maintaining excellent and good quality of life outcomes depending on anesthesiological risk, with a 95% confidence interval (risk ASA f=lc – anesthesiological risk ASA Stage I–II; risk ASA f=hc – anesthesiological risk ASA Stage III–IV).

The log-rank test indicates no statistically significant differences between the survival curves of patients with different ASA classifications (Z = 0.9294, p-value = 0.3356). As with all previous observations, these results cannot be considered statistically significant. Rather, they point to a trend that undoubtedly requires further study of THA outcomes over a longer follow-up period—at 10 and 15 years.

When assessing patients' quality of life (QoL) over five years after total hip replacement, excellent and good outcomes were considered. The probability of achieving such outcomes at any year during the follow-up period can be determined using survival probability curves.

The outcomes of total hip arthroplasty (THA) were analyzed in two groups: the first group included patients with low comorbidity (LC) (practically healthy clinical cases or patients with mild systemic disease, CCI: 0–2); the second group consisted of cases with high comorbidity (HC) (patients with a combination of several mild or a single severe systemic disease, CCI: 3 and above) (Fig. 4.5).

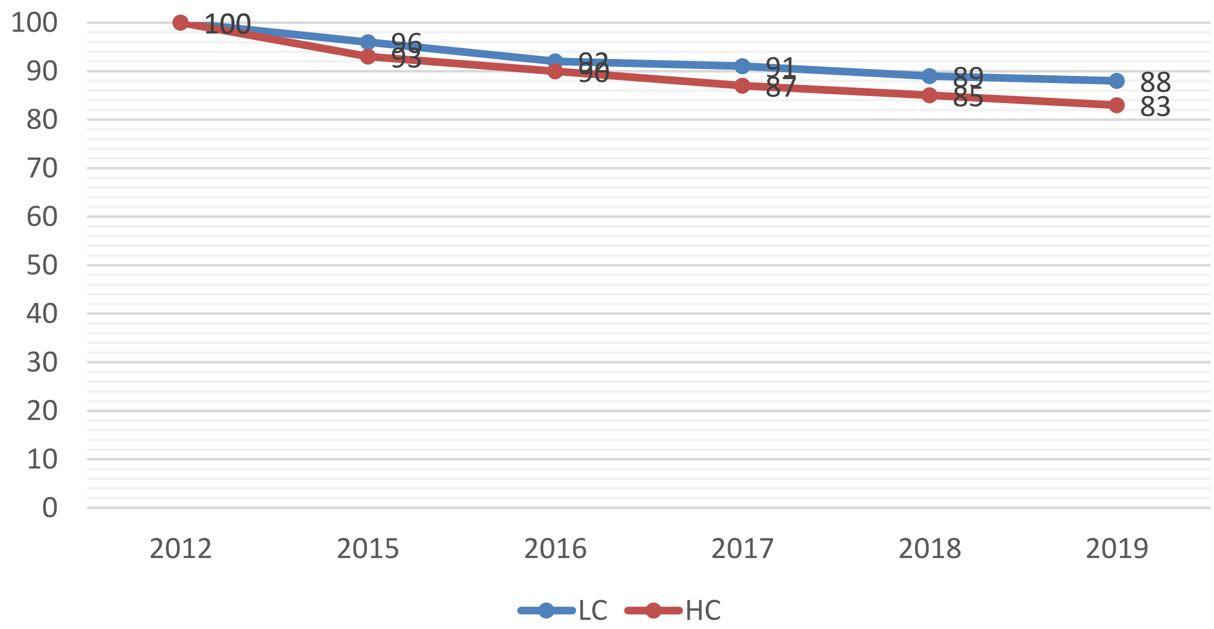



Figure 4.5. Risk curve of maintaining excellent and good quality of life outcomes after total hip arthroplasty depending on comorbidity level with a 95% confidence interval (LC – low comorbidity; HC – high comorbidity).

As shown by the data presented in Figure 4.5, the long-term outcomes of THA among clinical cases with a low level of comorbidity (less severe comorbid pathology) were somewhat better. The probability of maintaining excellent or good QoL by the end of the 5-year follow-up period in the LC group was 0.88 (0.82; 0.93). In patients with significant comorbid pathology (HC – high level of comorbidity), this indicator was slightly lower — 0.83 (0.78; 0.87). However, no statistically significant differences between the survival curves of patients with varying levels of comorbidity were observed, as indicated by the log-rank test ($Z = 0.92$ and p-value $= 0.33$). These differences cannot be considered statistically significant. In this case, we are talking about a trend, which undoubtedly requires further study of THA outcomes in a longer-term perspective — at 10 and 15 years post-surgery.

In general, based on the analysis of five-year THA outcomes, excellent and good QoL can be expected in 86% of patients. Approximately 14% of patients assess their quality of life as fair or poor. Five-year outcomes of hip arthroplasty do not show significant differences between groups with and without pronounced comorbid pathology ($p > 0.05$). The survival analysis method for studying long-term treatment outcomes is of particular interest due to the high probability of losing contact with patients in the distant postoperative period, as it allows censored observations to be used. Based on the presented example and interpreting the results in terms more understandable to practicing physicians, the following conclusions can be drawn: by the end of the 5-year follow-up period after total hip arthroplasty for osteoarthritis, excellent and good QoL can be expected in 85% of patients.

Fair and poor outcomes are observed in 15% of patients. Quality of life 5 years after THA tends to be somewhat worse in elderly female patients with comorbidities; however, these differences are not statistically significant ($p > 0.05$). These are trends that require further investigation.

Case No. 1

Patient I., 59 years old, was admitted to the clinic with the diagnosis: Stage III osteoarthritis of the right hip joint with severe pain syndrome (Figures 4.6 A, B). The patient's weight was 102 kg, height 162 cm, BMI = 38.9 kg/m² (Grade 2 obesity). At admission, she complained of pain and restricted movement in the right hip joint for 10 years. Conservative treatment had been attempted: physiotherapy (thermal procedures), NSAIDs, and chondroprotectors (MSM (methylsulfonylmethane) complexes). After the courses of conservative treatment, only moderate positive effects were observed.

Recently, the treatment became ineffective, and a decision was made to perform total hip arthroplasty. Upon examination by an anesthesiologist, the anesthesia risk was assessed as ASA Class III. Spinal anesthesia was chosen.

On September 20, 2017, total cementless right hip arthroplasty was performed (Figure 4.6 C).

Prophylaxis of thromboembolic complications included the use of electrical neuromuscular stimulation combined with direct oral anticoagulants.

Immediately after surgery, an injection of diprospan was administered into each sacroiliac joint, and NSAIDs were prescribed. Pain syndrome was minimized by the evening of the surgery day.

A. B. C D

**Fig. 4.6. Radiographs of Patient I. (59 years old).** Osteoarthritis of the right hip joint, Stage III (A — anteroposterior view; B — lateral view). C — radiographs after total cementless hip arthroplasty. Implant-to-bone relationship — satisfactory. D — instability of the acetabular and femoral components of the prosthesis.

The inpatient stage proceeded without complications. The patient was discharged for outpatient treatment in satisfactory condition. After 1.5 years, the patient began to experience the onset of pain and restricted range of motion in the hip joint.

She began outpatient treatment with non-steroidal anti-inflammatory drugs and underwent a course of physiotherapy (UHF therapy, phonophoresis with hydrocortisone). Two years after the surgery and discharge from the hospital, the patient reported pain and limitation of motion in the right hip joint. Radiographic examination revealed instability of the acetabular and femoral components of the prosthesis (see Fig. 4.6 D).

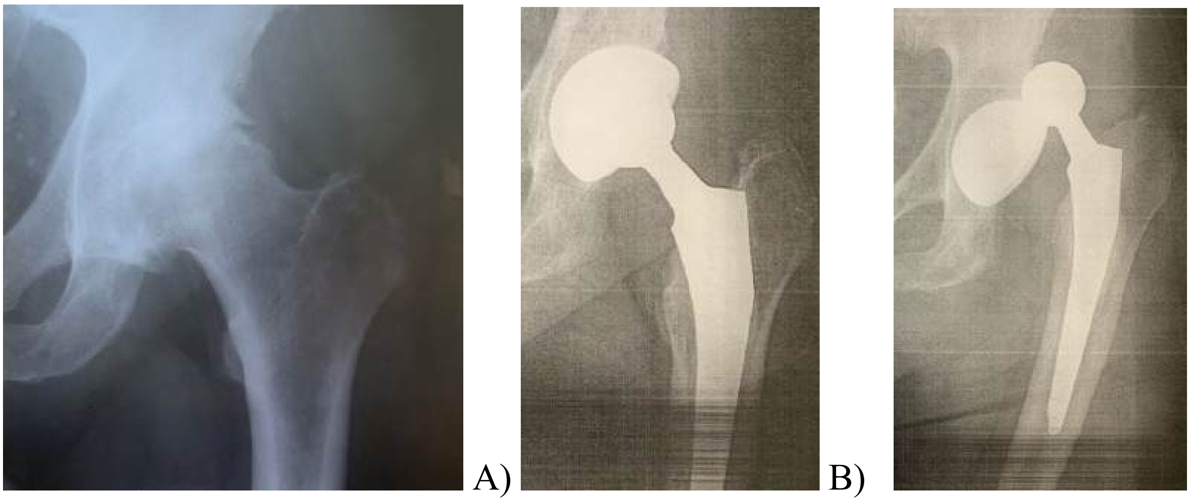
Due to instability of both the acetabular and femoral components, the patient was referred for revision total hip arthroplasty of the right hip joint.

Case No. 2

Patient E., 51 years old, was admitted in 2017 to the Department of Orthopedics and Traumatology at the Mechnikov North-Western State Medical University for planned hospitalization.

Upon admission, the patient was diagnosed with Stage III left hip osteoarthritis (see Fig. 4.7 A). Comorbidities included Stage II hypertension. The patient had a low comorbidity index (CCI: 1). He had no history of inpatient treatment; BMI was 24.6 (height — 170 cm, weight — 71 kg).

There were no absolute contraindications to total hip arthroplasty (THA). Before surgery, the patient underwent a full preoperative evaluation, during which the anesthesiologist assessed the anesthesia risk as ASA Class III. Spinal anesthesia was planned. All necessary preoperative preparations were completed, and the patient was prepared for total cementless hip arthroplasty of the left hip (see Fig. 4.7 B). The surgery lasted 90 minutes, with an intraoperative blood loss of 500 ml. The postoperative period was uneventful. Sutures were removed on the 12th day, and the patient was discharged for outpatient treatment in satisfactory condition.



A) B) C)

**Fig. 4.7. Radiographs of Patient E. (51 years old).** Stage III osteoarthritis of the left hip joint (A). B — radiographs after total cementless hip arthroplasty. The implant-to-bone relationship is satisfactory. C — radiograph 6 months after surgery. Dislocation of the prosthetic head.

Six months after the surgery, the patient experienced a prosthetic dislocation, which was managed by closed reduction during hospitalization (Fig. 4.7C). Subsequently, the dislocation recurred multiple times, approximately 3–4 times per year. During follow-up examinations up to the present time, recurrent dislocations have been observed. The patient continues to refuse revision hip arthroplasty. The functional outcomes and quality of life were assessed as unsatisfactory.

Case No. 3

In 2016, Patient S., a 35-year-old woman, first presented to her local outpatient clinic with complaints of pain in the area of the right hip joint. Following radiographic examination, she was diagnosed with stage III osteoarthritis of the right hip (Fig. 4.8A). She underwent multiple courses of outpatient and inpatient treatment.

Upon examination: comorbidity (CCI: 1) – low comorbidity (LC). Anesthesia risk was assessed as ASA II. Total uncemented hip arthroplasty of the right hip joint was planned.

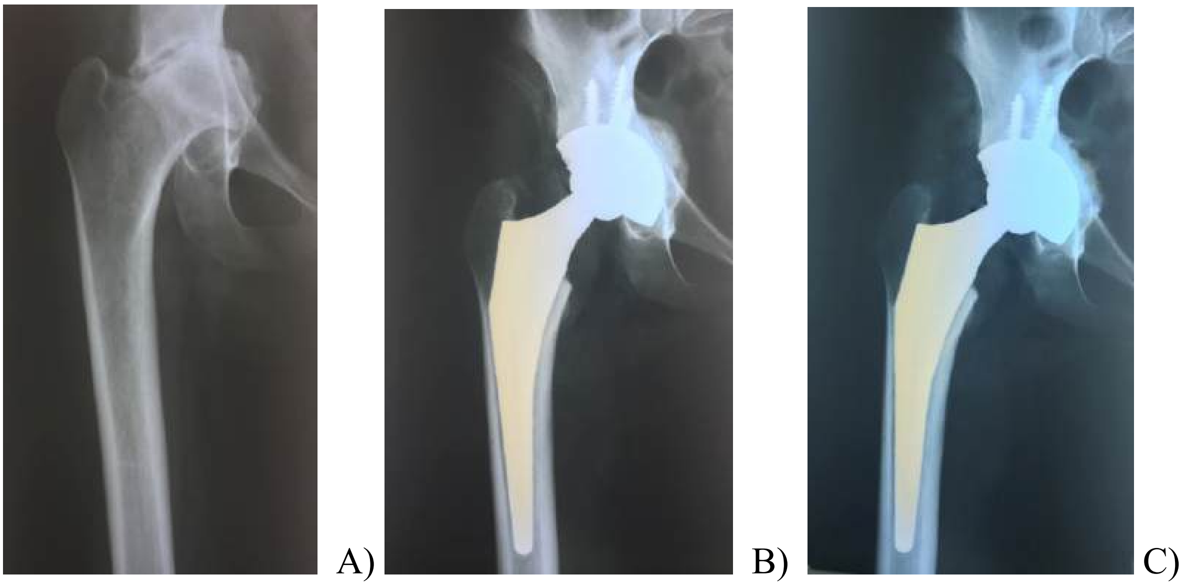



Fig. 4.8. Radiographic findings of Patient S., 35 years old. A) Signs of stage III osteoarthritis of the right hip. B) Radiograph after total uncemented right hip arthroplasty. C) Radiograph five years after surgery. Implant–bone relationship is satisfactory.

The surgery proceeded without complications (Fig. 4.8B). The duration of the operation was 1 hour and 30 minutes, and blood loss amounted to 400 mL. Sutures were removed on the 12th postoperative day. The recovery period was uneventful. Subsequently, functional outcomes and quality of life were assessed as "excellent." At the five-year follow-up, control radiography was performed (Fig. 4.8C). The implant–bone relationship remained satisfactory. Functional outcomes and the patient's quality of life were again assessed as "excellent."

Overall, the treatment outcomes in patients with idiopathic or post-traumatic osteoarthritis of the hip joint cannot be considered unequivocally positive. Clinical observations indicate that the consequences of total hip arthroplasty (THA) are often unfavorable.

Postoperative complications frequently occur in patients of different ages and with various medical histories, regardless of the presence of comorbidities. The proportion of patients whose functional outcomes cannot be regarded as positive (classified as satisfactory or unsatisfactory) increases with each year after hip arthroplasty, rising from 3% to 13.4% over a five-year period (Table 4.7). The next chapter of the dissertation will analyze one of the causes leading to premature or unjustified THA procedures.

# CHAPTER 5. JUSTIFICATION FOR HIP JOINT ARTHROPLASTY. MORPHOLOGICAL STUDY

Hip osteoarthritis (OA) today ranks among the most socially significant and widespread forms of major joint disorders. In Saint Petersburg, OA has been diagnosed in more than 275,000 individuals (Mazurov V.I. et al., 2021). By 2030, experts predict that OA will become one of the leading causes of disability. Existing societies and groups focused on OA research (such as OARSI, ESCEO, and others) have not yet developed a unified treatment approach (Bruyère O. et al., 2019).

An analysis of the cost-effectiveness of hip joint arthroplasty has revealed that hip replacement is economically justified only in patients with end-stage osteoarthritis (Kamaruzaman, H. et al., 2017). Premature or inappropriate selection of surgical treatment is one of the reasons for unsatisfactory outcomes of hip joint arthroplasty (Vorokov A.A. et al., 2020). The indications and contraindications for hip joint arthroplasty in OA patients remain a subject of active discussion both in Russia and worldwide. According to S.P. Mironov and G.P. Kotelnikov (2008), the indications and contraindications for hip arthroplasty may depend on the severity of pain syndrome, comorbidity, and other factors (Vorokov A.A. et al., 2020; Doronina A.A. et al., 2020).

A pathomorphological study of the excised femoral heads was conducted in order to retrospectively assess the justification for performing hip joint arthroplasty. The results of this research have been published (Khaidarov V.M., Mansurov D.S., 2023; Khaidarov V.M. et al., 2022; Tkachenko A.N. et al., 2023).

In 2022, the Department of Traumatology and Orthopedics at North-Western State Medical University named after I.I. Mechnikov (FGBU VO SZGMU) performed 112 hip replacement surgeries in patients with osteoarthritis. For the morphological study, materials were randomly selected from 30 patients aged 38 to 78 years (17 women and 13 men). The mean patient age was 57.4±8.8 years (ranging from 28 to 88 years).

Data on the age and gender of the 112 patients discharged after hip arthroplasty from the clinic are presented in Table 5.1.

Table 5.1 – Distribution of patients who underwent primary total hip arthroplasty for osteoarthritis in 2022 by age and gender

| Age groups, years | Number of patients (%) | | | | | |
|---|---|---|---|---|---|---|
| | Men | | Women | | Total | |
| | Abs. | % | Abs. | % | Abs. | % |
| 18– 44 | 3 | 2,7 | 7 | 6,2 | 10 | 8,9 |
| 45-– 64 | 23 | 20,5 | 32 | 28,6 | 55 | 49,1 |
| 65 and older | 19 | 17,0 | 28 | 25,0 | 47 | 42,0 |
| Total | 45 | 40,2 | 67 | 59,8 | 112 | 100 |

As follows from the data presented in Table 5.1, women predominated in all age groups. The male-to-female ratio was 2:3. There were 45 male patients (40.2%) and 67 female patients (59.5%). Among younger patients, the male-to-female ratio was 1:2 (2.7% and 6.2%, respectively).

