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THE ROLE OF ARTHROSCOPY IN THE TREATMENT OF KNEE OSTEOARTHRITIS

Scientific specialty – 3.1.8. Traumatology and orthopaedics

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INTRODUCTION

Study rationale. Knee osteoarthritis (OA) is one of the most common diseases worldwide. It is treated by orthopedic traumatologists, rheumatologists, physicians, rehabilitation specialists, physiotherapists, and others. Osteoarthritis treatment methods are diverse, including conservative therapy, endoscopic interventions, partial or total knee replacement. Therapeutic and diagnostic arthroscopy is actively used for the disease management. However, the impact of arthroscopy to the knee OA treatment strategy remains controversial in the medical community (Yudin V.E. et al., 2022; Driban J.B. et al., 2023).

Currently, minimally invasive low-blood loss operations are preferred in surgical practice, and arthroscopy is one of those (Lisitsyna E.M. et al., 2016; Adams J.E. et al., 2015; Goebel L., Madry H., 2016). In the end-stage knee OA, possitive treatment results could only be achieved by applying a comprehensive approach including both surgical methods and conservative treatment options (Wang W.J. et al., 2018; Ekanayake C.D. et al., 2022; Kulm S. et al., 2022). In the absence of early disease detection and comprehensive treatment applied, the number of total joint replacements is increasing (Liebs T.R., Berger S., 2017; Mansurov D.S. et al., 2023). There is also the unreasonable expansion of arthroplasty indications that is accompanied by the increased frequency of unsatisfactory results of primary and revision arthroplasty (Lychagin A. V. et al., 2019; Vorokov A.A. et al., 2020; Hawker G. et al., 2015).

Many specialists believe that the indications for arthroscopy should be expanded (Zaremuk A.M., et al., 2017; Mayr H.O. et al., 2013; Dzhumabekov S.A., Shambetov J.Z., 2022). According to many authors, the key to positive treatment results is not only a perfected technic of knee arthroplasty, but also optimization of the surgery indications. In the treatment of stage 3 knee OA, arthroplasty is currently a preferred method, thus arthroscopy is underutilized (Jenny, J.Y., 2018; Wang, W.J. et al., 2018; Reynolds A.W. et al., 2022). Questions on treatment strategies optimization in patients with knee OA, especially those of young and middle age, are actively discussed at various medical forums. Many authors deem important to clarify the arthroscopy indications to utilize it

widely in the OA patients in order to delay arthroplasty. This warrants a scientific study dedicated to the impact of arthroscopy in the treatment of knee OA.

Extent of previous investigation. Despite the widespread use of arthroscopy for the treatment of knee injuries and diseases, some questions on the use of these organ-preserving intervention remain unsolved. In a step-by-step comprehensive treatment of patients with stage 3 knee OA, the use of arthroscopy is still a matter of discussion.

Study purpose. To improve the treatment results in patients with stage 3 knee OA by introducing of a comprehensive strategy using the expanded list of arthroscopy indications.

Study objectives

1. To assess the direct outcomes of arthroscopy and arthroplasty in the treatment of patients with stage 3 knee OA, as well as the structure of short- and long-term outcomes of the knee OA surgical treatment.
2. To determine the validity of knee arthroplasty based on the retrospective study of the removed joints patho-morphology.
3. To study the long-term results of arthroscopy in patients with stage 3 knee OA.
4. To find the ways of improvement of the long-term outcomes of knee OA treatment by developing and testing a comprehensive treatment strategy.

Study scientific novelty. The long-term functional outcomes in a group of patients who underwent arthroscopy instead of arthroplasty were analyzed for the first time.

A comprehensive treatment strategy for knee OA including the use of arthroscop, was proposed and tested for the first time. According to the strategy, organ-preserving operations (arthroscopy) should precede knee arthroplasty.

The results of morphological examination were assessed in terms of the knee arthroplasty validity for the first time.

Study theoretical and practical relevance. The knowledge has been expanded on the course of early and late postoperative period in patients with end-stage knee OA who underwent arthroscopy in advance to arthroplasty.

The comprehensive treatment strategy for knee OA was developed and its

application was justified. The knee replacement can be postponed with the introduction of the strategy to clinical practice.

Practical recommendations were developed for the prevention of long-term unsatisfactory outcomes of treatment in patients assigned for arthroplasty, which include conservative treatment and arthroscopic interventions as steps preceding arthroplasty. These steps are described in the proposed strategy considering the types and scope of examination, prophylaxis, and treatment.

Study materials and methods. The study was conducted in accordance with the principles of evidence-based medicine. The methods of clinical, laboratory, functional, and statistical investigations were used. Study objects were the patients aged from 29 to 88 years, hospitalized for knee replacement, organ-preserving intervention, or conservative treatment due to OA in the the Clinic of Traumatology and Orthopedics of I.I. Mechnikov North-Western State Medical University (the Clinic). Study subjects were risk factors for unsatisfactory functional outcomes of treatment and poor quality of life in patients with knee OA.

This was a retrospective-prospective single-center unblinded open-label non-randomized clinical study. Inclusion criteria were age over 18 years; diagnosis of idiopathic or post-traumatic knee OA of stage 3; time and place of treatment. Exclusion criteria were patient death while inpatient and revision knee arthroplasty.

The main statistical data on therapeutic and surgical treatment of patients with knee OA in the specialized scientific and clinical center of arthrology of I.I. Mechnikov NWSMU were analyzed.

Theses submitted for approval:

1. Hematoma and synovitis are the most common complications in the early postoperative period after arthroscopy. Hematoma and surgical site infection (SSI) are the most common in the early postoperative period after arthroplasty. Intraoperative and early postoperative complications are more than 2 times frequent in arthroplasty compared to arthroscopy.

2. The histological examination of arthroplasty materials may reveal a discrepancy between the morphological stage of OA and that determined preoperatively

by radiology. In some cases, patho-morphological examination verifies stage 1-2 OA, which suggests the knee arthroplasty was performed unreasonably and prematurely.

3. Arthroscopic treatment of stage 3 knee OA improves the functional outcomes in most patients. Excellent and good functional outcomes are observed in 80% of patients 2 years after knee arthroscopy.

4. The main way to improve the treatment results in patients with stage 3 knee OA is to restrict the indications for arthroplasty and to postpone the operation, if possible, instead arthroscopic intervention and conservative methods should be applied as a step preceding arthroplasty.

Main scientific results. The literature review represents the current trends and needs for improvement of the treatment results in knee OA and describes the role of arthroscopy in the management of such patients. A significant number of publications have been analyzed, and different scientific opinions on the study topic have been summarized. In addition, the history of the use of arthroscopy is described in a separate section.1. P. 29; 4. P. 24; 5. P. 29; 8. P. 11-25; 9. P. 28; 10. P. 31; 13. P. 40;

During arthroscopic interventions intraoperatively, cartilage tissue damage is most often noted – 5 (2.4%) of observations. Local intraoperative complications during knee replacement were noted in 6.6% of cases; damage to the lig. collaterale tibiale was most often verified in 7 (1.0%) patients. In patients who underwent arthroscopy of the knee joint, synovitis – 8 (3.8%) and hematomas – 8 (3.8%) were detected in the near term after surgery. In 2 cases (0.9%), a superficial infection of the surgical intervention area was verified, the incidence of infection of the surgical intervention area during knee arthroplasty was 3.7% (25 cases), while deep infection was diagnosed in 12 (1.8%) patients. Complications from other organs and systems were detected only during knee arthroplasty – 25 (3.7%) cases. Intraoperative and early postoperative complications were diagnosed in a total of 16 (7.6%) patients after knee arthroscopy and in 106 (15.7%) cases of knee replacement with an implant. 2 years after surgery, the number of excellent and good results after knee arthroscopy decreased from 91% to 82.8%, and after arthroplasty – from 99.4% to 93.2%. 2. P. 57; 3. P. 57; 4. P. 57; 5. P. 58; 6. P. 31, 57;

A lifetime pathomorphological examination of sawdust after the EX revealed that

stage 3 osteoarthritis was verified in 19 (63.3%) cases. In the remaining 11 (36.7%) patients who underwent arthroplasty, stage 1-2 osteoarthritis of the knee joint was determined, which did not correspond to the X-ray preoperative picture and was an indirect confirmation of the prematurity of the endoprosthesis.11. P. 57- 64; 14. P. 57-64;