A history review revealed that only 33 patients (29.5%) had undergone at least one course of inpatient conservative treatment for hip osteoarthritis before arthroplasty. In most cases (79 observations, 70.5%), only outpatient treatment had been administered.

All 112 patients underwent radiographic examination of the hip joint before surgery. Magnetic resonance imaging (MRI) was performed in 17 cases (15.2%). After the standard preoperative assessment, the diagnosis of "Stage III hip osteoarthritis" was established in 73 patients (65.2%). In 39 cases (34.8%), Stage II–III hip osteoarthritis was diagnosed.

During total hip arthroplasty (THA) and in the early postoperative period, both local and systemic complications were identified. In the vast majority of cases, the outcomes of hip joint replacement with an implant were assessed as positive. However, intraoperative and postoperative complications were noted in 12 patients (10.7%).


Fig. 5.1. Macroscopic view of femoral heads removed during total hip arthroplasty: A – Stage I; B – Stage II–III; C – Stage III.

Among intraoperative complications, local complications were noted in 3 cases (2.7%). These included a fracture of the greater trochanter, nerve trunk injury, and acetabular damage (one case each – 0.9%). Postoperative complications were recorded in 7 patients (6.3%): 3 cases (2.7%) of lymphorrhea, 2 cases (1.8%) of hematoma, and 2 cases (1.8%) of superficial surgical site infection. Among general complications, cardiac disturbances predominated (4 cases – 3.4%) (Linnik S.A. et al., 2021).

There were no fatal outcomes during surgery or in the early postoperative period.

Of the 112 patients, 30 were randomly selected for postoperative pathological examination. The femoral head was subjected to study (Fig. 5.1).

On total frontal sections of the pelvis obtained at autopsy from individuals with a confirmed antemortem diagnosis of osteoarthritis (Fig. 5.2), a marked decrease in the number of trabeculae functioning as buttresses in the proximal epiphysis of the femur was clearly visible. Thinning of the subchondral bone plate on the articular surfaces, reduced density of the spongy bone of the femoral head and acetabulum, and the formation of cystic lesions (thin arrows) appearing as rounded radiolucent areas were noted. A significant reduction in the thickness of the cortical bone on the superior surface of the femoral neck was also observed (thick arrow). An identical pattern was found on the specimen of the removed femoral head (Fig. 5.3) (Khaidarov V.M., Mansurov D.S., 2023).

Fig. 5.2. Frontal section of the hip joint, plastinated with epoxy resin. Autopsy. Osteoarthritis, stage II.

Fig. 5.3. Frontal section of the femoral head after THA, plastinated with epoxy resin. Patient No. 1. Hip osteoarthritis, stage III.

During the study of histological specimens, cases of both early stages of hip osteoarthritis (HOA) and stages II and III were identified. It should be noted that among the 30 morphological examinations performed, stage I HOA was verified in 3 patients (10%) (Fig. 5.4 A) (Tkachenko A.N. et al., 2023).

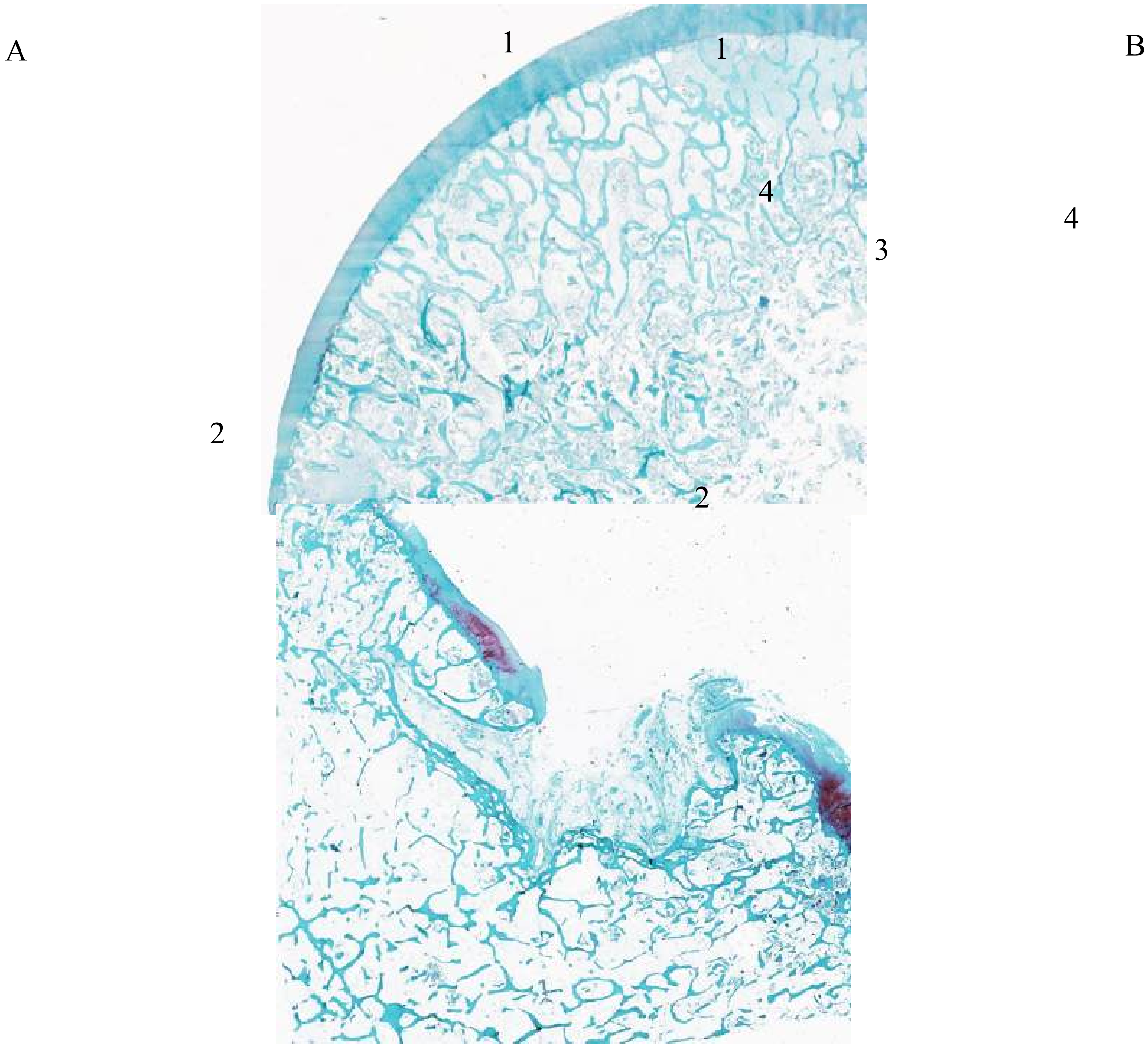



Fig. 5.4. Histotopograms of femoral heads at various stages of damage: A – Stage I; B – Area of marginal osteophytes in the region of the fovea capitis. 1 – preserved layer of hyaline cartilage tissue; 2 – cancellous bone of the femoral head; 3 – fovea capitis; 4 – osteophytes. Staining: Safranin. Magnification: A ×40; B ×100.

In 9 cases (30%), stage II OA was diagnosed (Fig. 5.4B), and in 18 cases (60%), stage III hip OA was confirmed (Fig. 5.5).

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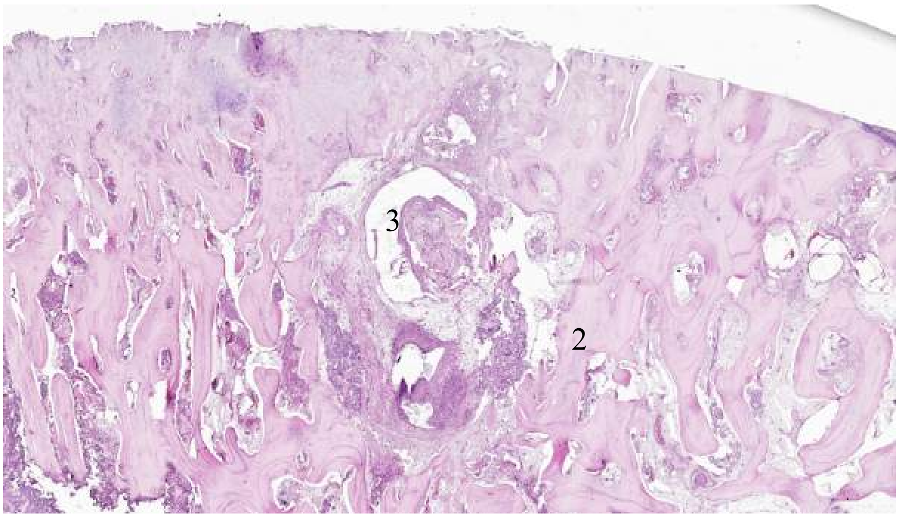



Fig. 5.5. Surface of the femoral head, stage III: osteosclerosis of the subchondral bone; 1 – bone surface devoid of hyaline cartilage; 2 – lamellar bone tissue; 3 – microcysts. Staining: hematoxylin and eosin. Magnification ×100.

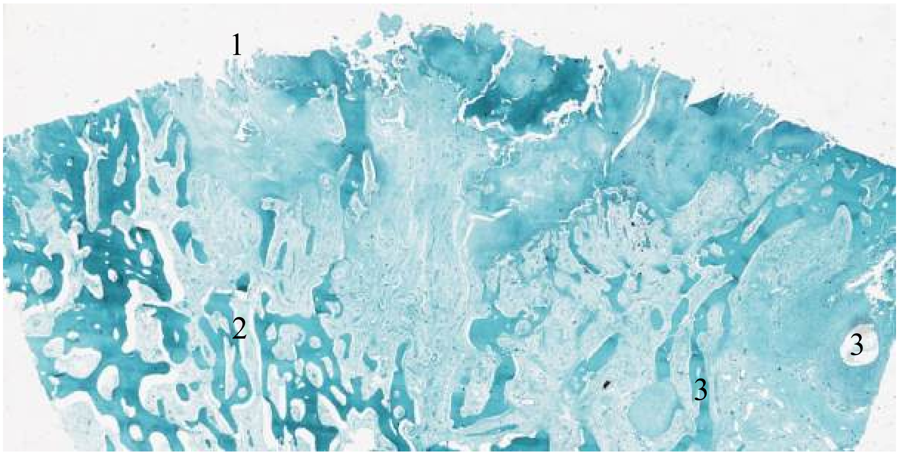



Fig. 5.6. Surface of the femoral head, stage III: Microcysts filled with fibrous connective tissue. 1 – bone surface devoid of hyaline cartilage; 2 – lamellar bone tissue; 3 – microcysts. Staining: safranin. Magnification ×100.

Characteristic pathological features of stage II and III hip osteoarthritis (HOA) include uneven thinning of the subchondral bone plate on the articular surfaces, the formation of cysts (dashed arrows) in the spongy substance of the femoral head measuring 3 to 6 mm, as well as the development of osteophytes (solid arrows) along the edges of the articular surface. Similar bony outgrowths were observed at the fovea of the femoral head and resembled a "surging wave." These osteophytes formed a narrow bony ring that compressed the ligament of the femoral head. A reduction in the diameter of the blood vessels passing through the ligament was noted. The severity of the aforementioned pathological features was greater in patients clinically diagnosed with stage III disease (Figs. 5.5, 5.6).

The use of a novel morphological research method — epoxy plastination — allowed the detection, at the mesoscale level, of characteristic pathological features of HOA that were difficult to identify by conventional imaging techniques. These features included thinning of the subchondral plate of the articular surfaces combined with the formation of cystic structures up to 6 mm in size within the spongy substance of the femoral head. According to patient history, the development of bony outgrowths along the margins of the articular surfaces was associated with pain syndrome and directly correlated with its intensity. Osteophytes in the region of the femoral head fovea formed a bony ring compressing the blood vessels of the ligament, as evidenced by the reduced diameter and density of vascular distribution in this area. It is evident that impaired blood supply to the proximal part of the femoral head in the setting of deforming osteoarthritis contributes to bone tissue ischemia and may be considered an additional pathogenic factor in the development of HOA. The observed decrease in the number of trabeculae in the femoral head and neck, together with thinning of the cortical substance, explains the reduced strength of the femoral neck, which frequently leads to fractures in elderly patients.

Undoubtedly, when deciding on total hip arthroplasty (THA), orthopedic surgeons based their decisions not only on radiographic or tomographic findings and the presumed stage of osteoarthritis (OA). Clinical features (such as pain intensity, effectiveness of conservative treatment, and disease duration), the nature of comorbidities, and other factors were also taken into account. However, it is noteworthy that in every fifth case — 192 (19.9%) out of 963 observations — total hip arthroplasty served as the initial reason for hospital admission related to hip osteoarthritis.

Hip joint replacement with an implant is not an organ-preserving intervention. During this surgery, all components of the joint (articular surfaces, synovial membrane, and joint capsule) are removed and replaced with a prosthesis (whose service life is not unlimited). From a formal standpoint, this procedure is comparable to limb segment amputation and is, in fact, mutilating, differing only in that limb prostheses can be replaced an unlimited number of times without harm to the patient, whereas the outcomes of revision arthroplasty are significantly worse than those of primary joint replacement. In addition, THA, like any surgical intervention, carries the risk of intraoperative or postoperative complications, including mortality. Patients do not always comply with medical recommendations regarding restrictions on movements in the operated joint and adherence to a special postoperative regimen, which also leads to various complications (Khaidarov V.M. et al., 2022).

Furthermore, the indications for arthroplasty are imperfect and are continually being refined toward greater restriction. On the other hand, the healthcare system in the Russian Federation does not provide for a dispensary follow-up system for patients with osteoarthritis; inpatient treatment of such patients within the framework of compulsory health insurance is associated with the lowest reimbursement rates, and there is no strict algorithm regulating the interaction between therapists, orthopedic surgeons, rheumatologists, rehabilitation specialists, and physical medicine practitioners. A similar situation is observed not only in Russia, but also in the United States, the European Union countries, and Asia (Vorokov A.A. et al., 2020; Doronina A.A. et al., 2020).

Based on the morphological study findings, it can be assumed that in 12 cases (40%) of patients with stage I or II osteoarthritis, total hip arthroplasty was performed prematurely, without utilizing the potential of conservative or minimally invasive surgical treatment options for hip osteoarthritis.

The presented results serve as an impetus for conducting a dedicated scientific study aimed at developing a treatment strategy for patients with hip osteoarthritis. This strategy should encompass outpatient diagnostics and treatment, inpatient conservative therapy, minimally invasive surgical techniques, total hip arthroplasty as a last resort, and rehabilitation.

In the Russian Federation, as well as worldwide, there is a growing number of publications highlighting that total hip arthroplasty for osteoarthritis is often performed prematurely, without fully utilizing the potential of conservative and minimally invasive surgical treatments.

Among patients hospitalized for total hip arthroplasty, only 256 (26.6%) — that is, approximately every fourth patient — had previously undergone at least one course of inpatient conservative or minimally invasive surgical treatment for hip osteoarthritis.

According to morphological study findings, stage III osteoarthritis was confirmed in 18 patients (60%). In the remaining 12 clinical observations (40%) of patients who underwent arthroplasty, stage I or II osteoarthritis was verified.

In order to develop a treatment strategy for patients with hip osteoarthritis, it is necessary to design an algorithm for interaction among specialists, involving therapists, orthopedic surgeons, rheumatologists, rehabilitation physicians, and physical medicine specialists at the outpatient, inpatient, and spa therapy levels (Khaidarov V.M. et al., 2022; Urazovskaya I.L. et al., 2023).

The next chapter of this dissertation will address the possibilities for early diagnosis of the initial stages of osteoarthritis in an experimental setting.

# CHAPTER 6. COMPARATIVE CHARACTERISTICS OF RADIOLOGICAL AND PATHOMORPHOLOGICAL CHANGES IN JOINTS IN EXPERIMENTAL OSTEOARTHRITIS

Osteoarthritis, as one of the most common diseases globally, presents medical specialists—including orthopedic traumatologists, physicians, rheumatologists, and rehabilitation specialists—with the urgent challenge of early diagnosis and treatment. The identification of the early stages of osteoarthritis remains a significant problem, which researchers are actively investigating through experiments aimed at finding effective methods for the early diagnosis and treatment of this condition. Radiographic examination continues to be the global standard for diagnosing osteoarthritis. Internationally, the Kellgren–Lawrence classification is more commonly used, whereas in Russia, the clinical and radiological classification developed by N.S. Kosinskaya (1961) is more widely applied. At the same time, radiological changes do not always correlate with the intensity of the pain syndrome or with the morphological picture. Many researchers note the obvious discrepancy between radiographic findings and patient symptomatology.

In some examined patients, progressive osteoarthritis was associated with minimal loss of work capacity, while in others, severe pain, stiffness, and disability at the early stages of the disease were not accompanied by pronounced radiological changes. Moreover, a much higher incidence of asymptomatic osteoarthritis diagnosed by radiography, compared to symptomatic osteoarthritis, has been noted, as confirmed by data from a number of cohort studies.

At this stage of the study, an attempt was made to assess and compare the radiological and morphological changes that occur following the administration of monoiodoacetate (MIA) and human synovial fluid from a patient with stage II osteoarthritis (according to the Kellgren–Lawrence classification) into the knee joint of rats. It is assumed that the changes developing during osteoarthritis induction by the administration of MIA and patient synovial fluid may have similar radiological and pathomorphological characteristics but differ in the rate and nature of intra-articular changes. The results have been published in open access sources (Urazovskaya I.L. et al., 2024).

The experiment was conducted at the Department of Industrial Ecology of SPHFA of the Ministry of Health of Russia, in compliance with all safety measures, on 20 male Wistar rats weighing 180–250 g. The animals were obtained from the "Elektrogorsk Branch" of the Federal State Budgetary Institution of Science, Research Center for Biomedical Technologies, FMBA of Russia. A complete feed, LBK-120 for rats and mice (ZAO Tosnensky Feed Mill), was used for feeding; food and water were provided ad libitum. Animal mobility was restricted under standard vivarium conditions. Under clinical and veterinary supervision, the rats received the same amount of food and water daily and were kept individually in cages at a box temperature of 19–23°C, relative humidity of 60±10%, and with a light cycle of at least 12 hours per day.

All manipulations with animals were performed in accordance with the principles of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986), Directive 2010/63/EU of the European Parliament and the Council of the European Union of 22 September 2010 on the protection of animals used for scientific purposes, and Recommendation No. 33 of the Board of the Eurasian Economic Commission dated 14 November 2023 "On the Guidance for Working with Laboratory (Experimental) Animals in Preclinical (Non-Clinical) Studies." The study was approved by the Bioethics Committee of SPHFA of the Ministry of Health of Russia (Protocol No. Rats-SA-15.01.2024).

During the adaptation period, the animals were randomly assigned into groups of five in polycarbonate cages with bedding made of wood shavings (LLC "Biosphere", St. Petersburg).

Subsequently, the animals were randomly divided into four groups of five rats each (groups K, S, M, and MS).

The control group (Group K) received intra-articular injections of sterile 0.9% sodium chloride solution in a volume of 10 μl into both knee joints.

In Group S, 10 µl of synovial fluid obtained from patients with knee osteoarthritis during arthroscopic examination was injected into the right knee joint, and 10 µl of sterile 0.9% sodium chloride solution was injected into the left knee joint.

In Group M, 10 µl of a monoiodoacetate (MIA) solution (2 mg per 10 µl) was injected into the right knee joint, and 10 µl of 0.9% sodium chloride solution was injected into the left knee joint. The MIA solution was prepared on the day of injection by weighing 30 mg of monoiodoacetate (Sigma) and dissolving it in 150 µl of sterile physiological solution. After preparation, the solution was filtered through a 0.22 µm pore-size filter and used within 24 hours (Urazovskaya I.L. et al., 2024).

In Group MS, 10 µl of synovial fluid was injected into the right knee joint and 10 µl of the MIA solution into the left knee joint.

To assess the rate and nature of morphological changes in the joints and tissues by means of radiographic examination of the knee joints followed by histopathological analysis, the animals were sacrificed according to the following schedule: one animal from each group on day 10 after injection, and two animals from each group on days 25 and 46 after a single administration of the substances.

Euthanasia of the experimental animal groups (rats) was performed using the inhalation anesthetic isoflurane. For this purpose, a cotton ball soaked in isoflurane was placed in a desiccator. All manipulations were carried out under a fume hood to ensure safety and compliance with regulations governing the handling of narcotic substances. After euthanasia, the rats were positioned supine with 0° hip flexion, abduction, internal and external rotation. Both limbs were fixed to the table with adhesive tape.

Anteroposterior radiographs of the knee and hip joints were taken using the portable veterinary X-ray machine DS.Xray 5010t/5080t. Lateral views were also performed with 45° flexion and abduction and 0° internal and external rotation. Radiographic examinations were conducted on days 10, 25, and 46. Radiographs were classified according to the Kellgren–Lawrence (KL) system: grade 0 (none: no radiographic features of OA), grade 1 (doubtful: possible joint space narrowing [JSN] and possible osteophytic lipping), grade 2 (minimal: definite osteophytes and possible JSN), grade 3 (moderate: multiple osteophytes, definite JSN, sclerosis, possible bony deformity), and grade 4 (severe: large osteophytes, marked JSN, severe sclerosis, and definite bony deformity).

Histopathomorphological assessment of changes in the knee joints of rats with presumed chemically induced osteoarthritis was conducted following a specific protocol. In the first stage, the tissues were fixed in 10% neutral buffered formalin (BioVitrum, Russia) in a ratio of 1:2 for 72 hours. Cartilage tissue characteristics were evaluated using a modified Mankin scoring system (0–3 points; Mankin H.J. et al., 1971), as well as the OARSI histopathology scoring system for rats. The study investigated the radiographic and morphological features of experimental osteoarthritis induced by the administration of MIA and synovial fluid from a patient with stage II–III osteoarthritis.

In the second stage, the limb was dissected to remove the surrounding skin and soft tissues, placed again in 10% neutral buffered formalin (BioVitrum, Russia) in a ratio of 1:20, and fixed for 72 hours (Urazovskaya I.L. et al., 2024).

At the third stage, histological sample preparation was performed. Decalcification was carried out using "Electrolytic Decalcifying Solution" (BioVitrum, Russia) at a ratio of 1:50 for 36 hours, with daily replacement of the decalcifying solution. To determine the endpoint of decalcification, physical tests such as bending and puncturing with a fine needle were performed: decalcification was considered complete when the material bent easily and the needle passed through the bone without resistance. After decalcification, the samples were trimmed to the required size, placed into histological cassettes, and washed in running tap water for 30 minutes. Histological processing, embedding, and sectioning at 3–5 µm thickness were performed according to standard protocols. Multiple sections were prepared from each sample and stained with two types of general-purpose dyes (hematoxylin and eosin, and Safranin O).

At the fourth stage, stained samples were evaluated. The evaluation was performed according to the Mankin scale (Mankin H.J. et al., 1971) and the OARSI scale for histological assessment of osteoarthritis in rats (Gerwin N. et al., 2010). The following parameters were assessed: cartilage matrix thickness, scale of degenerative cartilage changes, depth of lesion, osteophyte assessment scale, scale of cartilage calcification and subchondral bone destruction, and synovial membrane assessment (type and degree of inflammatory changes).

During the experiment, radiographic examination of the joints in the groups that received intra-articular injections of 0.9% sodium chloride solution revealed no changes in joint structure or joint space width. The histological structure also corresponded to normal findings. The synovial membranes were preserved, projecting into the joint cavity in the form of wedge-shaped folds. Synoviocytes were longitudinally oriented in two to three layers of cells. The hyaline cartilage displayed a well-defined zonal structure. Cartilage thickness was uniform across all areas, and chondrocytes were clearly visualized, located within lacunae.

In groups S and MS, a discrepancy between radiographic and pathological findings was observed (Urazovskaya I.L. et al., 2024). At day 10 of the experiment, no changes were detected in the joints injected with synovial fluid from a patient with osteoarthritis compared to the control groups receiving 0.9% sodium chloride solution (Fig. 6.1a, b). By day 25, non-specific tissue densification and moderate narrowing of the joint space without structural alterations were observed in these groups (Fig. 6.1c, d). These changes showed minimal progression by day 46 (Fig. 6.1e, f). The pathological findings at days 25 and 46 differed notably from the radiographic data. In addition to increasing edema, focal hyperplasia of the synovial membrane was observed. In several microscopic fields, the synovial lining was infiltrated with lymphocytes and plasma cells. Narrowing of the joint space and uneven thinning of the cartilage were noted, although no focal areas of cartilage destruction were detected. From day 10 to day 46, a progressive edema and loosening of the synovial matrix were observed (Fig. 6.2).

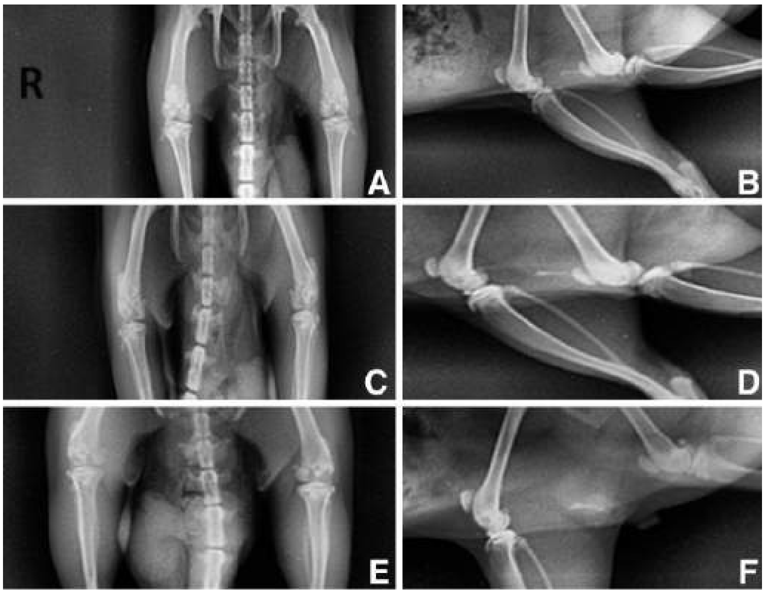



Fig. 6.1. Radiographic changes in the knee joints of animals from group S (synovial fluid from a patient with osteoarthritis injected into the right knee joint). Day 10 of the experiment (a–b), day 25 of the experiment (c–d), day 46 of the experiment (e–f).

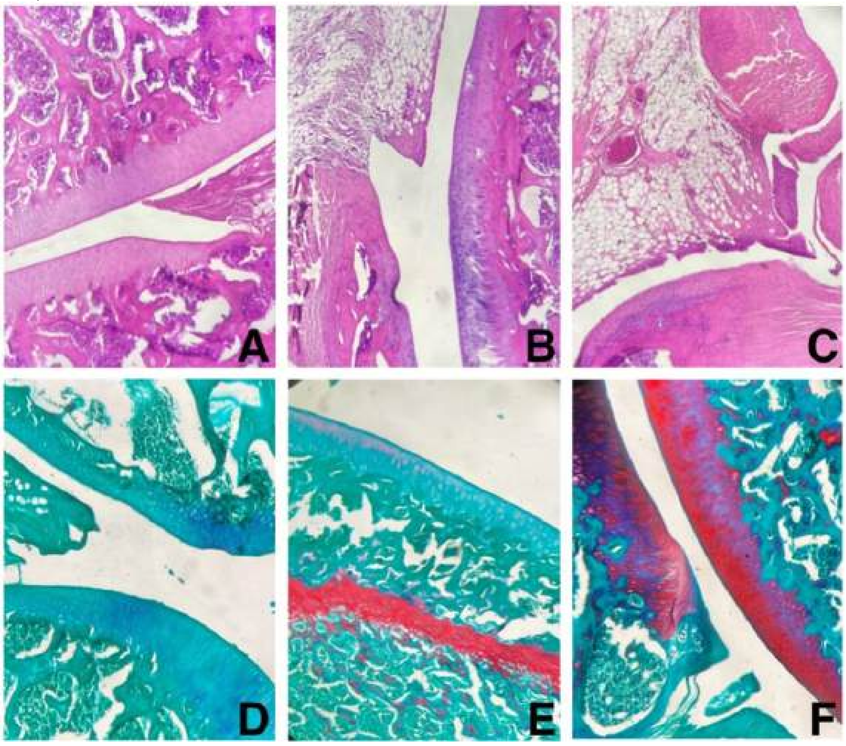



Fig. 6.2. Pathomorphological characteristics of histological specimens of the knee joints of rats from group S (synovial fluid from a patient with osteoarthritis injected into the right knee joint) (staining: hematoxylin–eosin, Safranin O). Day 10 of the experiment, OOCHAS score: 1 (a–d); day 25 of the experiment, OOCHAS score: 2 (b–e); day 46 of the experiment, OOCHAS score: 3 (c–f).

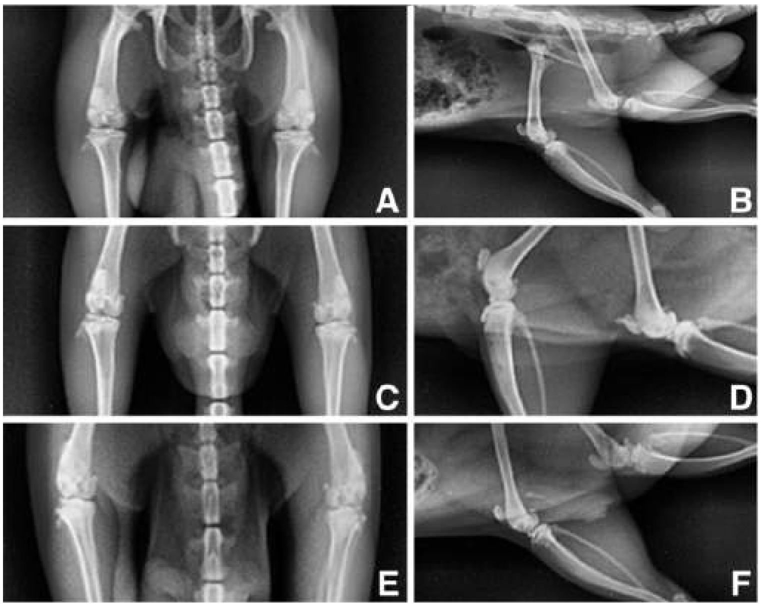



Fig. 6.3. Radiographic changes in the knee joints of rats from group MS (synovial fluid from a patient with OA injected into the right knee joint, sodium monoiodoacetate injected into the left knee joint). Day 10 of the experiment (a–b); day 25 of the experiment (c–d); day 46 of the experiment (e–f).

The synovium was hyperplastic, with areas of proliferation of newly formed hyperemic vessels. Signs of dystrophic changes in the cartilage tissue were noted, including reduced cartilage thickness, chaotic arrangement of chondrocytes, and the presence of isolated acellular areas. The subchondral bone remained intact.

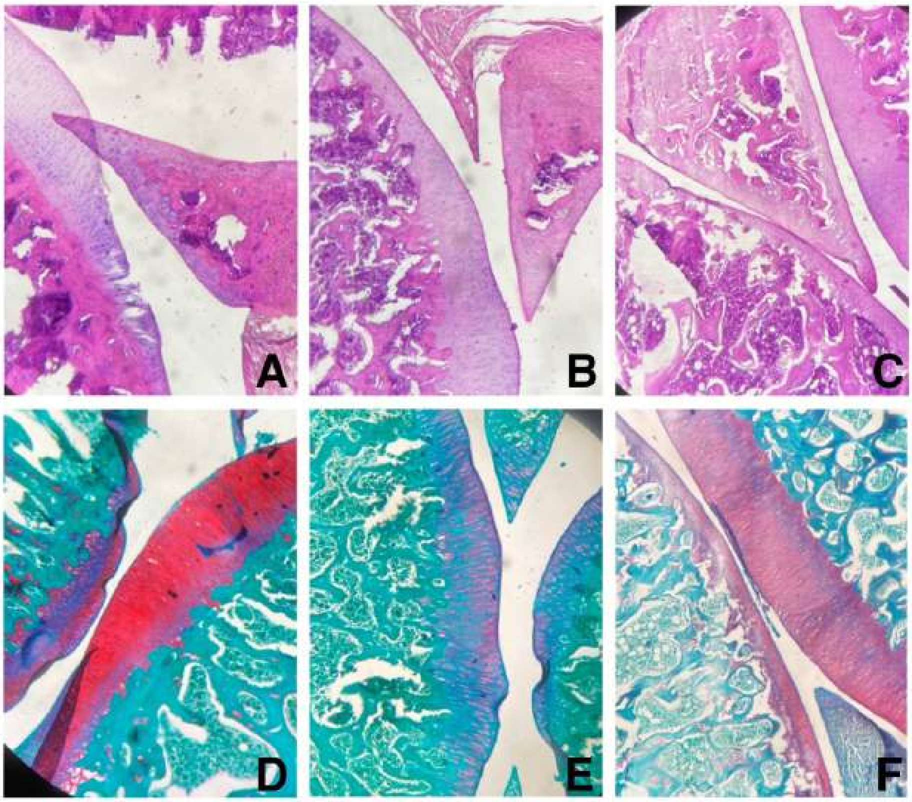


**Fig. 6.4.** Pathomorphological characteristics of histological samples of rat knee joints from group MS (synovial fluid from a patient with osteoarthritis injected into the right knee joint, sodium monoiodoacetate into the left knee joint; staining with hematoxylin–eosin and Safranin O). 10th day of the experiment, OOCHAS score: 1 (a–d); 25th day of the experiment, OOCHAS score: 2 (b–e); 46th day of the experiment, OOCHAS score: 3 (c–f).

Following MIA injection, the most pronounced inflammatory changes were observed from the 10th day of the experiment, progressively worsening by the end of the 6th week: osteophyte formation, near-complete absence of the joint space, and destruction of the femoral condyles were observed, corresponding to the end-stage of osteoarthritis according to the KL classification. At the same time, in rats from the M and MS groups sacrificed on day 10 (first experimental point), macroscopic examination of the joint surfaces mainly revealed subacute inflammation characterized by marked edema and narrowing of the joint space in the right knee (Fig. 6.3 a, b). By day 25 (second experimental point), signs of irreversible joint apparatus damage were evident (Fig. 6.3 c, d).

The pathomorphological picture on day 10 showed synovial membrane edema and lymphoplasmacytic infiltration, with localized cartilage thinning (Fig. 6.4 a, d). By day 25, progressive changes were noted, with marked synovial membrane thickening, areas of fibrosis, numerous thin-walled newly formed vessels, and lymphoplasmacytic infiltration (Fig. 6.4 b, e). A pronounced narrowing of the joint space was observed, up to complete obliteration. Destructive changes in the cartilage were most notable, with almost complete thinning down to the subchondral bone. The zonal cartilage structure was lost, layers were indistinct, chondrocytes were chaotically arranged, large acellular areas were present, and destruction of the subchondral bone was observed (Fig. 6.4 c, f).

Today, osteoarthritis is one of the leading causes of disability worldwide, rivaling cardiovascular diseases, malignancies, and disorders of the nervous and respiratory systems (Wang F. et al., 2025). According to long-term WHO studies, the number of patients with OA continues to grow and currently affects approximately 10–15% of the global population (Long H. et al., 2022). In Russia, the incidence of OA is steadily increasing, but the distribution of patients is uneven across regions. Previous studies conducted in the Northwestern Federal District showed that the prevalence of OA among residents of Saint Petersburg significantly exceeded both the regional and district averages. This trend persisted throughout the 2012–2019 study period. Currently, the incidence rate of OA in Saint Petersburg is more than twice that of Moscow and Russia as a whole. In 2021, the overall incidence of OA in Russia increased by 2%, reaching 3287.4 cases per 100,000 population (3,806,414 individuals) (Mazurov V.I. et al., 2021).