Knee replacement with an implant was performed in 33.3% of patients during the first year after arthroscopy performed with stage 3 osteoartrithis. In another 22.4% of patients, knee replacement was performed during the second year after arthroscopy. Among the remaining patients with preserved knee joint, excellent and good functional results were verified in 80.5% of cases 2 years after knee arthroscopy.8. P. 72; 12.P. 72;

The developed algorithm of a differentiated approach to the complex treatment of patients with osteoarthritis of the knee joint includes a stable interaction of non-surgical methods of treatment and minimally invasive organ-preserving surgery, as a result of which knee arthroplasty is postponed to a later date, and indications for it are being clarified. The main ways to improve the results of treatment of patients with stage 3 osteoarthritis are: verification of the osteoarthritis stage and rehabilitation of the joint cavity in combination with conservative methods of treatment of knee osteoarthritis in accordance with the algorithm preceding knee arthroplasty. The use in practice of the algorithm of complex treatment of osteoarthritis of the knee joint makes it possible to preserve the joint for at least two years with an excellent and good quality of life for every third patient.7. P. 29, 40; 12. P. 67;

Publications related to the study

1. Balgley, A.G. Limitation of indications for primary knee arthroplasty / A.G. Balgley, A.N. Tkachenko, V.M. Khaidarov, Y.B. Tsololo, T. Mangushev // In: VII International Congress of Association of Rheumatic Disease Surgeons. Theses. - Voronezh, - 2023. - pp. 141-143.

2. Mansurov D.S. Limitation of indications for primary knee arthroplasty / D.S. Mansurov, A.A. Spichko, A.N. Tkachenko, V.M. Khaidarov, A.G. Balgley // In: V International Congress of Association of Rheumatic Disease Surgeons. Theses. Editorial Board: M.A. Makarov [et al]. Voronezh, - 2021. - pp. 75-77.

3. Spichko A.A. Long-term results of knee arthroplasty / A.A. Spichko, D.Sh.

Mansurov, A.N. Tkachenko, V.M. Khaidarov, A.G. Balgley, B.G. Aliev // In: V International Congress of Association of Rheumatic Disease Surgeons. Theses. Editorial Board: M.A. Makarov [et al]. Voronezh, - 2021. - pp. 89-90.

4. Khaidarov V.M. Results of combined treatment of knee injuries with concomitant varicose vein disease of the lower limbs in middle-aged and elderly people / V.M. Khaidarov, D.Sh. Mansurov, A.A. Spichko, B.M. Mamasoliev, A.N. Tkachenko, A.G. Balgley, B.G. Aliev // In: V International Congress of Association of Rheumatic Disease Surgeons. Theses. Editorial Board: M.A. Makarov [et al]. Voronezh, - 2021. - pp. 96-97.

5. Mazurov V.I. Prevalence of osteoarthritis and problems of its statistical accounting / V.I. Mazurov, S.A. Sayganov, A.N. Tkachenko, O.V. Inamova, I.L. Urazovskaya, D.Sh. Mansurov, V.M. Khaidarov, B.G. Aliev, A.A. Spichko, A.G. Balgley // Health - the Basis of Human Potential: Problems and Solution. - 2021. - Vol. 16. - 2. - pp. 764-770.

6. Tkachenko A.N. Causes of arthroplasty unsatisfactory results in knee osteoarthritis in the long-term postoperative period: a literature review / A.N. Tkachenko, A.K. Dulaev, A.A. Spichko, D.Sh. Mansurov, V.M. Khaidarov, A.G. Balgley, I.L. Urazovskaya, A.A. Khromov, E. Ulhak, J.B. Tsololo // N.N. Priorov Bulletin of Traumatology and Orthopaedics. - 2022. - Vol. 29 - 3. - pp. 317-328.

7. Mansurov D.Sh. The role of arthroplasty in the comprehensive treatment of knee osteoarthritis / D.Sh. Mansurov, I.L. Urazovskaya, S.A. Sayganov, A.N. Tkachenko, V.M. Khaidarov, A.G. Balgley, Z.A. Totoev // Polytrauma. - 2022. - 3. - pp. 80-88.

And other publications on the topic of the dissertation:

8. Balgley, A.G. Frequency and structure of complications in arthroscopic treatment of knee osteoarthritis / A.G. Balgley, A.N. Tkachenko, V.M. Khaidarov, D.Sh. Mansurov, I.L. Urazovskaya // I.I. Mechnikov NWSMU Bulletin. - 2022. - Vol. 14. - 2, - pp. 35-47.

9. Ismael, A. Causes of endoprosthesis components instability after hip and knee arthroplasty (a scientific review) / A. Ismael, A.N. Tkachenko, V.M. Khaidarov, D.Sh. Mansurov, A.G. Balgley, Z.A. Totoev // Physical and Rehabilitation Medicine. -

2022. - Vol. 4. - 3, - pp. 73-81.

10. Mansurov D.Sh. Limitations of the primary surgery for knee replacement / D.Sh. Mansurov, A.N. Tkachenko, B.M. Mamasoliev, A.G. Balgley, A.A. Spichko, V.M. Khaidarov, I.L. Urazovskaya // In: VII International Congress of Association of Rheumatic Disease Surgeons. Theses. - Voronezh, - 2023. - pp. 110-111.

11. Tkachenko A.N. Morphological characteristics of the of osteoarthritis in patients who underwent knee arthroplasty / A.N. Tkachenko, D.Sh. Mansurov, B.M. Mamasoliev, A.G. Balgley, A.A. Spichko, A.S. Kakhkharov, V.M. Khaidarov, I.L. Urazovskaya // In: VII International Congress of Association of Rheumatic Disease Surgeons. Theses. - Voronezh, - 2023. - pp. 112-113.

12. Tkachenko A.N. The first results of the Arthrology Research and Clinical Centre / A.N. Tkachenko, S.A. Sayganov, V.I. Mazurov, A.G. Balgley, V.M. Khaidarov, D.Sh. Mansurov, I.L. Urazovskaya // In: Medical care in traumas. Updates on organisation and technologies. Trauma factor in the modern world. Traumatic epidemics and a fight against them. Theses of VIII All-Russian Congress with international participation. To the 100th anniversary of the Corresponding Member of the USSR Academy of Medical Sciences S.S. Tkachenko. - St. Petersburg, - 2023. - P. 168.

13. Baranovsky A.A. Possibilities of tunneling in the treatment of knee osteoarthritis / A.A. Baranovsky, A.G. Balgley, A.N. Tkachenko, D.Sh. Mansurov, A.A. Khromov // Genius of Orthopaedics. - 2023. - Vol. 29. - 2. - pp. 204-210.

14. Tkachenko A.N. Morphological characteristics of osteoarthritis in patients who underwent knee arthroplasty / A.N. Tkachenko, R.V. Deev, A.G. Balgley, D.Sh. Mansurov, A.A. Khromov, P.P. Romashov, B.M. Mamasoliev, A.S. Kakhkharov // Modern Problems of Science and Education. - 2023. - 1. - P. 59.

Study results reliability and evaluation. The overall results of the study were evaluated based on the analysis of three groups of patients: those who underwent arthroplasty due to knee OA, those who underwent arthroscopy, and those who received conservative treatment. Considering the use of modern methods in the therapeutic and diagnostic process and the conventional statistical methodology, the data obtained are reliable and the results of the study are valid.

The study results were reported at Vth international Congress of association of rheumatic disease surgeons (Moscow, 2021); VIIth international Congress of association of rheumatic disease surgeons (Moscow, 2023) and the Ist international Congress Medical Rehabilitation: Scientific Research and Clinical Practice (St. Petersburg, 2022).

Scientific and practical recommendations based on the study results are implemented into practice in several medical institutions of St. Petersburg including the I.I. Mechnikov NWSMU Clinic of Traumatology and Orthopedics, Leningrad Regional Clinical Hospital, St. Petersburg Hospital for War Veterans. The study results also used for educational purposes at the I.I. Mechnikov NWSMU Department of Traumatology, Orthopedics and Military Surgery.