Recent studies have attempted to address this discrepancy by describing synovitis as the "missing link" between radiological findings and clinical symptoms (Yang X. et al., 2021).

The outcome of synovitis can vary widely depending on the triggering factors and the nature of the inflammatory response, ranging from rapid and complete resolution to chronic inflammation and structural joint damage. It is also important to remember that without pathomorphological evaluation in the early stages of inflammation, it is impossible to differentiate synovitis associated with autoimmune conditions, such as rheumatoid arthritis, from synovitis in osteoarthritis (Alekseeva O.G., 2018). The inflammatory response in OA is less pronounced than in rheumatoid arthritis. For diagnosis, EULAR recommends using various additional imaging techniques, such as ultrasound and MRI. Findings from these diagnostic modalities are correlated with the pathomorphological features of tissue samples obtained via arthroscopy and/or arthrocentesis (Mathiessen A., Conaghan P.G., 2017).

Histological changes in synovitis include synovial membrane thickening, leukocytic infiltration, increased stromal density, enhanced vascularization, and fibrosis. The proliferative synovial membrane often consists of more than eight cell layers, disrupting blood supply processes and stimulating fibroblasts to produce pro-angiogenic factors. However, without effective vascularization, the progression of inflammation becomes impaired, as demonstrated in animal models (Caliogna L. et al., 2024).

Early diagnosis of synovitis, which underlies arthritis in general and, in particular, changes leading to the development of chronic inflammation with joint dysfunction and deformity, plays a key role in determining the treatment strategy for patients. The use of arthroscopy and/or arthrocentesis at early clinical or, where indicated, preclinical stages of arthritis provides an opportunity to assess the morphological picture of the disease. This, in turn, allows for the development of a more individualized therapeutic approach, making the exacerbation and progression of arthritis potentially reversible. Rheumatologists were among the first to develop and implement arthroscopy in clinical practice before World War II. Today, cartilage is mainly visualized using magnetic resonance imaging (MRI); however, certain features of osteoarthritis, such as the high prevalence of visible calcification, still require further investigation through arthroscopy (Urazovskaya I.L. et al., 2024).

Although ultrasound-guided biopsy is gradually replacing arthroscopy, the latter retains several important advantages, including the ability to obtain larger tissue samples, direct visual guidance for biopsy site selection, and sampling from multiple areas. In addition, the therapeutic benefits of lavage and debridement during arthroscopy should be considered. Nevertheless, arthroscopy remains underutilized in clinical practice. The introduction of new miniscopes and renewed interest in clinical arthroscopy make this method highly promising and effective for early diagnosis and for tailoring therapy aimed at preventing disease progression and achieving reversibility of inflammation at the earliest stages (Urazovskaya I.L. et al., 2024).

Thus, the conducted study clearly demonstrated the discrepancy between radiological and pathomorphological findings in joint changes. The rate of progression of these changes was also found to differ, showing an accelerated, induced character. Irreversible changes detected by radiological examination following MIA injection were accompanied by worsening pathomorphological alterations, with increasing destructive and degenerative changes in joint tissues. In contrast, after injection of synovial fluid from OA patients, disease progression was less pronounced, characterized by moderate alterations on histological examination, which, however, were not detected by radiographic imaging. This highlights the limitations of X-ray diagnostics, particularly in patients presenting with initial clinical manifestations of joint pathology.

The next chapter of the dissertation analyzes the results of nonoperative treatment methods for patients with hip osteoarthritis.

# CHAPTER 7. NONOPERATIVE METHODS FOR THE TREATMENT OF PATIENTS WITH HIP OSTEOARTHRITIS

At the Department of Traumatology and Orthopedics of the Clinic of North-Western State Medical University named after I.I. Mechnikov of the Ministry of Health of Russia, from 2012 to 2019, 277 patients with idiopathic or post-traumatic osteoarthritis of the hip joint, aged 63.4 ± 6.6 years (ranging from 43 to 89 years), underwent non-operative treatment. Data on the patients' gender distribution and age are presented in Table 7.1.

Table 7.1 – Distribution of Patients Undergoing Inpatient Non-Operative Treatment for Hip Osteoarthritis by Age and Gender

| Age groups, years | Number of patients (%) | | | | | |
|---|---|---|---|---|---|---|
| | Men | | Woman | | Total | |
| | Abs. | % | Abs. | % | Abs. | % |
| 18– 44 | 7 | 2,5 | 17 | 6,1 | 23 | 8,3 |
| 45-– 64 | 24 | 8,7 | 75 | 27,1 | 107 | 38,6 |
| 65 and older | 64 | 23,1 | 90 | 32,5 | 147 | 53,1 |
| Total | 95 | 34,3 | 182 | 65,7 | 277 | 100 |

he data presented in Table 7.1 show that the gender distribution of patients receiving non-operative treatment for hip osteoarthritis (HOA) was similar to that of patients who underwent hip arthroplasty. In both groups, women predominated, with a female-to-male ratio of 2:1 (65.7% and 34.3%, respectively). Among the patients, 130 (46.9%) were of working age, and 147 (53.1%) were of retirement age.

In the structure of observed patients (Table 7.2), cardiovascular diseases prevailed, such as arterial hypertension (54.1%), coronary heart disease (11.2%), and dyslipoproteinemia (47.2%). Obesity (18.0%), diabetes mellitus (18.7%), neuropsychiatric disorders (35%), and chronic obstructive pulmonary disease (COPD) (16.9%) were also common.

Older and elderly patients demonstrated a higher level of comorbidity, which significantly worsened the prognosis for hip arthroplasty compared to patients undergoing non-operative treatment.

Table 7.2 – Comorbidities in different age groups identified in patients undergoing conservative treatment (n=277)

| Comorbidity | Age groups, years | | | Total |
|---|---|---|---|---|
| | 18–44 | 45–64 | 65 and older | |
| **Cardiovascular diseases** | | | | |
| Hypertension | 12 (37,5) | 69 (52,3) | 69 (61,0) | 150 (54,1) |
| Ischemic heart disease (IHD) | 2 (6,3) | 11 (8,3) | 18 (15,9) | 31 (11,2) |
| Myocardial infarction | 1 (3,1) | 1 (0,6) | 2 (1,7) | 4 (1,4) |
| Chronic heart failure | 2 (6,2) | 4 (3,0) | 7 (6,1) | 13 (4,6) |
| Dyslipoproteinemia | 14 (43,8) | 46 (34,9) | 71 (62,8) | 131 (47,2) |
| Cerebrovascular diseases | 2 (6,3) | 6 (4,6) | 6 (5,3) | 14 (5,0) |
| **Obesity** | 6 (18,8) | 19 (14,4) | 25 (22,1) | 50 (18,0) |
| **Type 2 diabetes mellitus** | 7 (21,9) | 22 (16,7) | 23 (20,3) | 52 (18,7) |
| **Hypothyroidism** | 4 (12,5) | 17 (12,9) | 18 (15,9) | 39 (14,1) |
| **Gastrointestinal diseases** | | | | |
| Peptic ulcer disease | 6 (18,8) | 16 (12,2) | 18 (15,9) | 40 (14,4) |
| Gastritis | 7 (21,8) | 11 (8,3) | 13 (11,5) | 31 (11,1) |
| Chronic liver diseases (mild to moderate) | 3 (9,4) | 11 (8,4) | 9 (7,9) | 23 (8,3) |
| **Chronic lung diseases** | | | | |
| Chronic obstructive pulmonary disease (COPD) | 5 (15,6) | 17 (12,9) | 25 (22,1) | 47 (16,9) |
| Bronchial asthma | 4 (12,5) | 14 (10,6) | 16 (14,1) | 34 (12,2) |
| Malignant neoplasms | 2 (6,2) | 4 (3,0) | 5 (3,7 | 11 (4,0) |
| **Chronic kidney disease** | 1 (3,1) | 1 (0,7) | 2 (1,5) | 4 (1,4) |
| **Gout** | 2 (6,3) | 10 (7,6) | 11 (9,7) | 23 (8,3) |
| **Neuropsychiatric disorders** | | | | |
| Sleep disorders | 10 (3,1) | 8 (6,0) | 16 (14,1) | 34 (12,3) |
| Sleep apnea | 2 (6,3) | 5 (3,7) | 11(9,7) | 18 (6,5) |
| Depression | 20 (62,5) | 15 (11,3) | 10 (8,8) | 45 (16,2) |
| **Total patients** | **32** | **132** | **113** | **277** |

According to the data presented in Table 7.2, among patients under the age of 44, the most common comorbidities were arterial hypertension (37.5%), dyslipoproteinemia (43.8%), hypothyroidism (12.5%), type 2 diabetes mellitus (21.9%), gastrointestinal diseases (50%), and depressive disorders (62.5%). The intensity of pain was directly associated with mobility restrictions, reduced work capacity, and, consequently, the assignment of disability status.

Overall, in all age groups, the changes led to increased anxiety, sleep problems—most often in the form of insomnia—and the development of depression. Patients who maintained physical activity, regularly performed therapeutic exercise programs, and participated in rehabilitation activities were significantly more likely to experience longer periods without joint pain or rated their pain as minor.

The increase in the comorbidity index with age was mainly due to the growing number of patients suffering from cardiovascular diseases (rising from 37.5% to 61%). During pain management, in which various drug groups, mainly NSAIDs and antiplatelet agents, were widely used, a significant increase in the incidence of cardiovascular diseases was observed.

In the vast majority of cases, high comorbidity led to an increase in the number of prescribed medications and, consequently, to polypharmacy. Among patients of all age groups (compared to average population indicators), long-term use of NSAIDs often led to exacerbations of gastrointestinal diseases, primarily gastritis and gastric ulcers, even with the use of proton pump inhibitors. Frequent exacerbations of gastrointestinal diseases resulted in impaired digestion and absorption processes, accompanied by complaints of swallowing difficulties, digestive disorders, and bowel motility problems, predominantly constipation. A concurrent factor was weight loss and the development of sarcopenia, which worsened the course of not only osteoarthritis but also other comorbid conditions.

The prevalence of type 2 diabetes mellitus and hypothyroidism varied depending on comorbidity levels, being most common in groups with low comorbidity. In most cases, across all age groups, hypothyroidism presented in a subclinical form associated with autoimmune thyroiditis. With age, the frequency of hypothyroidism and type 2 diabetes mellitus in the observation groups remained practically unchanged.

In patients with obesity, metabolic syndrome, as well as those with cardiovascular diseases and chronic kidney disease, type 2 diabetes mellitus was detected significantly more often, consistent with general population trends, regardless of osteoarthritis presence. The prevalence of bronchopulmonary diseases in groups with low and high comorbidity did not show statistically significant differences. Nevertheless, it remained higher than in the general population according to official statistics.

In patients with hip osteoarthritis who had a high comorbidity index, there was a significant correlation with increased cardiovascular mortality, especially among those with type 2 diabetes mellitus, obesity, and metabolic syndrome. Their existing pain and limited mobility led to an increased use of analgesics, primarily nonsteroidal anti-inflammatory drugs (NSAIDs). With advancing age, the number of comorbid conditions and the need for multiple medications increased, which, in turn, exacerbated the progression of osteoarthritis due to polypharmacy.

Overall, comorbidity parameters in groups of patients who underwent THA (Chapter 4) and those undergoing conservative treatment for hip osteoarthritis were identical.

All 277 (100%) patients with hip osteoarthritis received non-pharmacological therapy aimed at reducing the load on the affected joints.

For patients with osteoarthritis, exercise programs were used to increase the range of motion, stretching, and to strengthen muscle strength (both isometric and isotonic exercises). Each therapeutic exercise program was individually tailored, taking into account the patient's age, body mass index, presence of comorbidities, severity of osteoarthritis, and other factors (see Table 7.3).

Table 7.3 – Non-Operative Treatment Methods for Patients with Hip Osteoarthritis (HOA)

| Types of Treatment | Number of patients (%) |
|---|---|
| Physical therapy (exercises for muscle strengthening (isometric and isotonic), range of motion exercises, stretching exercises, aerobic exercises) | 277 (100) |
| Physiotherapeutic methods (super high-frequency and high-frequency electromagnetic field therapy, ultrasound therapy, electrophoresis of anti-inflammatory drugs, laser therapy, heat carrier applications, hydrotherapy) | 166 (59,9) |

| | |
|---|---|
| Radiotherapy | 25 (9,0) |
| Pharmacological treatment<br>-non-steroidal anti-inflammatory drugs (NSAIDs) (under gastroprotective coverage) | 179 (64,6) |
| -B-group vitamins | 170 (61,4) |
| -drugs improving microcirculation (pentoxifylline, dipyridamole) | 91 (32,9) |
| -antihistamine therapy (suprastin, tavegil) | 50 (18,1) |
| -antioxidant therapy (α-tocopherol acetate – vitamin E) | 41 (14,8) |
| -SYSADOA (Symptomatic Slow-Acting Drugs in Osteoarthritis) | 33 (11,9) |
| I-ntra-articular injections of hyaluronic acid preparations (Synocrom, Ostenil, Fermathron, etc.) | 38 (13,7) |
| -PRP therapy | 68 (24,5) |
| Total number of patients | 277 (100) |

In 166 patients (59.9%) of this group, treatment was supplemented with physical exercises and physiotherapeutic procedures (laser therapy, ultrasound therapy including phonophoresis of anti-inflammatory agents, exposure to super high-frequency and high-frequency electromagnetic fields, applications using paraffin, ozokerite, and peat mud, electrophoresis with anti-inflammatory drugs (hydrocortisone), as well as hydrotherapy). In 111 cases (40.1% of the total number), physiotherapy procedures were deemed contraindicated, and these patients were recommended for radiotherapy.

In terms of pharmacological treatment, 33 patients (11.9% of the total number) received basic chondroprotective therapy with SYSADOA. Some specialists, analyzing the effects of SYSADOA, note its potential to slow the progression of hip osteoarthritis (HOA) and recommend prescribing it to all patients with this condition, believing it leads to improved treatment outcomes (Lila A.M. et al., 2019; Bishnoi M. et al., 2016).

The effectiveness of non-operative treatment of HOA over a period of 5 years was assessed using the W.H. Harris scale (1969, 1987), developed for evaluating the outcomes of hip treatment. This scale allows not only for analyzing the results after hip arthroplasty but also for monitoring the recovery dynamics of patients following a course of conservative treatment for HOA (Table 7.4, Fig. 7.1).

Table 7.4 – Long-term functional outcomes in patients who received inpatient non-operative treatment for hip osteoarthritis (HOA)

| Years of follow-up | Number of patients (%) | Excellent and good outcomes (%) | Fair and poor outcomes (%) |
|---|---|---|---|
| 1 | 277 (100,0) | 159 (57,4) | 118 (42,6) |
| 2 | 256 (92,4) | 145 (56,6) | 111 (43,4) |
| 3 | 249 (89,9) | 139 (55,8) | 110 (44,2) |
| 4 | 184 (66,4) | 102 (55,4) | 82 (44,6) |
| 5 | 153 (55,2) | 77 (50,3) | 76 (49,7) |
| 6 | 135 (48,7) | 70 (51,9) | 65 (48,1) |

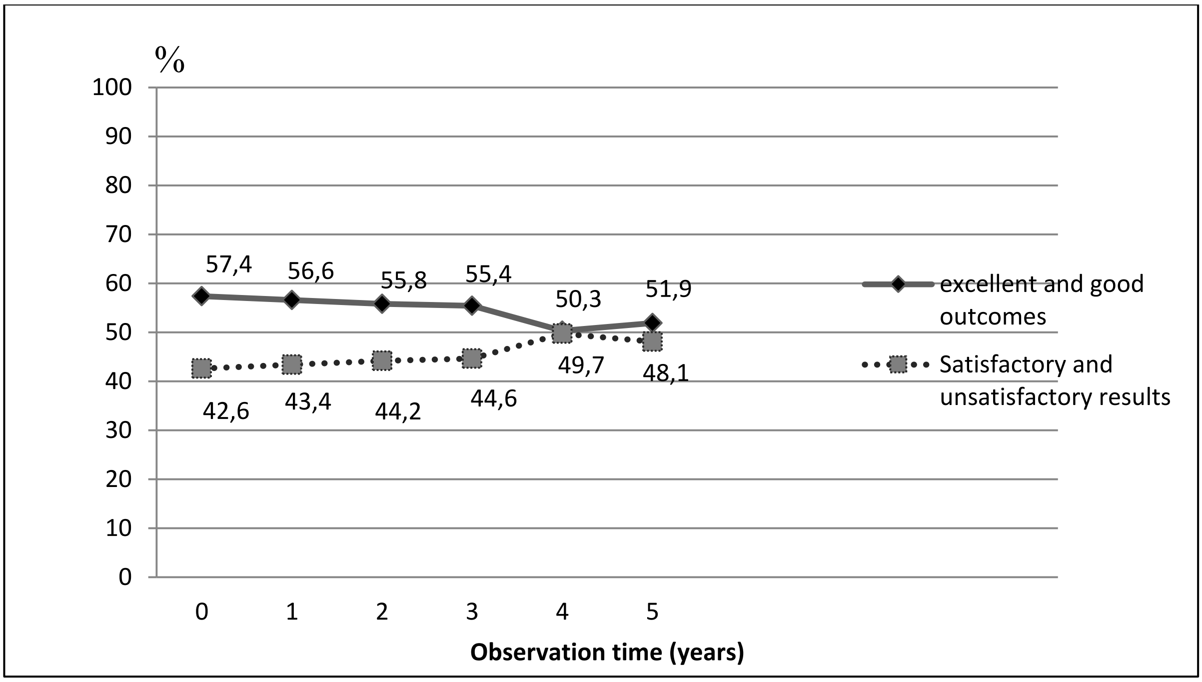



Figure 7.1. Graph of changes in the risk assessment of maintaining functional outcomes (W.H. Harris, 1969) after nonoperative treatment of HOA.

The effectiveness of conservative treatment of HOA, characterized by excellent and good functional outcomes, decreased to 50.3% by the 5-year follow-up, which did not show statistically significant differences (p>0.05). However, according to the W.H. Harris scale (1969), the functional outcomes after THA demonstrated a more substantial decline: from 97% excellent and good outcomes in the first year of follow-up to 86.6% by the fifth year (Table 4.8).