Applicant contribution. The applicant has formulated the purpose and objectives of the study, analyzed domestic and foreign literature on the study problem, developed the study plan, statistical documents, expert charts, and questionnaires, collected and processed the data, summarized the study results. The applicant participated directly in the management and treatment of patients in the prospective group. The author contribution was as follows: statistical data collection - 90%, expert evaluation - 85%, material processing - 90%, study results generalization and analysis – 100%.

Dissertation size and structure. The dissertation is presented on 113 pages (in English) of typewritten text, illustrated with 41 figures, contains 19 tables; includes an introduction, four chapters, a resume, conclusions, practical recommendations, an appendix, and a list of references containing 191 sources, including 59 Russian and 132 foreign sources.

CHAPTER 1. ARTHROSCOPY IN THE TREATMENT OF KNEE PATHOLOGY: POSSIBILITIES AND PROSPECTS

1.1. History of Arthroscopy

In 1912, at the 41st Congress of the German Society of Surgeons in Berlin, the Danish surgeon S. Nordentoft presented an endoscope with a trocar of a 5 mm diameter that could be used for suprapubic cystoscopy, laparoscopy, and knee arthroscopy (Nordentoft S., 1912). Nordentoft was the first to use the term “arthroscopy”. He was also the first to use the endoscopic method to examine the knee joint, despite significant limitations due to imperfect optics and insufficient illumination (Keiser C.W., Jackson R.W., 2001). However, Nordentoft's works were not highly appreciated in the medical community. (The main results of the literature study were published in the open press: Balgley A.G. et al., 2022).

In 1918, K. Takagi from Tokyo used the cystoscope to examine the knee joints of patients with tuberculosis. Takagi produced his first arthroscope in 1920; however, the instrument had an optical cannula with a diameter of 7.3 mm, which made its practical use difficult. In 1931, he introduced an arthroscope with a diameter of 3.5 mm, which he successfully applied to practice (Takagi K., 1933). Following years, Takagi continued to refine his arthroscope and presented its 12th design in 1938 (Takagi K., 1939).

In parallel, E. Bircher published his favorable experience with arthroscopy in diagnosing knee joint meniscus pathology in 60 patients in Switzerland (Bircher E., 1921). He used a modification of the H.C. Jacobaeus laparothoracoscope and called the technique “arthroendoscopy”. Bircher's publication was the first to describe the use of arthroscopy followed by arthrotomy in real patients. However, akin to all the initial arthroscopes, the one employed by Bircher had a limited field of view (90° to the side) and inadequate illumination. Later on, Bricher shifted his focus from arthroscopy to the advancement of arthrographic techniques, which he believed could provide a more precise diagnosis of meniscus pathology (Keiser C.W., Jackson R.W., 2003).

In the United States, the pioneer of arthroscopy was P. Kreuscher, a sports physician whose primary focus was on injuries to the semilunar cartilage of the knee joint (Kreuscher P., 1925). He performed arthroscopy on 25–30 patients, but the same

technological imperfections were the reasons for failure in the use of the arthroscope. In some cases, after examining the knee joint with an arthroscope, Kreuscher injected lipiodol intra-articularly, followed by radiography. Therefore, the foundation for arthrography was established.

In 1931, in New York, M.S. Burman investigated the possibility of using a 4 mm arthroscope, which was developed by R. Wappler, the founder of the company that later became American Cystoscope Makers Inc (ACMI) (Burman M.S., 1931). Subsequently, Burman and his colleagues published the results of studies involving patients (Burman M.S. et al., 1934). In addition, Burman presented 20 color images of arthroscopic findings of various joints, which were the first visual images of arthroscopic findings, to the scientific community.

During the 1920s and 1930s, different scientists practiced knee joint arthroscopy and published their results including E. S. Geist, presenting his findings in the Lancet (1926), S. Iino (Japan, 1939), R. Sommer (1937) and E. Vaubel (1938) in Germany. Further scientific advancements in joint arthroscopy were suspended due to the outbreak of World War II.

The development of arthroscopy was greatly influenced by M. Watanabe, who continued the investigations of K. Takagi. In 1954, Watanabe developed the 13th and 14th modifications of the Takagi arthroscope, in which the optical and electronic components were improved (Fig. 1.1).

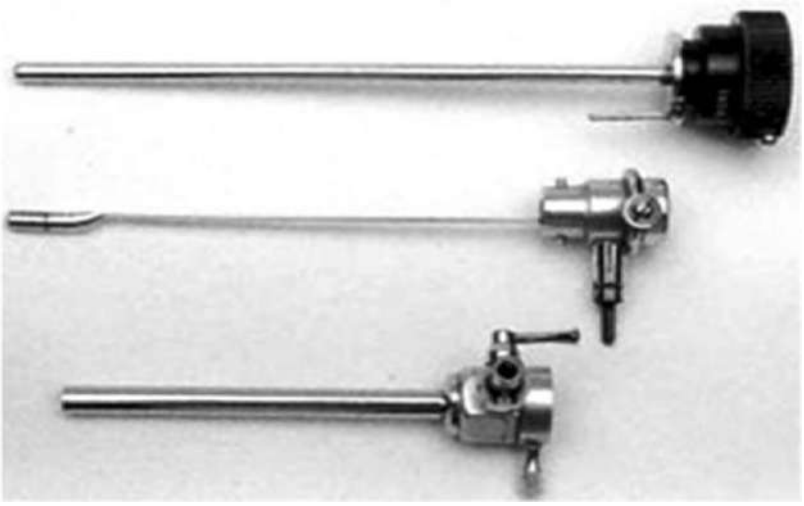


Figure 1.1 - Arthroscopes by M. Watanabe (cited in A.C.L. Magrill et al., 2017)

In 1955, Watanabe was the first to perform arthroscopic knee surgery. In 1957, he

presented the results of his research at the International Society of Orthopedic Surgery and Traumatology (SICOT) meeting in Spain, however, did not receive any recognition from the scientific community. Nevertheless, he continued his research on arthroscope optimization.

Same year, Watanabe created the first atlas on arthroscopy (the second one was published in 1969), where the first images of the knee joint cavity were presented. In 1958, he proposed the 21st design of a 6 mm arthroscope possessing optical lens with the field of view of 101°, and the depth of field of view of a 1 mm or less. That was the first ever arthroscope to be put into mass production. In 1967, Watanabe developed arthroscope #22, which used fiber light ("cold" light) instead of incandescent lamp. In 1970, he introduced the first ultra-thin 2 mm fiber optic arthroscope with a "selfoc", single optical fiber of 1.7 mm diameter (Watanabe M., 1986). Subsequently, Watanabe's ideas were implemented by H. Ikeuchi. It should be noted that the studies of Watanabe significantly influenced the works of other researchers and contributed to the knee arthroscopy popularization.

For instance, R.W. Jackson, had learnt Watanabe arthroscopy techniques, after which he performed arthroscopy with arthroscope #21 in 25 patients in Toronto in 1965. By 1966, Jackson performed up to 70 arthroscopies (Jackson R.W., 1987). Moreover, since 1968 he conducted trainings on arthroscopy techniques at the American Academy of Orthopaedic Surgeons (AAOS), and gradually this method grew practitioners. In 1976, Jackson, in co-authorship with D. Dandy, published the first textbook on knee arthroscopy in English (Jackson R.W., Dandy D.J., 1976).

In 1974, Jackson founded the International Arthroscopy Association (IAA) and in 1982, the Arthroscopy Association of North America (AANA), which allowed scientists from different countries to exchange experience. In, 1967 J.J. Joyce III began to actively study arthroscopic anatomy of the knee joint, inspired by Jackson.

Learning from the works of Watanabe, R.L. O'Connor widely performed arthroscopic partial meniscectomy in USA since 1974 and developed the first operating arthroscope with an offset eyepiece and a long straight working channel.

After reading a note on the arthroscopy performed by Watanabe, S.W. Casscells

had ordered arthroscope #21 for his research, the results of which he presented in 1971 (Casscells S.W., 1971). In 1985, Casscells became the editor of the Arthroscopy, a journal, which later evolved into one of the largest journals worldwide specialized on arthroscopic techniques.

In the mid-1970s, R.W. Metcalf established a specialized center for arthroscopic surgery, where he provided trainings on arthroscopy and arthroscopic surgery, contributing to the introduction of this technique into clinical practice (McGinty J.B., 1991).

An arthroscope with a small needle developed by Dyonics was initially used by L.L. Johnson, who proposed performing multiple punctures of the knee joint to study all available areas. Subsequently, he began to examine other joints arthroscopically including shoulder, elbow, and big toe joints. Johnson explored the possibilities of the arthroscopy of closed and narrow spaces, such as the fascial planes of the tibia. He was also involved in the development of arthroscopy instrumentation and was one of the first to use the astroscopic technique for the treatment of degenerative joint disease (osteoarthritis).

In the Netherlands, H.R. Eikelaar, who received his first doctorate in arthroscopy in 1975, in cooperation with Storz (Germany) developed the first 30° tilted arthroscope with HOPKINS optics, which made it possible to expand the field of view when examining a joint.

In Sweden, arthroscopy was practiced by E. Eriksson, who was also the founder of the European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA), similar to the AANA in United States. In 1973, J. Gillquist from Sweden proposed a “central” access to the knee joint through the patella tendon.

In Russia, the first steps in arthroscopy were made back in the 60s-70s of the last century. In 1962, N.A. Polyak presented the results of arthroscopic examination of the knee joint in 60 patients using a pediatric cystoscope; subsequently, the diagnosis in the patients was confirmed by arthrotomy. In 1964, S.L. Khmelevskaya performed 5 arthroscopies, and I.G. Gertsen performed 1 arthroscopy. In 1965, V.I. Kirsanov reported 32 cases of arthroscopy performed in cadavers and 12 of those performed in patients. His conclusion on the necessity of introducing a large amount of fluid into the joint cavity to

improve visualization is noteworthy. However, V.I. Kirsanov believed that arthroscopy would not spread due to its technical difficulties.

In 1969, V.F. Wagner performed 7 experimental arthroscopies. In 1978, O.A.Ushakova presented the results of arthroscopy using Watanabe arthroscope #24 in 7 patients and 12 cadavers (Ushakova O.A., 1978). She emphasized the prospect of this technique within the practical and scientific activities of specialized medical institutions.

A significant contribution to the development of arthroscopy in Russia was made by the staff of the Central Institute of Traumatology (CITO). Since 1976, the doctors of the Sports and Ballet Trauma Department directed by Z.S. Mironova widely used therapeutic and diagnostic arthroscopy for the management of various injuries (Faleh F.Y., 1979; Mironova Z.S. et al., 1980; Mironova Z.S., Faleh F.Y., 1982). In 1985, Mironova provided a section on knee joint arthroscopy to the “Manual of Clinical Endoscopy” (edited by Acad. of Medical Sciences V.S. Saveliev).

Further research of knee joint arthroscopy was guided by Prof. S.P. Mironov. Arthroscopy became not only a diagnostic but also a surgical treatment method for knee joint pathology. Surgeons in CITO performed partial and subtotal meniscectomies, cruciate ligament plasty, and other operations (Ushakova O.A. et al., 1991; Lisitsyn M.P., 1996; Mironov S.P. et al., 1999; Mironov S.P. et al., 2001). In 1996, M.P. Lisitsyn initiated the establishment of the Russian Arthroscopic Society.

However, until the early 2000s, only a small number of surgeons practiced arthroscopy. Nevertheless, arthroscopy gradually became widespread, and the number of diagnostic and surgical arthroscopic interventions increased.

Thus, in 2009, V.I. Shevtsov et al. presented the results of the arthroscopical examination of 111 patients with knee and elbow joints pathology. The authors proposed local subchondral tunnelization of the knee joint articular ends in case of chondromalacia of the loaded joint surfaces in combination with various meniscus injuries.

In 2000, A.P. Trachuk published a practical guide to knee joints diagnostic arthroscopy. In 2001, C.V. Ivannikov described laser arthroscopic chondroplasty, meniscectomy, and synovectomy for degenerative lesions of the joint (A.P. Trachuk et al., 2000).

In addition to the knee arthroscopy, the arthroscopical examination of other joints is now widely used. Arthroscopic interventions on the shoulder joint are used in case of joint instability, sports injuries, articular labrum pathology and rotator cuff damage (S.A. Stolbikov et al., 2019, Paxton E.S. et al., 2013). Arthroscopy has many advantages. The procedure is minimally invasive, provides good postoperative and cosmetic results, needs no narcotic analgesics administration, requires antibiotics treatment prior to the intervention only, reduces inpatient time, as well as encourages patients recovery in the postoperative period. At the same time, the complications rate of shoulder arthroscopy is 1-2%, and the repeated hospitalization rate is less than 1% (Rossi M.J. et al., 2017; Tsikouris G.D. et al., 2018).

Hip arthroscopy is now widely used for the diagnosis and treatment of a wide range of pathologies including acetabular labrum lesions, articular cartilage damage, femur round ligament injury, septic arthritis, synovial chondromatosis, joint capsule pathology, femoral head necrosis, etc. (Yakupova E.R., 2020; Freeman K.L. et al., 2021).

Ankle arthroscopy is being actively introduced for injuries diagnostics, internal ligaments reconstruction, arthrodesis, etc. The ankle arthroscopy is used for the treatment of posttraumatic cruciarthrosis, bone and cartilage lesions, transverse ligament ruptures, infectious arthritis, and fractures (Gorodnichenko A.I. et al., 2015; Leonchuk S.S., et al., 2021; Cooper M.T., 2020; Connelly J, Ferkel RD., 2021; Shah R., Bandikalla V.S., 2021).

Elbow arthroscopy is indicated for the diagnosis and treatment of early osteoarthritis, chondromatosis, dissecting osteochondritis, lateral epicondylitis, synovitis, and rheumatoid arthritis (Bennett J.M., 2013; Adams J.E. et al., 2015; Haasters F. C et al., 2019).

With the improvement of arthroscopic technique and the availability of high-precision optics, the arthroscopy of smaller joints started to evolve (Golubev I.O. et al., 2018; Ahsan Z.S., Yao J., 2017; Liu B. et al., 2019). The use of arthroscopy significantly expanded the scope of surgical treatment in temporomandibular joint pathology (Sysolyatin S.P. et al., 2020; Ângelo D.F. et al., 2021).

Arthroscopy is now an important technique in traumatologic and orthopedic practice. Most specialists worldwide deem necessary to improve the technology, develop

clear criteria for patient selection, determine indications for this type of surgical interventions, and optimize the technique of arthroscopic operation, as well as to minimize intraoperative and postoperative complications (Sarayev A.V. et al., 2020; Giorgini A. et al., 2022; Balgley A.G. et al., 2022).

In recent years, arthroscopy is used everywhere, actively developing, and gaining new modern equipment and instrumentation. It is now considered by scientific community as a reference method of visualization and surgical treatment of knee joint pathology (Samoilov V.V. et al., 2006; Shevtsov V.I. et al., 2009; Prizov A.P. et al., 2019; Katz J.N. et al., 2014; Banach A. et al., 2021).

Modern arthroscopes possess a small diameter of 1.7-6.5 mm. Innovative optical and digital technologies allow the usage of wide-angle high degree resolution optical systems during arthroscopy, which in combination with fiberglass elements provide clear and contrast images of internal joint cavities and intra-articular structures (Gorshkov M. D., 2019; Banach A. et al., 2021). In addition, photos and videos can be captures during the procedure now, and the real-time arthroscopy can be performed (Tanaka M.et al., 2003; Hurmusiadis V. et al., 2011).

The history of arthroscopy dates back more than 110 years. Born in Europe, the technique gradually spread to North America, Asia, Russia, and other countries. The design of arthroscopes is still being improved, indications for arthroscopic interventions are being expanded, and the number of specialists united in professional societies of arthroscopic surgeons is growing, as is the number of specialized publications devoted to arthroscopy. At the same time, the knee joint remains the most widely examining one, and the problems of knee joint pathology treatment, arthroscopy complications and consequences continue to be discussed by investigators all over the world.