At the same time, no significant differences were found in the survival curves between the conservative treatment group and the post-THA group. Nevertheless, in patients who underwent THA, the rate of decline in the number of high-quality and successful outcomes was more pronounced. To demonstrate the effectiveness of nonoperative treatment methods, the following clinical observations are presented.

Case No. 1

In January 2018, a 68-year-old working pensioner, M., consulted a trauma orthopedic surgeon with complaints of reduced mobility and pain in the left hip joint. The patient's medical history indicated the presence of a pronounced pain syndrome in the left hip joint for more than five years, with no reported traumatic injuries. Following an examination, the diagnosis was established: left-sided coxarthrosis, stage III (Fig. 7.2 A). The patient's weight was 98 kg, height 167 cm, BMI = 35.1 kg/m² (Grade II obesity). Comorbidity was low (CCI: 2).

Conservative therapy for left-sided coxarthrosis had been repeatedly administered at the patient's local outpatient clinic, including the use of nonsteroidal anti-inflammatory drugs (celecoxib, nimesulide), oral chondroprotectors (Artra), physiotherapy (Almag device), and therapeutic exercise.

Given the lack of positive dynamics during outpatient treatment over the past year, planned total hip arthroplasty (THA) of the left hip joint was recommended. Comprehensive inpatient treatment of the left hip joint was proposed and carried out at the Clinic of Traumatology and Orthopedics.

The patient was hospitalized on February 12, 2018. During hospitalization, physical, laboratory, and instrumental examinations were conducted. At the initial examination, the patient was able to walk independently, limping on the left leg and using a cane on the right side for support. Movements in the left hip joint were accompanied by sharp pain and were limited: flexion was 90°, extension 10°, abduction 5°, and internal and external rotation up to 10°. Relative shortening of the left lower limb by 2 centimeters was noted. No acute circulatory disturbances or neurological pathology were detected in the lower extremities.

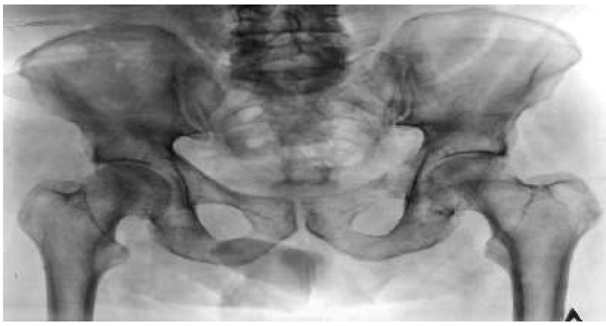
 A)  B)

Fig. 7.2. Patient M., 68 years old. A) Osteoarthritis of the left hip joint, stage III. B) Radiographic findings two years after comprehensive treatment. Patient M., 70 years old. Osteoarthritis of the left hip joint, stage III.

The function of the hip joint and the effectiveness of osteoarthritis treatment were assessed using the modified Harris Hip Score, while the dynamics of pain syndrome were monitored with the Visual Analogue Scale (VAS). According to the Harris Hip Score, the patient scored 62 points, corresponding to an unsatisfactory result, and 6 points on the VAS. To clarify the diagnosis, radiography of the pelvis and hip joints was performed. Quality of life was assessed at 9 points (satisfactory).

The treatment included: NSAIDs, physiotherapy (magnetotherapy, laser therapy, phonophoresis with hydrocortisone), therapeutic exercise, intra-articular and periarticular injections (hyaluronic acid, hormonal drugs), SYSADOA therapy, and therapeutic correction of comorbidities.

The patient underwent inpatient treatment in the department for 2 weeks, after which he was discharged for outpatient follow-up care with improvement. The results of joint function assessment were 78 points (satisfactory), and the pain intensity according to the VAS was 3 points. Quality of life was assessed at 12 points (good result).

Long-term follow-up showed high treatment efficacy for stage III coxarthrosis, with sustained analgesic effect. According to the VAS, pain was rated at 3 points after 6 months and 4 points after 12 months. The functional status of the joint, assessed by the Harris Hip Score, was 76 points after 1 month (satisfactory result) and 70 points after 6 months (also satisfactory). Comprehensive treatment effectively relieved the patient's pain for two years, which was sufficient to stabilize comorbid conditions and prepare him for planned total hip arthroplasty.

Radiographic follow-up: left-sided stage III coxarthrosis (Fig. 7.2B). No negative radiological dynamics were observed over the two-year period.

Case No. 2

Patient P., 42 years old, lathe operator, was admitted to the Department of Traumatology and Orthopedics on March 28, 2019, with the diagnosis: left-sided stage III coxarthrosis.

The patient presented with complaints of nocturnal pain in the left hip joint and limited mobility. He reported experiencing pain for four years and had undergone conservative treatment for osteoarthritis without improvement. Over the past 3–4 months, limb function had significantly worsened. Comorbidity was low (CCI: 1).

The patient's condition was assessed as satisfactory. The skin and visible mucous membranes were clean and of normal color. The patient was normosthenic, with a body mass index (BMI) of 28.09. He moved with the aid of a cane. Blood pressure was 125/70 mm Hg, pulse 76 beats per minute, rhythmic and adequately filled. Heart sounds were clear and rhythmic, breathing was vesicular without rales, and respiratory rate was 18 per minute. The abdomen was soft, without tenderness; the liver and spleen were not palpable. No neurological or trophic disorders were detected. Shortening of the left lower limb by 3 cm was noted.

Laboratory test results revealed no deviations from age norms. Radiographic examination was performed. Radiographs revealed stage III osteoarthritis of the left hip joint (Fig. 7.3A).


A)

B)

Fig. 7.3. Radiographs of patient P., 42 years old. A) Left-sided stage III coxarthrosis. B) Radiographic image two years after comprehensive treatment. Left-sided stage III coxarthrosis.

The use of anti-inflammatory drugs (Celecoxib 200 mg, Arcoxia 90 mg) was combined with therapeutic exercise sessions with an instructor: walking with crutches and partial weight-bearing were allowed. To reduce synovitis, magnetotherapy, phonophoresis with hydrocortisone, and TECAR therapy were prescribed.

Discharge recommendations: wear orthopedic footwear, walk with a controlled load on the left leg, perform the learned set of therapeutic exercises daily until the follow-up visit in 3 months, and take chondroprotectors (Mucosat, Alflutop). The range of active motion in the left hip joint increased. Given the absence of negative clinical and radiological dynamics, it was recommended to postpone total hip arthroplasty, continue therapeutic exercises for 10–15 minutes twice a day, undergo physical therapy courses 2–3 times a year (thermal methods), and continue SYSADOA treatment courses.

Follow-up visit 6 months after hospital discharge: the patient walks with a cane, trying not to exceed the recommended load on the left leg. He reports minor pain in the joint area and some restriction of movement. He performs therapeutic exercises daily for about 15–20 minutes. Follow-up radiographs showed left-sided stage III coxarthrosis without negative dynamics. Considering the new complaints, the motor regimen was maintained, therapeutic exercises 2–3 times per week (exercises for coxarthrosis) were recommended, and physical therapy 2–3 times a year was advised. No neurological or hemodynamic disorders were identified. Dynamic follow-up continues. The patient continues to abstain from total hip arthroplasty.

The presented cases demonstrate the effectiveness of non-operative treatment methods. Pain syndrome was reduced, joint range of motion increased, and disease progression was halted. Total hip arthroplasty was successfully postponed for two years.

Analysis of the five-year outcomes of conservative inpatient treatment for hip osteoarthritis (HOA) in the entire study cohort (n=153) shows that the ratio of excellent and good functional outcomes to fair and poor outcomes is approximately 1:1, whereas after total hip arthroplasty (THA), this ratio reaches 6:1 (Aliev B.G. et al., 2023).

Forecasting the dynamics of the decline in the number of patients with good and excellent functional outcomes indicates a high probability of convergence of the curves demonstrating these trends (Fig. 7.4). Overall, to study this tendency in more detail, continued follow-up of patients who have undergone both non-operative and surgical treatment for HOA over a period of 10–15 years is necessary.

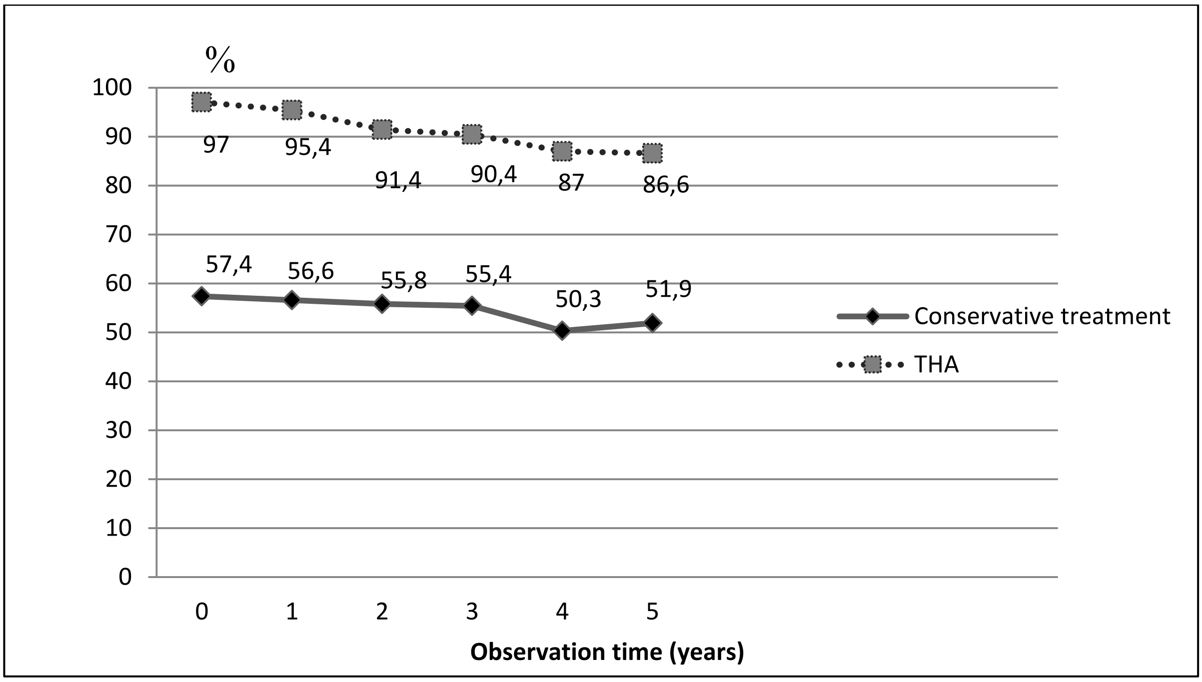



**Figure 7.4.** Curve of functional outcome changes (W.H. Harris, 1969) after total hip arthroplasty and non-operative treatment of hip osteoarthritis (HOA)

During the dissertation study, specific features of the organization of non-surgical treatment for patients with hip osteoarthritis (HOA) were identified. Analysis of the retrospective group, including 963 patients hospitalized for total hip arthroplasty (THA), showed that only 256 patients (26.6%) had previously undergone inpatient non-operative treatment. Although HOA is a common condition, the number of patients hospitalized for conservative treatment in surgical and therapeutic departments remains low. This is likely due to low reimbursement rates. Currently, there is no established system for dispensary follow-up of patients with osteoarthritis. Within the framework of the dissertation study, the identified issues in optimizing non-operative treatment of patients with HOA represent key directions for further research in this field (Khaidarov V.M. et al., 2022; Urazovskaya I.L. et al., 2023; Aliev B.G. et al., 2023; Tkachenko A.N. et al., 2023).

# CHAPTER 8. JUSTIFICATION OF THE STRATEGY FOR AN INTERDISCIPLINARY APPROACH TO THE TREATMENT OF HIP OSTEOARTHRITIS

In developing a strategy for the interdisciplinary treatment of hip osteoarthritis (HOA), several factors were taken into account.

Prevalence of osteoarthritis. According to many years of research by the WHO, the number of patients with OA is steadily increasing and currently accounts for about 10–15% of the world's population (Long H. et al., 2022). In Russia, the incidence of OA is also continuously growing; however, there is an uneven distribution of patients across different regions. Previous studies in the Northwestern Federal District regions have shown that the prevalence of OA among residents of Saint Petersburg significantly exceeds not only the indicators for the Northwestern Federal District regions but also the district average as a whole. This trend was observed throughout the entire study period from 2012 to 2019. Currently, the incidence of OA in Saint Petersburg is more than twice as high as the figures for Moscow and Russia as a whole, and in 2021, the overall incidence of OA in the Russian Federation increased by 2%, reaching 3287.4 cases per 100,000 population (3,806,414 people) (Mazurov V.I. et al., 2021).

Lack of a dispensary registration and monitoring system for OA patients both in Russia and in other countries. Numerous recent studies have demonstrated a strong association between osteoarthritis and life-threatening diseases. OA increases the risk of developing stroke, peptic ulcer disease, and metabolic syndrome. The presence of OA raises the overall mortality risk by 1.5 times and cardiovascular mortality by 1.7 times, starting from the age of 35, primarily due to reduced physical activity, the presence of comorbidities, and adverse effects of medications used in OA treatment. Osteoarthritis can significantly influence the onset, course, and outcomes of cardiovascular diseases. Conversely, cardiovascular diseases can worsen the course of OA.

Many specialists are involved in the treatment of patients with osteoarthritis: general practitioners, rheumatologists, orthopedic surgeons, rehabilitation specialists, physiotherapists, among others. Often, the positions of these specialists regarding osteoarthritis do not align and are sometimes even diametrically opposed. Today, a stable interaction between these specialists seems appropriate, particularly regarding early diagnosis and pathogenetically based treatment, as well as during the transition from non-surgical to surgical treatment methods.

Long-term outcomes of hip replacement surgery cannot be considered unconditionally positive, and the lifespan of an implant is not unlimited. Many specialists from various countries believe that a significant proportion of patients undergo joint replacement either unjustifiably or prematurely. Therefore, it is optimal to delay this surgical intervention for as long as possible whenever feasible.

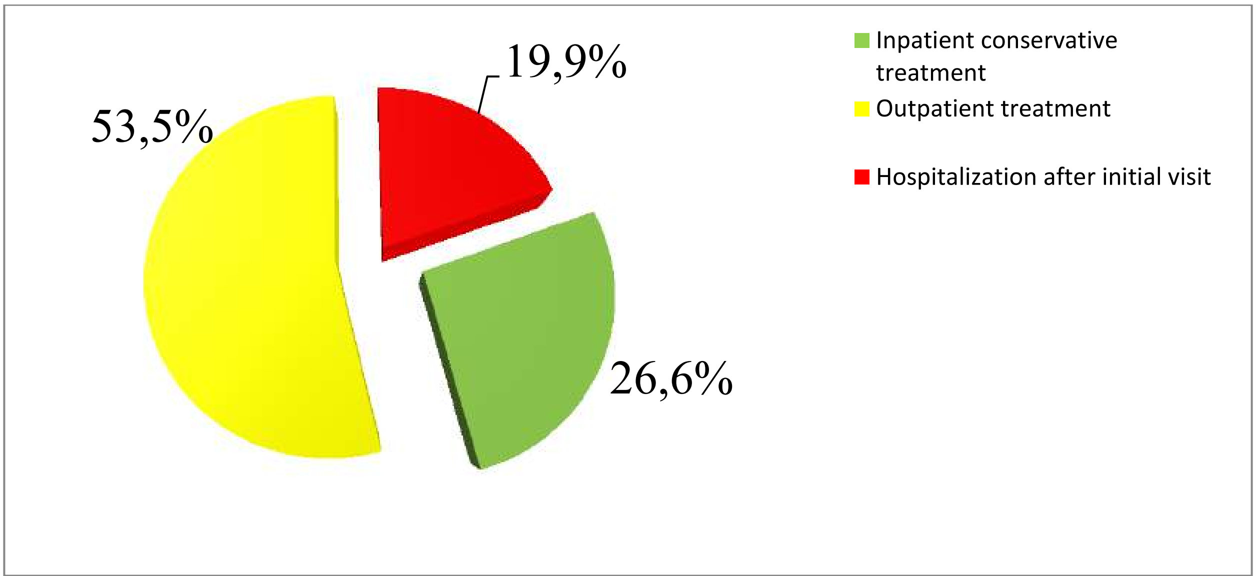



Fig. 8.1. Anamnestic data on prior non-surgical treatment of HOA before joint replacement with an implant

According to the results of the retrospective study (Fig. 8.1), prior to hospitalization for arthroplasty, 707 (73.4%) patients with HOA received outpatient therapy, which lacked a unified, structured protocol; 192 (19.9%) patients, or approximately every fifth individual, underwent surgery immediately after their first visit to a specialist at a polyclinic; 256 (26.6%) patients had a history of inpatient conservative treatment without surgical intervention.

In recent years, a significant number of studies have been published demonstrating the success of both conservative and surgical approaches in the management of osteoarthritis.

Within the framework of comprehensive treatment for patients with HOA, it is advisable to establish a stable interaction between specialists from various fields: orthopedists, rheumatologists, general practitioners, rehabilitation specialists, and experts in restorative medicine, physiotherapy, radiation therapy, therapeutic exercise, and other related disciplines.

Based on a review of the literature and the results of our own research, it can be assumed that the foundation of the interdisciplinary approach strategy in the treatment of hip osteoarthritis is the integrated cooperation of specialists from different fields of medicine to achieve the best possible treatment outcomes.

The primary objective of this strategy is to improve patients’ quality of life, reduce pain intensity, preserve joint function, slow disease progression, and maximize the delay of hip joint arthroplasty.

The main components of the strategy include: early diagnosis and assessment of disease severity; non-surgical treatment; physical rehabilitation; surgical intervention; psychological support; educational programs; integration of complementary therapies; and dynamic outpatient follow-up.