1.2. Knee Arthroscopy Complications: Incidence and Distribution

Even though knee arthroscopy is considered as minimally invasive operation, complications after surgical intervention are not uncommon. In the intra- and perioperative periods such complications can includes nerve and vessel injuries, port displacement, thrombosis, air embolism, instrumentation breakage and compartment syndrome associated with irrigation fluid leakage in case of a defect in the joint capsule

(Mendel T.et al., 2011). Complications such as hemarthrosis, thrombosis, embolism, infection, and synovial fistulas are possible in the postoperative period (Mayr H.O., Stoehr A., 2016). Arthrofibrosis, Albeck's disease, or aseptic osteonecrosis of the femur or tibia, as well as complex regional pain syndrome are extremely rare after arthroscopic interventions (Ryazantsev M.S. et al., 2018; Salzler M. J. et al. 2014). (The main results of the literature study were published in the open press: Balgley A.G. et al., 2022).

By the mid-1980s of the XX century, data on the advantages of knee arthroscopy compared to open surgical interventions had accumulated, and arthroscopy graduated the preferred treatment method of knee pathology (Treuting R., 2000; Bigony L., 2008). Through arthroscopic interventions it was possible to return the patient to active life more quickly. More and more often the operations could be performed on an outpatient basis, which reduced the cost of patient care and provided the patients with comfortable conditions. These advantages led to a rapid increase in the number of video-endosurgical operations performed at the end of the XX century. Thus, the number of arthroscopies amounted to 569 thousand in 1994, and more than 984 thousand in 2006 (Kozak L.J. et al., 1997; Kim S. et al., 2011).

In 1986, complications of arthroscopic surgery of the knee and other joints were studied by the members of AANA (Small N.C., 1986). A total of 375,069 arthroscopic interventions were evaluated. A total of 2215 (0.56%) complications were verified. The complication rates for meniscus repair and anterior cruciate ligament surgeries were 2.4% and 1.8% respectively.

From 1983 to 1989, German researchers performed about 4 thousand knee arthroscopies. Iatrogenic cartilage damage was found among the most frequent complications (Birr R. et al., 1990). The frequency of severe complications was 0.5%.

Different authors pointed out iatrogenic cartilage damage as the main reasons for unsatisfactory results of knee arthroscopy, which were observed in half of the cases (Beickert R., Probst J., 1991). It was explained by the introduction of more technically complex arthroscopic procedures into clinical practice amid insufficient experience of surgeons and attempts to improve the instrumentation (Katz J.N.et al., 2014).

In 2000, M. Milankov et al. presented the results of 1071 arthroscopic

manipulations performed between 1990 and 1998. Complications were detected in 39 patients (3.64%), with 10 (25.64%) patients had intraoperative complications (breakage of arthroscopic instruments, loss of meniscus parts, extravasation of fluid in the limb), while 29 (74.35%) had postoperative complications (infection, synovial sinus, thrombophlebitis, hemarthrosis, synovial effusion, pain in the postoperative wound). In 8 (1.72%) patients, complications were observed after diagnostic arthroscopy, while in 31 (5.09%) patients, those were observed after therapeutic arthroscopy. The insufficient training and experience of surgeons, deviations from the established method during the intervention, rough manipulations and inaccurate joint access were considered the reasons for knee arthroscopy complications.

In 2003, surgeons from Poland published the results of a retrospective analysis of complications in 10,770 arthroscopies performed between 1986 and 2001 (Widuchowski J. et al., 2003). Adverse events were detected in 731 (6.98%) cases including anesthetic and cardiovascular (0.15%), intraoperative (0.31%), and postoperative (6.34%) complications.

Currently, most arthroscopy specialists indicate a low risk of complications of minimally invasive surgical interventions, however, the incidence and structure of the complications vary. Russian authors indicate a low and very low risk of critical complications (Saraev A.V. et al., 2020).

K. Friberger Pajalic et al. (2018) studied the risk of complications within 30 days after knee arthroscopy using data from 18,735 patients in southern Sweden between 2005 and 2016 (Friberger Pajalic K.et al., 2018). The absolute risk of one or more complications after knee arthroscopy was only 1.1%. The odds ratio of any complication after knee arthroscopy was 9.4 (95% confidence interval [CI] 8.1:10.9), with a relative risk of septic arthritis of 115 (CI 75:174), venous thromboembolic complications of 6.8 (CI 5.1:9.1), and other complications of 7.7 (CI 6.3:9.5). However, the authors noted that 5% of all cases of knee septic arthritis in adults were associated with knee arthroscopy. In Iceland, the incidence of infectious complications after knee arthroscopy in adults increased from 9 cases per 100,000 per year in 1990-2002 to 25 cases per 100,000 per year from 2003-2017 ($p < 0.01$) (Gunnlaugsdóttir S. L. et al., 2022).

In the United States, the incidence of infections requiring repeated knee arthroscopies was 0.15% from 2004 to 2009. Infectious complications were more common among male patients in both the adult and pediatric populations, and in those over 60 years of age, the incidence of infections decreased during this period (Yeranosian M.G. et al., 2013). The risk of infectious complications was higher in more complex interventions compared to diagnostic arthroscopy.

According to a retrospective analysis of 12,271 knee arthroscopies from the American College of Surgeons National Surgical Quality Improvement Program database performed from 2005 to 2010, the overall complication rate within 30 days of the procedure was 1.6% (Martin C. T. et al., 2013). Serious complications requiring repeated surgery were identified in 0.76% of cases, there was one fatal case (0.008%). Minor complications, dominated by deep vein thrombosis or thrombophlebitis, accounted for 0.86%.

In a more recent study of the same database from 2005 to 2016, the overall rate of adverse outcomes in 78,864 knee arthroscopies was 1.24% (Gowd A. K. et al., 2019). It was observed that longer surgical interventions resulted in severe complications (including death) more often.

In an analysis of 68,346 knee arthroscopies (of which 47,446 i.e., 69.5%, were partial meniscectomies), R.M. Degen et al. (2020) reported the overall complication rate of 2.0% (n = 1333), with major complications identified in 0.9% (n = 639) and minor complications identified in 1.0% (n = 701) of procedures. Common complications included a return to the operating room (0.5%), deep vein thrombosis/thrombophlebitis (0.4%), and superficial infection (0.2%). Operating time > 90 min, diabetes, steroid use, American Society of Anesthesiologists (ASA) class 2+, and dialysis-dependency were the predictors of overall complication rates.

In a study of 301,701 knee arthroscopies in England, the 30-day re-admission rate was 0.64% and wound complication rate was 0.26%. The overall 30-day re-operation rate was 0.40% and the 90-day pulmonary embolism (PE) rate was 0.08%, of which six patients died; 90-day mortality was 0.02% (Jameson S.S. et al., 2011).

According to M.A. Bohensky et al (2014), among 166,770 elective knee

arthroscopies, the complication rate was 0.6%, including venous thromboembolism (VTE) of 0.3%, joint complications of 0.1%, and infectious complications of 0.1%. The excess 30-day cost per patient for venous thromboembolism was estimated as $USD +3227, for joint complications as $USD +2247, and for infections as $USD +4364.

Some authors indicate that the risk of embolism varies from 0 to 10.9% after arthroscopic interventions without thromboprophylaxis, more than 2.5 cases for every 10,000 interventions on average (Hetsroni I. et al., 2011; Maletis G.B. et al., 2012; Krych A.J. et al., 2015).

K.F. Mauck et al. (2013) conducted a population-based cohort study in 4833 residents of Olmsted County, Minnesota (USA), who underwent knee arthroscopy between 1988 and 2005 and did not receive thromboemboly prophylaxis (Mauck K. F. et al., 2013). Of all patients, only 18 developed deep vein thrombosis or PE (all within the first 6 weeks after surgery). The cumulative incidence rates of symptomatic VTE at 7, 14, and 35 days were 0.2%, 0.3%, and 0.4%, respectively.

In a prospective cohort study in 335 patients by M.R. Hoppener et al. (2006), the incidence of VTE at day 14 after knee arthroscopy was 5.7% (n=19), with only 2 cases being symptomatic and one patient developing non-fatal PE during the 8-week follow-up.

In 2022, A.W. Reynolds et al. evaluated the incidence of thromboembolic complications for knee arthroscopy amid prophylaxis with aspirin or low molecular weight heparin. Among the 1,276 knee arthroscopies, there were 26 VTE events (2.0%), including 23 with deep vein thrombosis (DVT), two pulmonary emboli (PE), and one patient with both DVT and PE. The VTE diagnosis occurred at, on average, 9 days postoperatively. There were no deaths or complications requiring hospitalization or re-operation.

A. Ashraf et al (2014) analyzed the results of 1002 knee arthroscopies in a pediatric population (age of patients under 17 years). The overall complication rate was 14.7% including septic arthritis (n=3, 0.3%), wound complication requiring operative revision (n=9, 0.9%), arthrofibrosis (n=4, 0.4%), other unplanned subsequent surgery (n=4, 0.4%), and death (n=1, 0.1%). The incidence of minor complications was 12.6%, which included

persistent effusion/hemarthrosis requiring arthrocentesis (n=59, 5.9%) and superficial wound infection (n=18, 1.8%). Surgeries with an anesthesia time of 265 minutes or greater (p=0.026), operative time of 220 minutes or greater (p=0.013), or tourniquet time of 114 minutes or greater ($p < 0.001$) and surgeries with 3 or more Current Procedural Terminology codes (p=0.003) had a statistically significant increase in risk of major complications. The incidence of VTE in a pediatric patient cohort was 0.25% (Murphy R.F. et al., 2019).

Among over 300,000 patients of 65 years old who underwent arthroscopic meniscectomy, 0.4% developed septic arthritis, 0.8% developed deep vein thrombosis, and 0.3% developed PE (Hame S.L. et al., 2012).

In a comparative analysis of the incidence of arthroscopy and arthrotomy perioperative complications by Y.E. Kerbel et al. (2021), no significant differences were revealed. Major complications occurred in 3.8% of patients undergone arthroscopy and 5.4% of patients undergone arthrotomy (p=0.20), the incidence of minor complications was also comparable, 12.5% vs. 13.9%, respectively (p=0.48).

On the other hand, a systematic review and meta-analysis of 20 studies involving 10,249 patients with septic arthritis of the knee who underwent arthrotomy or arthroscopy showed that arthroscopy provided a lower risk of recurrent infections, as well as a shorter inpatient stay (Acosta-Olivo C. et al., 2021).

A rare complication of arthroscopy is the entry of gas or air into the subcutaneous adipose tissue. This can lead to the development of serious potentially life-threatening conditions caused by gas-forming microorganisms, gas gangrene or necrotizing fasciitis characterized by rapid spread of infection through the subcutaneous and deep tissues. These conditions require immediate aggressive antibiotic therapy and surgical intervention. In contrast, benign subcutaneous emphysema is mostly confined to superficial subcutaneous adipose tissue, has no systemic symptoms, rarely progresses, and usually does not require surgical treatment.

The literature describes isolated cases of such complications after knee arthroscopy. Thus, A. Runer et al. (2021) presented a clinical case of a 77-year-old patient who underwent arthroscopic knee surgery for meniscus tear. Ten days after the operation

a subcutaneous emphysema was diagnosed. The patient underwent emergency fasciotomy and was prescribed with antibiotic therapy. Inpatient treatment lasted a total of 27 days with subsequent rehabilitation on an outpatient basis. At 128 days post-fasciotomy examination, good postoperative wound healing and functional outcomes were observed.

A casuistic case of “acute abdomen” during knee joint surgery in a 67-year-old patient was described by J.M. Ana et al. (2020). The authors assumed the rupture of the joint capsule to be the cause of the complication, although the available techniques did not confirm that.

Iatrogenic damage to nearby nerve structures (saphenous and peroneal nerves) is possible in case of therapeutic or diagnostic arthroscopy technic is violated or rough manipulations applied (Hill J. R. et al., 2022). The incidence of lower extremity neuropathy within 3 months after knee arthroscopy is 0.02% (Yacub J. N. et al., 2009).

Nowadays, compartment syndrome described previously is a rare complication of knee arthroscopy (Peek R.D., Haynes D.W., 1984; Fruensgaard S., Holm A., 1988; Ekman E.F., Poehling G.G., 1996).

Noteworthy, the patients with comorbidities have an increased risk of complications (Basques B.A. et al., 2015; Kothandaraman V. et al., 2021; Traven S. A. et al., 2021).

Thus, there is currently a low incidence of knee arthroscopy complications. At the same time, some data on the procedure adverse outcomes differ significantly and contradict each other. In the absence of complications, the recovery period after arthroscopy ranges from 2 to 6 weeks, during which patients may suffer from pain, joint swelling and function limitation, which lead to the reduction in daily activity (Lubowitz J.H. et al., 2008; Pihl K. et al., 2016; Jumabekov S.A., Shambetov J.Z., 2022).

1.3. Knee Arthroscopy Indications

The first knee arthroscopies were performed mainly in patients with chronic inflammatory joint diseases, especially in the knee joint tuberculous lesions, as tuberculosis was prevalent worldwide in the first half of the XX century and often had unfavorable outcomes (Jackson R.W., 2010). S. Nordentoft, who pioneered the

arthroscopic examination of the knee, performed arthroscopy in patients with fractures, sepsis, and tuberculosis (Nordentoft S., 1912). K. Takagi in Japan used the endoscope to examine knee joints in patients with tuberculosis as well. He believed that early diagnosis of knee tuberculosis with arthroscopy would facilitate timely treatment and prevention of a common long-term complications of the disease, ankylosis.

H. Finkelstein and L.E. Mayer (1931) used the endoscope they designed to examine patients with unknown synovial disease, mainly suspected tuberculosis. Later they joined forces in the study the knee joint anatomy (Burman M. S.et al., 1934).

Besides tuberculosis, the first arthroscopies were performed for meniscus pathology diagnostics and meniscectomy (Bircher E., 1921). In 1925, P. Kreuscher published an article on the early diagnosis of semilunar cartilages pathology with arthroscopy, mainly in sports injuries (Kreuscher P., 1925). M.S. Burman (1931) studied the arthroscopy in patients with the knee joint cartilage degenerative changes.

Knee arthroscopy was performed in chondromalacia patellae (Casscells S.W., 1971). R.W. Jackson (1987) used arthroscopy to study intra-articular pathology in pseudopodagra (Jayson M. I., Dixon A. S., 1968).

Arthroscopy has been also actively used in patients with synovial diseases (Yates D. B., Scott J. T., 1975; Fletcher M. R., Scott J. T., 1975; Lindblad S., Hedfors E., 1985), as well as in patients with rheumatoid arthritis (Stulberg S. D., Keller C. S., 1981; Arnold W. J., Kalunian K., 1989). In addition, arthroscopies were helpful when non-invasive diagnostic methods appeared inadequate for an accurate diagnosis (Ike R.W., 1993; Khaidarov V.M. et al., 2021).

Thus, arthroscopy was used initially as a diagnostic procedure and a research method to study the normal and pathological joint anatomy. However, gradually arthroscopy became a therapeutic method as well.

In 1955, M. Watanabe performed the first reported arthroscopically guided resection surgery, namely, a solitary giant cell tumor removal from the knee joint. The next were a loose body removal in 1961, and partial meniscectomy in 1962. Watanabe noted that many patients with osteoarthritis (AO) of the knee felt better after the arthroscopy was performed, even though it was considered a diagnostic procedure only.

He concluded that the arthroscopy possibly possesses both a high diagnostic value and a therapeutic effect. Watanabe developed the articular pumping technique to flush the joint (Watanabe M., 1949).

To date, indications for knee arthroscopy include meniscus damage; cruciate ligament damage; synovial membrane damage and disease; articular cartilage damage and disease; fat pad damage and disease; deforming arthrosis; rheumatoid arthritis; habitual patellar dislocation; loose bodies; intra-articular fractures (Korolev A.V. et al, 2008; Zubi Y.H. et al., 2015; Baburkina E.P., 2016; Tung K.-K. et al., 2021).

In all the above cases, arthroscopy allows determination of the pathological process localization and nature, as well as the optimal surgical tactics.