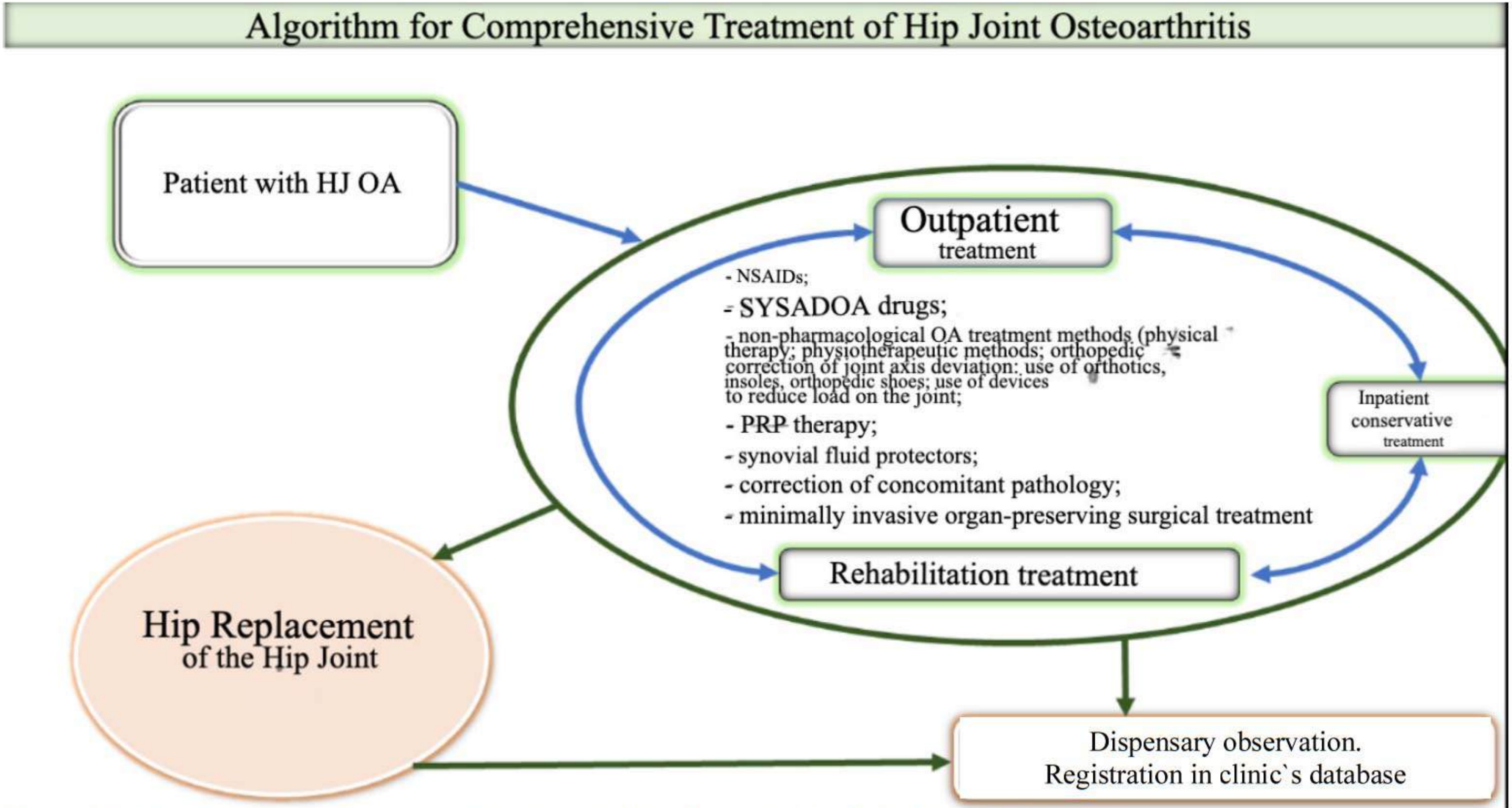



Figure 8.2. Multidisciplinary Treatment Algorithm for Hip Osteoarthritis (B.G. Aliev, 2024)

The advantages of the interdisciplinary approach strategy include the individualization of treatment considering the patient's specific characteristics; comprehensive impact on all aspects of the disease; improvement of functional outcomes and patient quality of life; reduction in the risk of complications and progression of osteoarthritis. This approach requires clear coordination among specialists from various fields and active patient participation in the treatment process.

The previously developed algorithm (Fig. 8.2) by the department's specialists incorporates the key components of the interdisciplinary approach strategy for the treatment of hip osteoarthritis; however, it will feature certain specifics in its practical implementation. The treatment of patients with hip OA involves specialists from various fields (therapists, rheumatologists, radiologists, physical therapy physicians, physiotherapists, orthopedic traumatologists, rehabilitation specialists, psychologists/psychotherapists, occupational therapists, among others). In the healthcare system of Russia, as in other countries, there is no structural unit that combines all these specialists. Therefore, within the framework of this dissertation research, the "Scientific and Clinical Center for Arthrology" was established at the North-Western State Medical University named after I.I. Mechnikov – Rector’s Order No. 2548-O dated 24.12.2021 (Fig. 8.3) (Khaidarov V.M. et al., 2022; Urazovskaya I.L. et al., 2023; Tkachenko A.N. et al., 2023).

The main tasks of the Center for Arthrology are: defining and developing priority scientific directions in the field of arthrology, as well as studying organizational and technological principles for providing medical care to patients with joint pathology; determining indications and contraindications for surgical and conservative treatment methods for joint diseases; and providing inpatient medical care for patients with joint pathology in accordance with federal mandatory medical insurance (MMI) tariffs and/or paid medical service tariffs.

Министерство здравоохранения Российской Федерации

федеральное государственное бюджетное образовательное учреждение высшего образования
” Северо-Западный государственный медицинский университет имени И.И. Мечникова“ Министерства здравоохранения Российской Федерации

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(ФГБОУ ВО СЗГМУ им. И.И. Мечникова Минздрава России)

ПРИКАЗ

«24» 12 2021 г. № мз-т-о

О создании Научно-клинического центра артрологии

На основании решения ученого совета ФГБОУ ВО СЗГМУ им. И,И.Мечникова Минздрава России (далее — Университет) от 24.12.2021, протокол № 1 1 п р и к а з ы в а ю:

1. Создать в Университете на функциональной основе Научно-клинический центр артрологии (далее — Центр) с 24.12.2021.

2. Назначить руководителем Центра Ткаченко Александра Николаевича, профессора кафедры травматологии, ортопедии и ВПХ.

3. Утвердить Положение о Центре (Приложение).

4. Ружоводителю Центра Ткаченко А.Н. разработать функциональные обязанности работников Центра в срок до 31.12.2021.

5. Пташникову Д.А., заведующему кафедрой травматологии, ортопедии и ВПХ, обеспечить размещение Центра по адресу: г, Санкт-Петербург, Пискаревский пр., пав. 20-3.

6. Контроль за исполнением настоящего приказа возложить на проректора по клинической работе Латария ЭЛ.

Ректор СА. Сайганов

Fig. 8.3. Order No. 2548-O of the Rector of North-Western State Medical University named after I.I. Mechnikov "On the Establishment of the Scientific and Clinical Center for Arthrology" dated 24.12.2021.

Provision of consultations for patients with joint pathologies referred by physicians from the University, healthcare institutions of Saint Petersburg, the Leningrad Region, and other regions of the Russian Federation.

Clinical testing of new diagnostic and therapeutic technologies with an evaluation of their efficacy and safety.

Development of clinical guidelines for the diagnosis and treatment of joint diseases.

(Haidarov V.M. et al., 2022; Urazovskaya I.L. et al., 2023; Tkachenko A.N. et al., 2023).

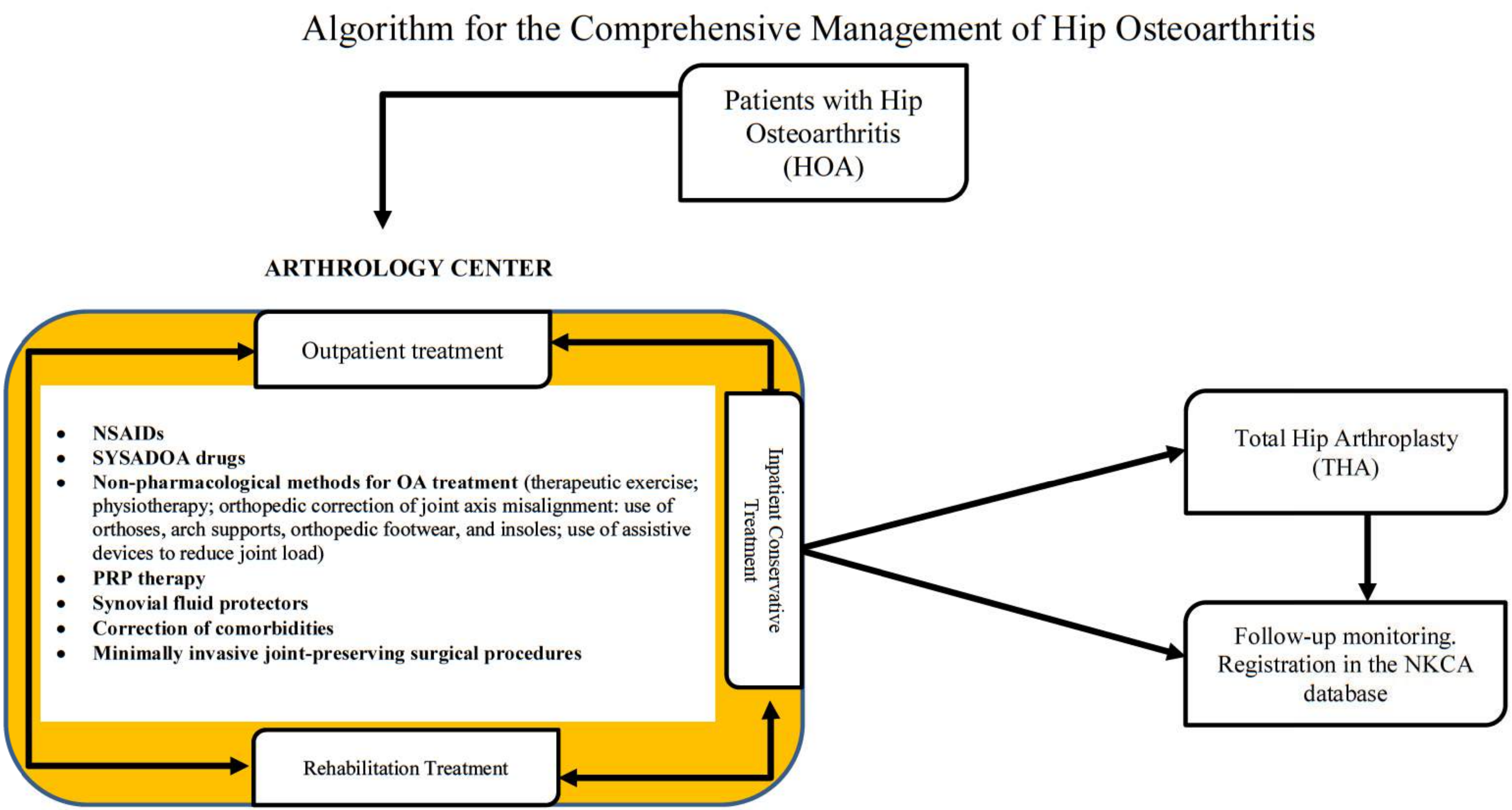


Figure 8.3. Algorithm of comprehensive treatment for hip osteoarthritis

The Arthrology Center includes specialists from the Departments of Traumatology, Orthopedics and Military Field Surgery; Therapy, Rheumatology, Medical Expertise of Temporary Disability and Quality of Care named after E.E. Eichwald; Hospital Therapy and Cardiology named after M.S. Kushakovsky; the Department of Traumatology and Orthopedics of the Clinic named after Peter the Great; the Pain Treatment Center; the Central Clinical Diagnostic Laboratory (CCDL); the Pathological Anatomy Department of the Clinic named after Peter the Great; the Bacteriological Laboratory, and several other units.

The developed algorithm of a comprehensive approach to the treatment of patients with hip osteoarthritis (HOA) has been refined taking into account the capabilities of the Scientific and Clinical Arthrology Center (SCAC) (Fig. 8.4), which allowed for an improvement in the immediate and long-term outcomes of HOA treatment in everyday clinical practice.

A full and objective evaluation of the Center’s performance and the effectiveness of the algorithm requires not only the accumulation of clinical data but also a follow-up period of 5–10 years.

Currently, the Center has been operating for 3 years and initial positive results have been observed. Nevertheless, a proper assessment of patients’ quality of life and long-term functional outcomes will only be possible after at least 5 years of observation. Therefore, it is proposed to validate the algorithm using the retrospective data from the conducted study (Khaydarov V.M. et al., 2022; Urazovskaya I.L. et al., 2023; Tkachenko A.N. et al., 2023).

The first group included patients who received systematic outpatient and inpatient treatment before undergoing hip arthroplasty, i.e., in accordance with the proposed algorithm. There were 256 such cases (26.6%). The remaining 707 (73.4%) patients received outpatient treatment that was irregular and unsystematic, and thus did not follow the algorithm (Fig. 8.4).

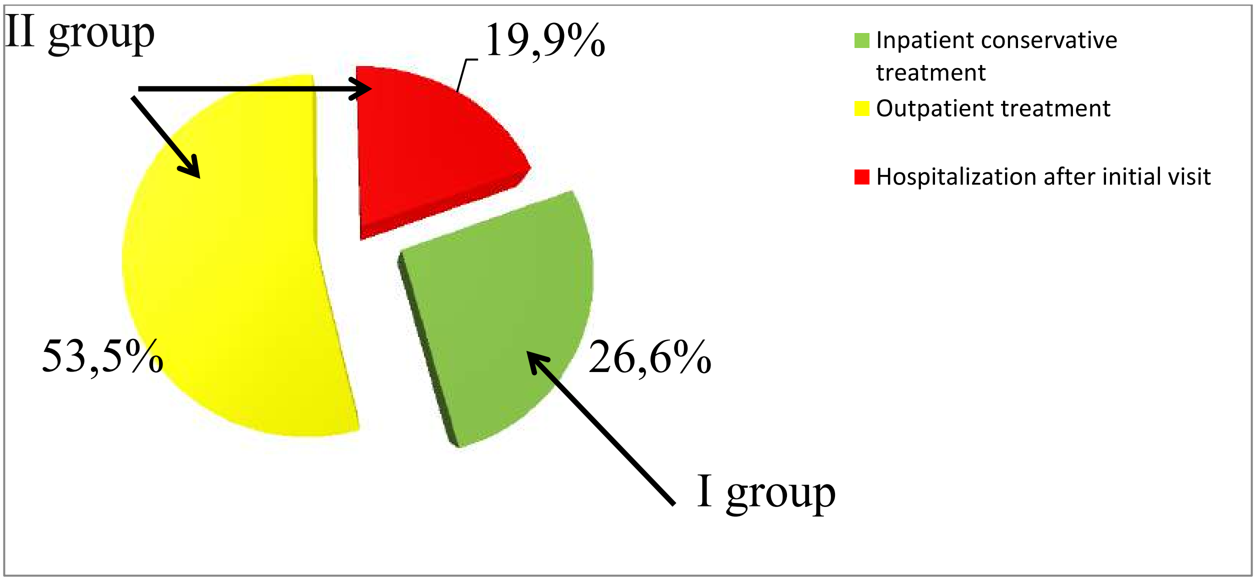


Fig. 8.4. Distribution of patients based on anamnesis data regarding prior non-surgical treatment of hip osteoarthritis before undergoing joint replacement with an implant.

For the retrospective evaluation of the effectiveness of the developed algorithm, data on 5-year outcomes were used. Such data were available for 726 (75.4%) out of 963 patients (Table 8.1).

Table 8.1 – Functional outcomes over 5 years of follow-up in patients who underwent hip arthroplasty (retrospective study).

| Functional outcomes | Years of follow-up after THA | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| - excellent and good (%) | 934 (97,0) | 793 (95,4) | 729 (91,4) | 602 (90,4) | 645 (87,0) | 629 (86,6) |
| - fair and poor (%) | 29(3,0) | 38(4,6) | 69 (8,5) | 64 (8,6) | 97(13,0) | 97 (13,4) |
| Number of patients (%) | 963 (100) | 831 (100) | 798 (100) | 766 (100) | 742 (100) | 726 (100) |

The main criterion for dividing patients into comparison groups was the presence of inpatient conservative treatment in the anamnesis.

It should be noted that the enrollment of patients for evaluating the effectiveness of the algorithm is ongoing, based on data from the work of the Scientific and Clinical Center for Arthrology (SCCA); however, this evaluation period must cover at least 5 years.

As shown in Table 8.1, by the end of the fifth year of follow-up, positive treatment outcomes were confirmed in 629 patients (86.6%), while fair and poor outcomes were observed in 97 patients (13.4%) out of 726.

The detailed statistics on positive outcomes, broken down by year of follow-up and by observation groups differentiated by the presence of inpatient conservative treatment for hip osteoarthritis (HOA) in the anamnesis, are presented separately in Table 8.2.

Table 8.2 – Excellent and Good Functional Outcomes Over 5 Years of Follow-up in Patients Who Underwent Hip Arthroplasty (Retrospective Study Considering Observation Groups).

| Years of Follow-up After THA | Excellent and Good Functional Outcomes with Prior Inpatient Non-Surgical Treatment Before THA | | | | Total |
|---|---|---|---|---|---|
| | was performed Group I (%) | n | was not performed Group II (%) | n | |
| 1 | 251 (98,0) | 256 | 663 (93,8) | 707 | 963 |
| 2 | 220 (96,9) | 227 | 558 (92,4) | 604 | 831 |
| 3 | 204 (95,8) | 213 | 519 (88,7) | 585 | 798 |
| 4 | 185 (92,4) | 198 | 486 (85,6) | 568 | 766 |
| 5 | 167 (92,3) | 181 | 459 (81,8) | 561 | 742 |
| 6 | 159 (90,9) | 175 | 443 (80,4) | 551 | 726 |

Excellent and good five-year functional outcomes in Group I were observed in 159 patients (90.9%). Among patients in Group II, who had no history of inpatient non-surgical treatment for hip osteoarthritis (HOA), positive outcomes after 5 years were confirmed in 443 cases (80.4%); however, these results cannot be considered statistically significant ($p>0.05$).