Arthroscopic synovectomy of the knee joint in patients with rheumatoid arthritis is performed in case of severe clinical manifestations of synovitis and inefficacy of conservative therapy (Ike R.W. et al., 2021). According to G.M. Kavalersky et al. (2009), omission of arthroscopic synovectomy in rheumatoid arthritis patients with indications for such and continuation of conservative therapy result in unsatisfactory treatment outcomes.

One of the most common diseases in orthopedic practice is OA of the knee. Treatment options for the disease include conservative methods, arthroscopic debridement, and partial or total joint replacement. Arthroscopic treatment of knee pathology is now routinely performed in clinical practice. However, the role of arthroscopy in the treatment of knee OA remains the matter of discussion in the medical scientific community (Yudin V.E. et al., 2022).

In 2002, J.B. Moseley et al. presented the results of a placebo-controlled study in 180 patients with OA of the knee who were randomly assigned to receive arthroscopic debridement, arthroscopic lavage, or placebo surgery. At 24-month follow-up, the outcomes after arthroscopic lavage or arthroscopic debridement were no better than those after a placebo procedure. This study questioned the positive effect of arthroscopy in the treatment of OA.

In 2012, A. Potts et al. analyzed the arthroscopic interventions performed in the United States and concluded that the publication of Moseley et al. (2002) contributed to

the decrease in the number of arthroscopies performed. According to the American Board of Orthopaedic Surgery (ABOS) database, the number of knee arthroscopies in patients with OA had decreased significantly by 2009, comprised 966 cases (1.40 case per surgeon), compared to 1621 cases (2.36 cases per surgeon) in 2001. The proportion of knee arthroscopy in the total number of orthopedic procedures decreased from 9.9% in 2003 to 8.6% in 2009 ($p < 0.0001$).

According to a multicenter retrospective study conducted in the United Kingdom, the number of annual arthroscopies decreased from 2028 to 1099 cases between 2013 and 2017 (Khatri C. et al., 2021).

According to E.K. Wai et al. (2002), unnecessarily frequent arthroscopies in patients with OA over 50 years of age increase the need for early total knee arthroplasty. For instance, 9.2% of patients required total knee arthroplasty within one year after the debridement, and 18.4% of patients had undergone total knee replacement within three years following the debridement. Moreover, patients aged 70 years and older were 4.7 times more likely to have total knee arthroplasty within one year after the debridement than were those less than 60 years of age (19.0% vs. 4.0%, $p < 0.05$). These results demonstrated the need for careful selection of patients with AO for arthroscopic treatment, considering their age.

Several randomized controlled trials had evidenced that arthroscopic surgery lacks efficacy in OA treatment (Chang R.W. et al., 1993; Bradley J.D. et al., 2002; Herrlin S. et al., 2007; Kirkley A. et al., 2008; Risberg M.A., 2009). Based on those, the American Academy of Orthopaedic Surgeons (AAOS) had not recommended the use of arthroscopic debridement or lavage in patients with a primary diagnosis of symptomatic knee OA (Richmond J. et al., 2009).

A systematic review of 13 randomized clinical trials and 12 observational studies comparing the outcomes of arthroscopic surgery with those of conservative OA treatment found no benefit of the first one (Brignardello-Petersen R. et al., 2017).

At the same time, other studies had shown a sustained positive effect of arthroscopic intervention.

For instance, in a cohort observational study by J. Fond et al. (2002), 32 of 36

patients with OA (88.9%) were satisfied with the functional outcomes of the knee arthroscopy 2 years after the procedure. Mean Hospital for Special Surgery (HSS) scale scores improved from 29.2 to 48.0. After 5 years, 25 of 36 patients (69.4%) rated the results of arthroscopy as good to excellent, with a mean scale score of 43.2. The authors noted that positive arthroscopy results were observed in patients with flexion contractures less than 10° and HSS scale score more than 22 points preoperatively.

Based on the results of a cross-sectional study in 122 patients who underwent arthroscopic debridement for knee OA due to conservative anti-inflammatory therapy ineffectiveness, R.K. Aaron et al. (2006) concluded that the clinical outcome of arthroscopy is influenced by the severity of arthritis. Thus, 52 (92%) of 58 patients with mild OA showed a positive effect of arthroscopic treatment. With this, only 5 (25%) out of 20 patients with severe OA showed clinical improvement. The authors concluded that the findings also have important implications for determining the indications for arthroscopy in patients with knee OA.

According to the meta-analysis of 30 scientific publications, arthroscopic treatment of knee OA provides excellent or good results in about 60% of patients within 5 years after the procedure (Spahn G. et al., 2013). At the same time, the outcome of surgery is influenced by numerous factors, including OA radiologic stage, patient characteristics (disease duration, overweight, smoking), as well as the knee joint local characteristics, such as axial displacement, presence/absence of effusion and massive crepitation.

A survey of 170 surgeons of the European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA) with at least 10 years of experience also showed that arthroscopy for OA is more effective under certain conditions: mild disease severity, lower limb neutral axis, less than 6 months symptoms duration, and less than 60 years age (Mayr H.O. et al., 2013). At the same time, arthroscopic debridement in knee OA had a positive effect - the result of the intervention was mostly evaluated as satisfactory. However, the majority of surgeons interviewed did not see indications for arthroscopic joint flushing, arthrofibrosis treatment and osteophytes removal in OA. In addition, the arthroscopy outcome was considered unfavorable in case of knee edema confirmed by magnetic resonance imaging. The authors stated the main task when planning

arthroscopic intervention to be proper patients selection for the procedure.

The comparison of the efficacy of physiotherapeutic and arthroscopic treatment of knee OA in patients with mild to moderate OA and meniscus tears showed no significant differences in functional outcomes of the treatments; however, 30% of patients who received physiotherapeutic treatment alone underwent surgery within the next 6 months (Katz J.N. et al., 2013).

Since joint replacement is highly costly and often requires revisions, especially in young active patients, close attention is paid to organ-preserving interventions for the treatment of OA (Vorokov A.A. et al., 2020; Saraev A.V. et al., 2020; Riddle D.L. et al., 2014; Ismael A. et al., 2022). This stimulates the search for techniques that will preserve the joint anatomo-functional integrity and will be less costly at the same time. In this regard, arthroscopy allows preserving the integrity of joint surrounding tissues and can be performed even in outpatient conditions, thus it is considered as a worthy alternative to joint arthroplasty for OA (Shumkov P.S., 2013). The study by J.R.B. Hutt et al. (2015) demonstrated not only good clinical and functional outcomes, as well as improved quality of life in patients with OA after arthroscopy, but also the cost-effectiveness of the method per the quality adjusted life year (QALY) gain (Ismael A. et al., 2022).

A randomized controlled trial conducted in Norway enrolled 140 middle-aged patients with degenerative medial meniscus tears, with 96% of them having no definite radiographic evidence of OA (Kise N.J. et al., 2016). Patients were divided into 2 groups: 12 weeks of exercise therapy alone or arthroscopic partial meniscectomy alone. No clinically relevant difference was found between the two groups in change in the Knee injury and Osteoarthritis Outcome Score (KOOS) at two years. During the two-year follow-up, 19% of the participants allocated to exercise therapy crossed over to surgery. This study emphasizes that in the absence of definite radiographic evidence of OA arthroscopic intervention should be avoided.

Russian authors (Ishtukov R.R. et al., 2018) presented the results of a retrospective analysis of knee OA arthroscopic treatment in 48 patients (mean age of 57 years). Positive dynamics was observed 2 weeks after the treatment: the patients reported a 2-fold decrease in pain when walking compared to baseline and a decrease in edema.

The diagnostic value of arthroscopy in detecting knee OA reaches 90-100% (Matveev R.P., Bragina S.V., 2014), and diagnostic arthroscopy is recommended for patients with OA to identify the disease severity and to determine further treatment tactics.

According to T.R. Liebs and S. Berger (2017), the tendency to refuse from arthroscopy for the treatment of patients with OA leads to an increase in the frequency of knee arthroplasty, since a significant proportion of patients fail to achieve an effect of conservative treatment (Liebs T.R., Berger S., 2017).

At the same time, there is an unjustified expansion of indications for knee arthroplasty, followed by an increase in the number of unsatisfactory surgeries and revision arthroplasties. According to A.A. Vorokov et al. (2020), the wrong choice of surgery type is one of the reasons for the inadequate arthroplasty (Mansurov D.S. et al., 2022; Mazurov V.I. et al., 2021; Balgley A.G. et al., 2023).