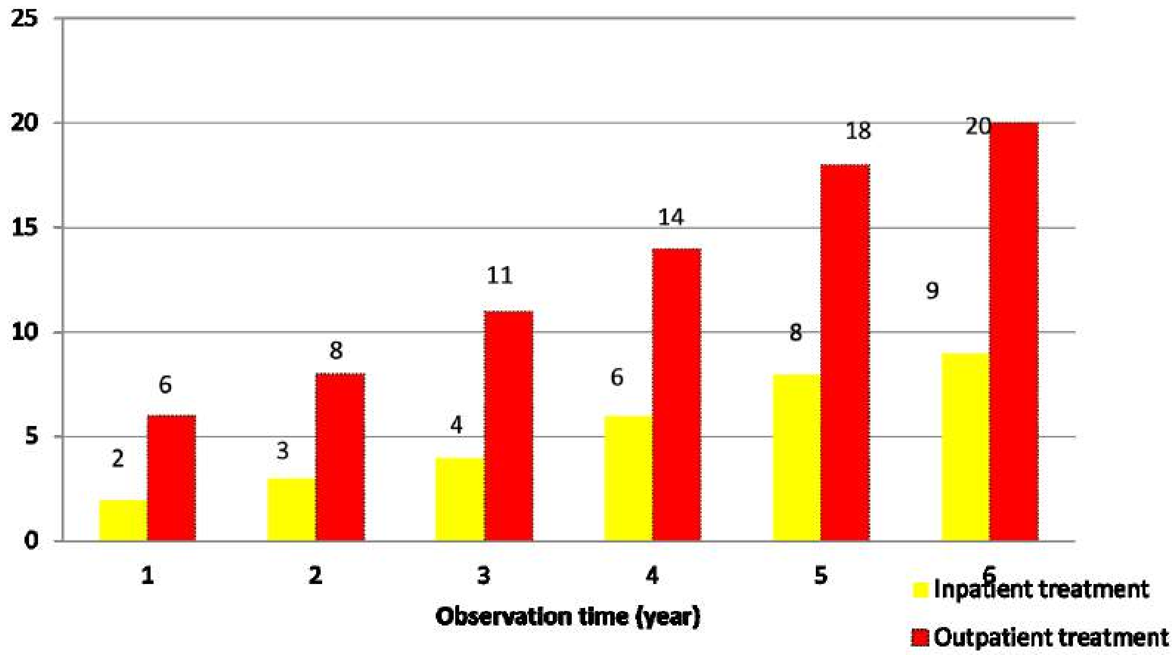


Figure 8.5. Number of satisfactory and unsatisfactory functional outcomes (W.H. Harris, 1969) after THA in cases with (Group I) and without (Group II) previous courses of inpatient non-surgical treatment for HOA.

By the end of the fifth year of follow-up, average and satisfactory functional outcomes were observed in 16 patients (9.1%) of Group I and 108 patients (19.6%) of Group II, as demonstrated in the diagram (Fig. 8.5). However, the statistical significance of the difference could not be confirmed, even though the indicators differed by more than twofold.

Although these results are not statistically significant according to evidence-based medicine criteria ($p > 0.05$), there is a consistent trend towards an increase in the number of patients with unsatisfactory and average outcomes with each year after THA.

The implementation of the developed multidisciplinary treatment algorithm for hip osteoarthritis (HOA), as part of a comprehensive interdisciplinary strategy, results in a twofold reduction in the number of patients with satisfactory or unsatisfactory treatment outcomes five years after surgery.

The number of Russian and international publications highlighting the premature or unjustified performance of arthroplasty in the treatment of degenerative joint diseases is growing. At the same time, more researchers are drawing attention to the insufficient use of non-surgical treatment methods for OA.

An analysis of conducted studies shows that the application of an algorithm based on a multidisciplinary approach to treating patients with HOA yields positive results. An individualized approach, involving collaboration between specialists from various fields and the application of the most sparing regimens, dietary measures, and a wide range of non-surgical treatment methods (as available during inpatient care), helps prevent or delay the need for THA. In some cases, non-surgical treatment can improve quality of life, enhance functional outcomes, and avoid the negative consequences associated with THA.

The algorithm can be effectively used as a basic component in the interdisciplinary treatment strategy for patients with hip osteoarthritis, provided there is a structured healthcare unit that includes the necessary specialists. (Haidarov V.M. et al., 2022; Urazovskaya I.L. et al., 2023; Tkachenko A.N. et al., 2023).

Despite the widespread prevalence of degenerative joint diseases and the recognition by the scientific community that the presence of osteoarthritis significantly increases the risk of life-threatening conditions (such as myocardial infarction, acute cerebrovascular accident, etc.), health check-up programs (dispensarization) for osteoarthritis are not provided for within the organizational structure of healthcare systems either in the Russian Federation or in other countries. Inpatient treatment of such patients within the healthcare institutions operating under the system of mandatory medical insurance is minimally funded, and interdisciplinary collaboration among specialists (therapists, orthopedic surgeons, rheumatologists, rehabilitation specialists, physiotherapists, and exercise therapy specialists) lacks clear regulation.

A similar situation is observed in other countries, including the USA, the EU member states, and Asian countries.

The main goal of this strategy is to improve patients’ quality of life, reduce pain intensity, preserve joint function, slow disease progression, and maximize the postponement of total hip arthroplasty.

The main components of the strategy include: early diagnosis and assessment of disease severity; non-surgical treatment; physical rehabilitation; surgical treatment; psychological support; educational programs; integration of complementary therapies; and dynamic follow-up care.

The advantages of an interdisciplinary strategy include individualized treatment based on patient-specific characteristics; comprehensive impact on all aspects of the disease; improvement of functional outcomes and quality of life; and reduction of the risk of complications and disease progression. Such an approach requires clear coordination of actions among specialists from different fields and active patient participation in the treatment process.

# CONCLUSION

Hip osteoarthritis (HOA) is one of the most prevalent and socially significant forms of joint disease. Alongside cardiovascular pathology, it has become a leading cause of medical consultations across a range of specialties. Most authors studying the epidemiology of osteoarthritis estimate that 15–20% of the global population exhibit symptoms of the disease. Despite the existence of specialized groups and societies dedicated to OA research (such as OARSI, ESCEO, and others), a unified strategy for the treatment of this degenerative-dystrophic condition has yet to be developed.

Total hip arthroplasty (THA), the treatment of choice for terminal stages of HOA, is associated with a considerable rate of unsatisfactory long-term outcomes. Many experts agree that joint replacement results cannot be regarded as unequivocally positive. Reported complication rates—both early and late—range from 2% to 27% and exhibit significant variability. The most severe complications include periprosthetic infection, periprosthetic fractures, prosthetic instability of various etiologies, and wear of prosthetic components.

In recent years, the range of non-surgical treatment options for HOA has expanded considerably. In addition to conventional therapies (nonsteroidal anti-inflammatory drugs, glucocorticosteroids, local therapies, and physiotherapy), the clinical application of tissue structure-modifying agents, platelet-rich plasma (PRP) therapy, and symptom-modifying slow-acting drugs for osteoarthritis (SYSADOA) has become increasingly common. Moreover, the field of minimally invasive hip surgery continues to advance, and techniques for autologous chondrocyte transplantation are being developed. These joint-preserving methods offer patients the opportunity to maintain joint function and, consequently, either prevent or significantly delay the need for prosthetic replacement.

Researchers from various scientific institutions are actively investigating the diagnosis and management of osteoarthritis. Key areas of focus include early detection of HOA—when intra-articular changes are potentially reversible—and determination of appropriate timing for transitioning from conservative management to surgical intervention at the late stages of the disease. The proposed solutions often remain controversial and continue to generate debate among orthopedic traumatologists and specialists from therapeutic disciplines alike. Today, the issue of comprehensive diagnostic evaluation and integrated treatment of patients with HOA is recognized as a matter of high social importance (Urazovskaya I.L. et al., 2023).

To achieve the study's objective—improving treatment outcomes for patients with HOA through the development and implementation of a multidisciplinary care strategy—a series of research tasks were undertaken. These included an analysis of the prevalence of degenerative-dystrophic joint diseases across various regions of the Russian Federation and an evaluation of the specific features of their statistical recording. The frequency and structure of complications among patients who underwent THA for HOA were assessed. Long-term functional outcomes and quality of life following THA for idiopathic and post-traumatic HOA were analyzed. The impact of comorbid conditions on the long-term results of hip arthroplasty for osteoarthritis was studied. The appropriateness of THA was evaluated based on retrospective analysis of pathomorphological studies of the resected femoral head. Radiological and morphological changes in an experimental model of induced osteoarthritis were compared to assess the rate and characteristics of intra-articular degeneration. The long-term results of conservative inpatient treatment of HOA were evaluated, along with determining the proportion of such patients among those who eventually required arthroplasty. Finally, the performance of the National Center for Arthrology (NCA) was assessed from the perspectives of healthcare organization and technological advancement in diagnostic and therapeutic processes.

During the course of the research, data from several patient groups were analyzed. Between 2012 and 2019, a retrospective study was conducted to examine the prevalence of osteoarthritis (OA) across several regions of the Russian Federation. The frequency of osteoarthritis was assessed among the population aged over 18 years in the regions of the Northwestern Federal District (NWFD). Non-personalized data were presented as regional indicators, calculated as the number of cases per 100,000 population. Separate data sets were also analyzed for Saint Petersburg, Moscow, and the Russian Federation as a whole.

The primary study group consisted of 965 patients treated at the clinic of traumatology and orthopedics between 2012 and 2019, who underwent total hip arthroplasty (THA) for idiopathic or post-traumatic hip osteoarthritis (HOA) (patient age range: 21–89 years; mean age 59.4±13.0 years). During the same study period, inpatient conservative treatment was provided to 277 patients at the same clinic (age range: 30–88 years; mean age 61.1±12.6 years). In terms of age and sex, both study groups (patients undergoing conservative treatment for HOA and those undergoing THA) were comparable.

Another group included 116 patients with HOA who were hospitalized in 2022 for hip replacement surgery. From this group, materials for in vivo pathomorphological examination were randomly sampled from 30 patients (18 women and 12 men).

The research tasks outlined in the dissertation would have been impossible to accomplish without conducting an experimental study. This experimental investigation focused on clinical-laboratory analyses and autopsy findings from laboratory animals with experimentally induced osteoarthritis.

The experimental work was carried out on 20 Wistar rats (weight 180–250 g), standardized by age and sex, at the Department of Industrial Ecology of the Saint Petersburg State Chemical Pharmaceutical University (SPCPU) of the Russian Ministry of Health. All safety protocols were strictly followed. The study assessed the rate and character of morphological changes in the joints and surrounding tissues, using radiological and histopathomorphological methods. Animals were euthanized sequentially: one rat from the group on day 10 of the experiment, and two rats from the group on days 25 and 46 following a single administration of inducing substances.

For histological examination, a macroscopic specimen of the knee joint was harvested from each animal. The limb was transected proximally at the mid-femur level and distally at the mid-level of the tibia and fibula. After removal of the skin and surrounding soft tissues, the joint was fixed in 10% neutral buffered formalin (BioVitrum, Russia) at a 1:20 tissue-to-fixative ratio for 72 hours. Histological specimen preparation followed standard protocols. Samples underwent decalcification in Softydec solution (BioVitrum, Russia) at a 1:50 tissue-to-solution ratio for 7 days, with daily solution changes. Completion of decalcification was determined using a mechanical probe test (bending and needle puncture); decalcification was considered complete when the tissue bent easily and the needle penetrated the bone without resistance. After decalcification, samples were washed under running water for 30 minutes. Standard protocols were followed for histological processing, paraffin embedding, microtomy (section thickness: 3–5 μm), and staining with hematoxylin and eosin.

The prevalence of osteoarthritis among Saint Petersburg residents was found to significantly exceed that of the NWFD regions and the federal district average. For example, the incidence of OA in Saint Petersburg was approximately three times higher than in the neighboring Leningrad Region. The overall OA morbidity rates averaged 7480.4 per 100,000 adult population in Saint Petersburg, 3725.8 in Moscow, and 3842.2 across the Russian Federation over the five-year period from 2015 to 2019. Overall, the incidence of osteoarthritis in Russia remains high, with no stable trend toward reduction in recent years.

The main study group consisted of 963 patients with idiopathic or post-traumatic HOA who underwent primary total hip arthroplasty between 2012 and 2019. Intraoperative complications were documented in 131 (13.6%) of these cases. These included cardiovascular complications in 15 patients (1.6%), fractures of the greater trochanter in 9 patients (1.0%), and major vascular injuries in 9 patients (1.0%).

Among the complications that developed following THA, the most common were hematoma (38 cases – 3.9%) and surgical site infection (48 cases – 5.0%) (Zamyatina K.N. et al., 2021).

Comorbidities were verified in 855 (88.8%) patients with HOA. All patients were divided into two groups based on their Charlson Comorbidity Index (CCI) scores: low and high comorbidity.

Following discharge from the clinic, all 963 patients were placed under dynamic follow-up. Low comorbidity (CCI: 0–2) was verified in 286 (29.7%) patients, while a greater number, 677 (70.3%), had high comorbidity (CCI: 3 or more). Long-term outcomes (by the sixth year of follow-up) were obtained for 726 (75.4%) patients. Among these, infectious complications were the most common, recorded in 56 (7.7%) cases, along with wear and loosening of implant components, which occurred in 53 (7.3%) cases.

Analysis of the dynamics of operated hip joint function over five years revealed a distinct trend toward a decrease in the frequency of positive outcomes (good and excellent) from 98.4% in the early postoperative period to 84.5% by the beginning of the sixth year.

Simultaneously, the quality of life (QoL) of patients in the long term after THA was evaluated. Overall, by the end of the fifth year of follow-up, the probability of maintaining good or excellent QoL (with a 95% confidence interval) was 0.875 (0.823; 0.911).

The conducted research revealed no statistically significant differences in QoL between male and female patients. The result of the log-rank test ($Z = -0.2714$) and the p-value ($p = 0.7273$) confirm this. The probability of maintaining good or excellent QoL declined to 0.85 (0.79; 0.88) for women and to 0.89 (0.83; 0.93) for men.

Similar results were obtained when evaluating QoL after THA among patients of different ages. Among younger patients (aged under 44 years), the probability of maintaining good or excellent QoL by the end of the fifth year was 0.91 (0.85; 0.93). In the middle-aged group (45–64 years), this indicator was slightly lower – 0.88 (0.77; 0.91). In patients aged 65 years and older, the probability was 0.84 (0.77; 0.88).

The absence of statistically significant differences in survival curves between age groups is indicated by the log-rank test (Chi-square = 2.9166, p = 0.2733). Nevertheless, a clear trend can be observed, suggesting the need for further research over 10–15 years postoperatively.

The analysis of long-term outcomes of THA in patients with a low degree of comorbidity (ASA Class I–II) showed somewhat better results. The probability of maintaining excellent or good QoL in this group by the end of the fifth year was 0.88 (0.82; 0.93), compared to 0.85 (0.83; 0.89) in patients with a high degree of comorbidity (ASA Class III–IV). However, the differences were not statistically significant, as indicated by the log-rank test (Z = 0.9294, p = 0.3356). Thus, as with previous findings, the results are not statistically significant. Nevertheless, a clear trend toward a growing difference can be observed, indicating the necessity of longer-term studies (10–15 years) of THA outcomes.

The overall analysis of QoL among the entire cohort of patients during the five-year period after THA showed that good QoL was confirmed in 86% of cases. The remaining 14% of patients rated their quality of life as satisfactory or poor.

Thus, the short-term outcomes of treatment in patients with idiopathic or post-traumatic HOA cannot be considered unequivocally positive. Intraoperative complications were verified in 8.7% of patients, with local complications observed in 5.0% of cases and general complications in 3.7%.

Postoperative complications occurred in 16.9% of patients. Local complications accounted for 13.8% of all cases, while complications involving other organs and systems were noted in 3.1%. The most frequent complications were superficial and deep surgical site infections (5.0%), postoperative wound hematomas (3.9%), and prosthesis dislocations (2.1%). In the long-term postoperative period, local infectious complications (7.7%), implant damage and loosening (7.3%), and prosthetic dislocations (6.7%) predominated.

Five years after THA, there is a decline in the proportion of patients with excellent or good QoL from 99% to 88%, and a decline in patients with excellent or good functional outcomes from 97% to 86.6%. Meanwhile, the proportion of patients demonstrating satisfactory and poor functional outcomes shows an upward trend, increasing from 3% to 13.4% over the five-year period (Zamyatina K.N. et al., 2021).

At the next stage of the study, with the aim of retrospectively determining the timeliness and appropriateness of THA, a pathomorphological examination of the resected femoral heads was carried out. A total of 112 patients hospitalized at the clinic in 2022 for THA were included, with sex and age characteristics matching those of the main study group. All patients underwent radiographic examination of the hip joint prior to implant placement. Magnetic resonance imaging (MRI) was performed in 17 (15.2%) patients. Preoperatively, the diagnosis of "hip osteoarthritis, stage III" was confirmed in 73 (65.2%) cases, while in the remaining 39 (34.8%) patients, the diagnosis was formulated as "hip osteoarthritis, stages II–III."

Among these 112 patients, 30 were randomly selected for postoperative pathomorphological examination of the femoral heads. It was found that among the 30 specimens examined, 3 (10%) patients had stage I hip osteoarthritis (HOA), 9 (30%) patients had stage II HOA, and 18 (60%) patients had stage III HOA. Based on the morphological examination data, it can be assumed that in 12 (40%) patients with stage I or II osteoarthritis, endoprosthetic replacement was either unwarranted or premature, without having exhausted the potential of nonoperative or minimally invasive surgical treatment of HOA.

Simultaneously with the clinical data analysis, an experimental study was conducted, evaluating and comparing radiological and morphological changes following the intra-articular administration of osteoarthritis inducers: monoiodoacetate (MIA) and synovial fluid from a patient with stage II osteoarthritis (according to the Kellgren–Lawrence classification) into the knee joints of rats.

On day 10 of the experiment, no radiographic or pathomorphological changes were observed in the joints after injection of patient-derived synovial fluid (compared to control groups receiving 0.9% sodium chloride solution). By day 25, changes were verified in the form of nonspecific tissue densification and moderate joint space narrowing without structural alterations. The changes observed by day 25 showed almost no progression by day 46. Pathomorphological examination at days 25 and 46 revealed discrepancies compared to radiographic findings. Microscopically, an increase in edema was noted, along with focal hyperplasia of the synovial membrane, which in some fields of view was infiltrated by lymphocytes and plasma cells. Joint space narrowing and uneven thinning of cartilage in different areas were also noted; however, no destructive foci were identified.

Edema and loosening of the synovial matrix progressively increased from day 10 to day 46. The synovial membrane was hyperplastic, with areas of proliferation of newly formed engorged blood vessels. In the cartilage tissue, signs of dystrophic changes were observed: cartilage thickness decreased against a background of chaotically arranged chondrocytes with the presence of isolated acellular areas. Throughout the experimental period, the subchondral bone remained intact.

The most significant inflammatory changes were observed after MIA administration, starting from day 10. Progression of the pathological process reached a maximum by day 46, with the appearance of osteophytes, near-complete loss of the joint space, and destruction of the femoral condyles, corresponding to the end stage of osteoarthritis according to the Kellgren–Lawrence classification.

At the same time, in rats of groups M and MS euthanized on day 10 (first experimental time point), macroscopic examination of the articular surfaces mainly revealed signs of subacute inflammation, with pronounced edema and narrowing of the right knee joint space. From day 25 onward (second experimental time point), signs of irreversible joint apparatus damage were observed. The pathomorphological picture at day 10 included edema of the synovial membrane and lymphoplasmacytic infiltration, with decreased cartilage thickness in certain areas. Thereafter, from day 25, progressive changes were noted, including marked thickening of the synovial membrane, areas of fibrosis, numerous thin-walled newly formed vessels, and lymphoplasmacytic infiltration. Notable findings included severe narrowing of the joint space, up to its complete obliteration. The most prominent changes were the destructive alterations of the cartilage tissue, with its almost complete thinning down to the subchondral bone. Zonal architecture was lost, with indistinguishable cartilage layers, chaotic distribution of chondrocytes, a large number of acellular zones, and destruction of the subchondral bone.

Thus, the conducted study clearly demonstrated a discrepancy between the radiological and pathomorphological pictures of changes in the knee joints. Radiographic findings lag behind morphological alterations. The rate of progression of these changes also differs and is of an accelerated, induced nature. Irreversible changes identified by radiographic examination following MIA administration were accompanied by pathomorphological evidence of increasing destructive and dystrophic changes in joint tissues. In contrast, after the injection of synovial fluid from a patient, the progression was less pronounced and characterized by moderate changes according to morphological analysis; however, these alterations were not detectable by radiography. This, in turn, highlights the limited diagnostic capabilities of joint radiography, especially at the initial clinical manifestations in patients. By the time radiographic changes appear that allow a diagnosis of osteoarthritis to be made, the morphological changes have already become irreversible.

Between 2012 and 2019, a total of 277 patients underwent conservative inpatient treatment. In 166 cases (59.9%), therapeutic exercise was combined with physiotherapy procedures. In 111 patients (40.1%), courses of radiotherapy were prescribed. Long-term therapy with basic chondroprotective agents—SYSADOA (Symptomatic Slow-Acting Drugs in Osteoarthritis)—supplemented by non-pharmacological treatments such as regular walking and individually tailored physical exercise programs was initiated in 33 patients (11.9%).

The effectiveness of conservative treatment for hip osteoarthritis (HOA) during the first five years was evaluated using the W.H. Harris scale (1969, 1987). The effectiveness of nonoperative treatment for HOA decreased over the five-year follow-up from 57.4% to 50.3%, while the effectiveness of THA declined from 97% at the first year of observation to 86.6% at five years.

The study, aimed at evaluating the effectiveness of total hip arthroplasty and conservative treatment methods for patients with HOA, enabled the development of an algorithm for a multidisciplinary treatment approach. The effectiveness of this algorithm was analyzed based on retrospective data collected from patients, most of whom (73.4%) had received predominantly outpatient care prior to hospitalization for THA, often irregularly. In 19.9% of cases (192 patients)—approximately one in five—hospitalization for THA was carried out immediately after the patient's first visit to a specialist at the outpatient clinic. Conservative inpatient treatment of HOA without previous surgery was noted in 256 patients (26.6%), accounting for approximately one in four cases.

The developed algorithm can be recognized as the foundation for a treatment strategy for patients with HOA, encompassing all stages of the disease—from the first symptoms to the terminal stage. This strategy includes a comprehensive approach that integrates outpatient and inpatient care, rehabilitation, and continuous dynamic monitoring.

To achieve the best outcomes in the treatment of patients with HOA, it is necessary to establish a stable network of collaboration among specialists from various fields: orthopedics, rheumatology, internal medicine, rehabilitation medicine, physiotherapy, radiotherapy, therapeutic exercise, and related disciplines.

The goal of the developed strategy is to improve the patient's quality of life, preserve joint function, reduce the intensity of pain, slow the progression of the disease, and maximize the delay in performing total hip arthroplasty.

The developed algorithm incorporates the key components of a multidisciplinary strategy for the treatment of hip osteoarthritis (HOA); however, its implementation in daily clinical practice has certain specific features. The treatment of patients with HOA involves specialists from various fields (internists, rheumatologists, radiologists, therapeutic exercise physicians, physiotherapists, orthopedic trauma surgeons, rehabilitation specialists, psychologists/psychotherapists, occupational therapists, and others). In the Russian healthcare system, as in other countries, there is no dedicated structural unit where all these specialists are integrated. Therefore, within the framework of this dissertation research, the "Scientific and Clinical Center for Arthrology" was established at the North-Western State Medical University named after I.I. Mechnikov (Order of the Rector of NWSMU No. 2548-O dated December 24, 2021 – see Fig. 8.3).

The capacities of the Scientific and Clinical Center for Arthrology made it possible to implement the algorithm of multidisciplinary treatment of hip osteoarthritis in practice. To fully and objectively assess the results of the center's activities and the effectiveness of the algorithm, it is necessary not only to accumulate clinical material but also to have a 5–10-year follow-up period. Currently, the center has been operating for 3 years, and the first positive results have been obtained. Nevertheless, it will be possible to assess the patients' quality of life and long-term functional outcomes only after a minimum of 5 years. Therefore, it was proposed to test the algorithm using retrospective research results.

Group I included patients who had undergone systematic outpatient treatment and who had a documented history of inpatient treatment prior to total hip arthroplasty (THA), thus corresponding to the proposed algorithm. There were 256 such cases (26.6%). The remaining 707 patients (73.4%) received outpatient treatment inconsistently and did not meet the algorithm's criteria.

To evaluate the algorithm's effectiveness, a retrospective validation was conducted. Long-term treatment outcome data over a five-year period were available for 726 (75.4%) of the 963 patients. After six years of follow-up, excellent and good treatment outcomes were recorded in 629 patients (86.6%), while 97 patients (13.4%) had fair or unsatisfactory outcomes. Subsequently, functional outcomes over the long term were separately analyzed in two groups of patients with different treatment results.

According to the five-year follow-up, fair and unsatisfactory functional outcomes were observed in 16 patients (9.1%) in Group I and in 108 patients (19.6%) in Group II. Five years after THA, the percentage difference in patients with fair and unsatisfactory outcomes was twice as high among those without a history of comprehensive inpatient conservative treatment.

The introduction of the developed multidisciplinary treatment algorithm for hip osteoarthritis into daily clinical practice, according to the interdisciplinary strategy, leads to a twofold reduction in the number of cases with fair or unsatisfactory outcomes (over a five-year period). Increasing attention is being paid in Russian and international journals to the issues of premature and unwarranted arthroplasty in degenerative-dystrophic joint diseases. Simultaneously, there is a growing number of publications highlighting the insufficient use of conservative treatment methods for osteoarthritis.

The study revealed that the application of the algorithm based on a multidisciplinary approach in the treatment of HOA patients demonstrates high effectiveness. An individualized approach involving specialists from various fields and the use of a wide range of non-surgical treatment methods (available in inpatient settings) helps avoid or postpone THA. In some cases, conservative treatment can improve quality of life, enhance functional outcomes, and minimize the negative consequences associated with THA.

The proposed algorithm can be effectively used as a fundamental component of the multidisciplinary treatment strategy for patients with hip osteoarthritis, provided that a healthcare facility has the appropriate specialists.

Despite the widespread prevalence of degenerative-dystrophic joint diseases and the acknowledgment by the scientific community that osteoarthritis significantly increases the risk of life-threatening conditions (such as myocardial infarction, acute cerebrovascular accidents, etc.), current healthcare organizational structures in both Russia and other countries do not provide for systematic follow-up (dispensary observation) for such patients. Inpatient treatment for these patients within the compulsory medical insurance system receives minimal funding, and interdisciplinary collaboration among internists, orthopedists, rheumatologists, rehabilitation specialists, physiotherapists, and therapeutic exercise specialists lacks clear regulation. A similar situation exists in the United States, European Union countries, and Asia.

The main goal of the strategy is to improve the patient's quality of life, reduce pain intensity, preserve joint function, slow disease progression, and maximize the postponement of total hip arthroplasty.

The fundamental components of the strategy may include the following interconnected elements: early diagnosis and assessment of disease severity; non-surgical treatment; physical rehabilitation; surgical treatment; psychological support; educational programs; integration of complementary methods; and dynamic dispensary follow-up.

Implementation of the proposed strategy offers several advantages: a personalized approach considering the patient's comorbidities; a comprehensive impact on all aspects of the disease; improved functional outcomes and quality of life; and reduced risks of complications and osteoarthritis progression. The approach requires clear coordination among specialists from different fields and active patient engagement in the treatment process.

# FINDINGS

1. The incidence of osteoarthritis in Saint Petersburg is more than twice as high as in Moscow and the Russian Federation overall. The overall osteoarthritis morbidity rate in Saint Petersburg is 7480.4 per 100,000 adults; in Moscow, 3725.8; and on average across Russia, 3842.2.

2. In patients with hip osteoarthritis undergoing total hip arthroplasty (THA), intraoperative complications were observed in 8.7% of cases: local (5.0%) and systemic (3.7%); postoperative complications occurred in 16.9% of cases: local (13.8%) and systemic (3.1%). Among these were postoperative wound hematoma (3.9%), surgical site infection (5.0%), and prosthetic dislocation (2.1%). In the structure of late postoperative complications, prosthesis wear and loosening were observed in 7.3% of patients, local infectious complications in 7.7%, and prosthetic dislocation in 6.7%.

3. Five years after THA, the proportion of patients with excellent and good quality of life decreased from 99% to 88%, and the proportion with excellent and good functional outcomes declined from 97% to 86.6%.

4. By the end of the 5th year of follow-up, the probability of excellent and good quality of life was 88% in patients with low comorbidity. Among patients with severe comorbidities (high comorbidity levels), this figure was slightly lower at 83%. No statistically significant differences in survival curves between groups with different comorbidity severities were found, as indicated by the log-rank test ($Z = 0.92$, p-value = 0.33).

5. According to morphological studies, Stage III osteoarthritis was confirmed in 18 (60%) patients. In the remaining 12 (40%) patients who underwent arthroplasty, Stage I–II osteoarthritis was verified, indirectly confirming the premature nature of arthroplasty without utilizing the potential of conservative or minimally invasive surgical treatment of hip osteoarthritis.

6. Early stages of osteoarthritis diagnosed radiographically were confirmed via histograms; however, the pathological process was already irreversible. When the

osteoarthritis-inducing factor was removed, early stages of the disease showed potential reversibility.

7. Excellent and good functional outcomes following inpatient non-surgical treatment of hip osteoarthritis (HOA) decreased from 57.4% to 50.3% over 5 years of follow-up. In comparison, THA outcomes showed a more pronounced dynamic: from 97% excellent and good outcomes at 1 year to 86.6% at 5 years. Inpatient non-surgical treatment was recorded in 26.6% of patients hospitalized for THA.

8. The developed comprehensive treatment algorithm for patients with hip osteoarthritis, incorporating both conservative and surgical approaches, includes full modern conservative and organ-preserving surgical treatments prior to arthroplasty, and provides for long-term follow-up within the structure of the Scientific and Clinical Center of Arthrology. Testing of the algorithm demonstrated that excellent and good five-year functional outcomes were achieved in 90.9% of patients treated according to the proposed multidisciplinary strategy. In the group without a history of inpatient non-surgical treatment, excellent and good outcomes were verified in 80.4% of cases.

9. The developed multidisciplinary strategy for the treatment of hip osteoarthritis proved effective in terms of the organization and technologies of the therapeutic and diagnostic process. Five years after THA, the proportion of patients with satisfactory and poor functional outcomes was twice as high among those who had not been treated according to the multidisciplinary strategy (9.1% versus 19.6%, respectively).

# PRACTICAL RECOMMENDATION

1. When developing a treatment strategy for hip osteoarthritis, it is recommended to apply the algorithm for managing patients with hip osteoarthritis, utilizing the resources of an arthrology center with an emphasis on non-surgical techniques and joint-preserving interventions. This algorithm enables postponement or avoidance of hip replacement surgery.

2. Hip replacement with an implant should be considered as a last-resort treatment for osteoarthritis, after all other methods have proven ineffective, given that the lifespan of a prosthesis is not unlimited.

3. The decision to perform hip arthroplasty should preferably be made only after the full range of non-surgical treatment options has been exhausted.

4. In cases of hip osteoarthritis with a clinical and radiographic presentation consistent with stage 3, it is important to recognize that radiological findings may not correspond to the true morphological stage and may mistakenly indicate a more advanced stage of the pathological process.

5. The presence of severe comorbidities or the risk of their progression should not be a decisive factor in opting for hip arthroplasty.

6. Considering the high prevalence of osteoarthritis and the associated risks of life-threatening conditions, which exceed the average population levels among these patients, it is advisable to register, monitor, treat, and follow up with such patients in regional healthcare facilities where a dedicated team of specialists—similar to arthrology centers—is available.

7. Early diagnosis of osteoarthritis, before the appearance of radiological symptoms, is considered optimal, as the pathological process at that stage may still be reversible.

# PROSPECTS FOR FURTHER RESEARCH

Several areas for further research appear promising. From an organizational standpoint, it would be advisable to undertake work aimed at improving statistical accounting methods and establishing a system that would provide a more accurate picture of the incidence and structure of osteoarthritis.

It is also planned to conduct a study that would refine the indications and contraindications (both relative and absolute) for total hip arthroplasty and implement stricter patient selection criteria for this intervention.

In light of the rapid development of arthroscopic technologies, a study aimed at determining the place and role of arthroscopy within the algorithm for the management of hip osteoarthritis is highly relevant. The investigation of arthroscopic diagnostics for the early stages of osteoarthritis could be considered as a separate area of research.

Collaboration with morphologists to clarify the definition of the term "joint" also appears to be of interest, as it is currently described as a connection or articulation, whereas in fact it represents a soft-tissue hollow organ (with the capsule, cartilage, and synovial membrane being its mandatory components) performing several important functions.

In future experimental studies, the use of an induced osteoarthritis model is possible for testing new pharmacological agents for osteoarthritis treatment. Finally, the idea of studying the feasibility of establishing regional arthrology centers (similar to specialized dispensaries) for the registration, management, treatment, and dynamic monitoring of patients with osteoarthritis appears to be a promising direction.

# LIST OF ABBREVIATIONS

BP — Blood Pressure

VAS — Visual Analog Scale

WHO — World Health Organization

FMH — Field Military Surgery

VTE — Venous Thromboembolism

HTN — Hypertension

GCS — Glucocorticosteroids

GS — Glucosamine Sulfate

BMI — Body Mass Index

SSI — Surgical Site Infection

QoL — Quality of Life

CT — Computed Tomography

PT — Physical Therapy

MIA — Monoiodoacetate

ICF — International Classification of Functioning, Disability and Health

MRI — Magnetic Resonance Imaging

NSAIDs — Non-Steroidal Anti-Inflammatory Drugs

OA — Osteoarthritis

HOA — Hip Osteoarthritis

NWFD — Northwestern Federal District

SPCPA — Saint Petersburg State Chemical-Pharmaceutical Academy

Hip Joint — Hip Joint (TBS — abbreviation retained in Russian as ТБС if needed for consistency)

PE — Pulmonary Embolism

USDG — Ultrasound Doppler Sonography

US — Ultrasound

FBS — Fibrobronchoscopy

EGD — Esophagogastroduodenoscopy

FGBNU NCBMT FMBA — Federal State Budgetary Scientific Institution

"Scientific Center for Biomedical Technologies of the Federal Medical-Biological Agency"

PTT — Physical Therapy Treatment

CS — Chondroitin Sulfate

COPD — Chronic Obstructive Pulmonary Disease

RR — Respiratory Rate

ECG — Electrocardiography

THA — Total Hip Arthroplasty

AAOS — American Academy of Orthopaedic Surgeons

ABOS — American Board of Orthopaedic Surgery

ADL — Activities of Daily Living

CCI — Charlson Comorbidity Index

CNT — Coxib and Traditional NSAID Trialists

MDPS — Merle d'Aubigné and Postel Score

OARSI — Osteoarthritis Research Society International

OOCHAS — OARSI Osteoarthritis Cartilage Histopathology Assessment System

OHS — Oxford Hip Score

PRP — Platelet-Rich Plasma

PRO — Patient-Reported Outcomes

KL — Kellgren–Lawrence

KM — Kaplan–Meier

UDAR — Universal Declaration of Animal Rights

SYSADOA — Symptomatic Slow-Acting Drugs in Osteoarthritis

WOMAC — Western Ontario and McMaster Universities Osteoarthritis Index

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