To date, there are no clear, standardized indications for knee arthroplasty. In each specific case, when planning an arthroplasty in OA, many factors should be taken to account: the disease stage, pain severity, joint dysfunction degree, comorbidities, the surgeon's experience, his preferred technique, etc. Although, many of these factors are subjective and often inconsistent (Maillefert J.F. et al., 2008; Hawker G. et al., 2015; Hofstede S.N. et al., 2016; Huynh C. et al., 2018, Moorhouse A., Giddins G., 2018). Total knee replacement can be considered as the operation of choice in end-stage OA, but still must have strict indications and cannot be used in all groups of patients (Matveev R.P., Bragina S.V., 2014). In recent years, there are reports on unjustified knee arthroplasties and insufficiently wide application of conservative treatment methods and arthroscopy.

Russian authors demonstrated that 39.3% of arthroplasties was not justified in 178 patients with gonarthrosis over 60 years of age (Lychagin A. V. et al., 2019). The authors suggested arthroscopic debridement combined with intra-articular drug administration as an alternative to knee arthroplasty.

According to a study conducted in the United States, about 1/3 of knee arthroplasties are inappropriate and performed unnecessarily (Riddle D.L. et al., 2014).

Unjustified knee and hip arthroplasties are observed in 7-34% of cases (Ghomrawi

H.M. et al., 2014; Franklin P. et al., 2015).

Therefore, the indications for arthroscopic intervention should be expanded. The study by A.M. Zaremuk et al. (2017) demonstrated that in end-stage degenerative OA, the use of debridement arthroscopy combined with a rehabilitation program leads to pain reduction, joint function partial recovery, gonarthrosis decreased progression, and allows delaying knee arthroplasty or performing surgery more beneficially for the patient when joint replacement is inevitable.

According to N.P. Kozel and V.A. Malchevsky (2009), knee arthroscopy is indicated for patients with post-traumatic gonarthrosis of I-II stages. There is often a discrepancy in these patients between clinical data, ultrasound local morphologic changes, and immunologic tests, which complicates the diagnosis and the choice of treatment tactics (Tkachenko et al., 2023).

At the current advancement of surgery, there is a shift from large open access operations to minimally invasive interventions providing less tissue traumatization, reduced inpatient period and postoperative rehabilitation period (Jenny J.Y., 2018; Urits I. et al., 2019). As a result, the patient can return to work, sports, and daily life in the shortest possible time. Arthroscopy is the very endoscopic method that allows minimally invasive access to intra-articular structures for diagnostic and therapeutic purposes. Nowadays, arthroscopy is considered as a standard procedure and has firmly entered the practice of traumatologists and orthopedists (Tkachenko et al., 2022).

To achieve a positive treatment result, it is necessary not only to have a well-developed surgical technique, but also to establish correct indications for these interventions. Arthroscopy is currently not widely used for the treatment of knee OA, as knee arthroplasty is preferred (Mansurov D.S. et al., 2023). Probably, an optimal strategy for the treatment of knee OA is the active introduction of minimally invasive surgeries, especially at the end-stage of the disease. Maximum possible delay of arthroplasty can reduce the risk of negative postoperative consequences resulting in a decrease in early disability. Thus, a study of the use of arthroscopic techniques in the complex treatment of patients with end-stage knee OA is deemed relevant.

CHAPTER 2. CLINICAL OBSERVATIONS AND METHODS OF RESEARCH

2.1. Clinical Observations

To elucidate the study objectives, the data on several patient groups were analyzed. A total of 211 patients aged 18 to 72 years (mean±SD 45.4±5.5 years) underwent therapeutic and diagnostic knee arthroscopy due to stage 3 OA at the Clinic of Traumatology and Orthopedics of I.I. Mechnikov North-Western State Medical University (NWSMU), hereinafter referred to as the Clinic, from 2019 to 2021 (inclusive). Valgus or varus deformities of mild or moderate severity were identified. In case of severe valgus or varus deformity (more than 15°), the arthroscopy was not performed. Posttraumatic knee OA was diagnosed in 144 (68.2%) patients; idiopathic osteoarthritis was diagnosed in 67 (31.8%) patients. No fatal outcomes were observed in the early postoperative period. All 211 patients with the knee arthroscopy were included in the study.

The patients were divided into three groups according to the age (Table 2.1).

Table 2.1 - Distribution of patients who underwent arthroscopic interventions for knee OA by age and gender

Age group, years	Number of patients (%)					
	Males		Females		Total	
	abs.	%	abs.	%	abs.	%
18–44	49	49.5	35	31.3	84	39.8
45–64	36	36.4	54	48.2	90	42.7
≥65	14	14.1	23	20.5	37	17.5
Total	99	46.9	112	53.1	211	100

Most patients (82.4%, n=174) presented in Table 2.1 were of the the working-age population. The long-term results of the OA treatment were evaluated in 3 to 5 years.

A total of 219 patients aged 44 to 79 years (mean±SD 59.3±7.3 years) underwent conservative treatment for the knee OA at the Clinic at the same time, from 2019 to 2021. These patients had no history of arthroscopy. The patients' age groups are shown in Table 2.2.

Table 2.2 - Distribution of patients who underwent inpatient conservative treatment for knee OA by age and gender

Age group, years	Number of patients (%)					
	Males		Females		Total	
	abs.	%	abs.	%	abs.	%
18–44	3	3.8	5	3.5	8	3.7
45–64	31	39.7	83	58.9	114	52.0
≥65	44	56.5	53	37.6	97	44.3
Total	78	35.6	141	64.4	219	100

As shown in Table 2.2, there were more patients of working age (55.7%, n=122) than those of non-working age (44.3%). However, these differences were not significant when compared to the group of patients who underwent knee arthroplasty ($p > 0.05$).

A total of 677 total knee replacements were performed due to idiopathic OA at the Peter the Great Hospital of NWSMU from 2019 to 2021. The mean±SD age of the patients was 69.3±7.3 years (from 40 to 88 years). The patients distribution by age and gender are shown in Table 2.3.

Table 2.3 - Distribution of patients who underwent primary total knee replacement for OA by age and gender

Age group, years	Number of patients (%)					
	Males		Females		Total	
	abs.	%	abs.	%	abs.	%
18–44	5	2.1	9	2.1	14	2.1
45–64	68	28.1	193	44.3	261	38.6
≥65	169	69.8	233	53.6	402	59.3
Total	242	35.7	435	64.3	677	100

As shown in Table 2.3, the half of the patients (52.9%, n=358) were of non-working age. Idiopathic OA was diagnosed in 512 (75.6%) patients; post-traumatic OA was diagnosed in 165 (24.4%) patients. The duration of knee trauma ranged from 1 to 45 years (mean±SD 15.4±6.5 years).

In general, three study groups (knee arthroscopy, conservative treatment, and

arthroplasty) were comparable in age.

The clinical observations groups analyzed in the study according to its objectives are presented in Table 2.4.

Table 2.4 - Clinical observation groups in the study

#	Clinical observation group	Study objective	Number of observations
1	The patients who underwent knee arthroscopic interventions at the Clinic of Traumatology and Orthopedics of I.I. Mechnikov North-Western State Medical University from 2019 to 2021 (retrospective)	Analyses of functional outcomes and patients' quality of life	211
2	The patients who underwent inpatient conservative treatment for the knee OA at the Clinic from 2019 to 2021 (retrospective)	Analyses of long-term functional outcomes and quality of life	219
3	The patients who underwent primary total knee replacement at the Clinic from 2019 to 2021 (retrospective)	Analyses of long-term functional outcomes and quality of life	677
4	The patients who underwent total knee replacement at the Clinic (prospective)	Morphological examination of the removed medial femoral condyle	30 of 187 total

The study design is presented in Figure 2.1. This was a retrospective-prospective single-center non-blinded open-label non-randomized clinical study. Inclusion criteria were age over 18 years; diagnosis of idiopathic or post-traumatic knee OA of stage 3; time and place of treatment. Exclusion criteria were patient death while inpatient and revision knee arthroplasty.

Study Design

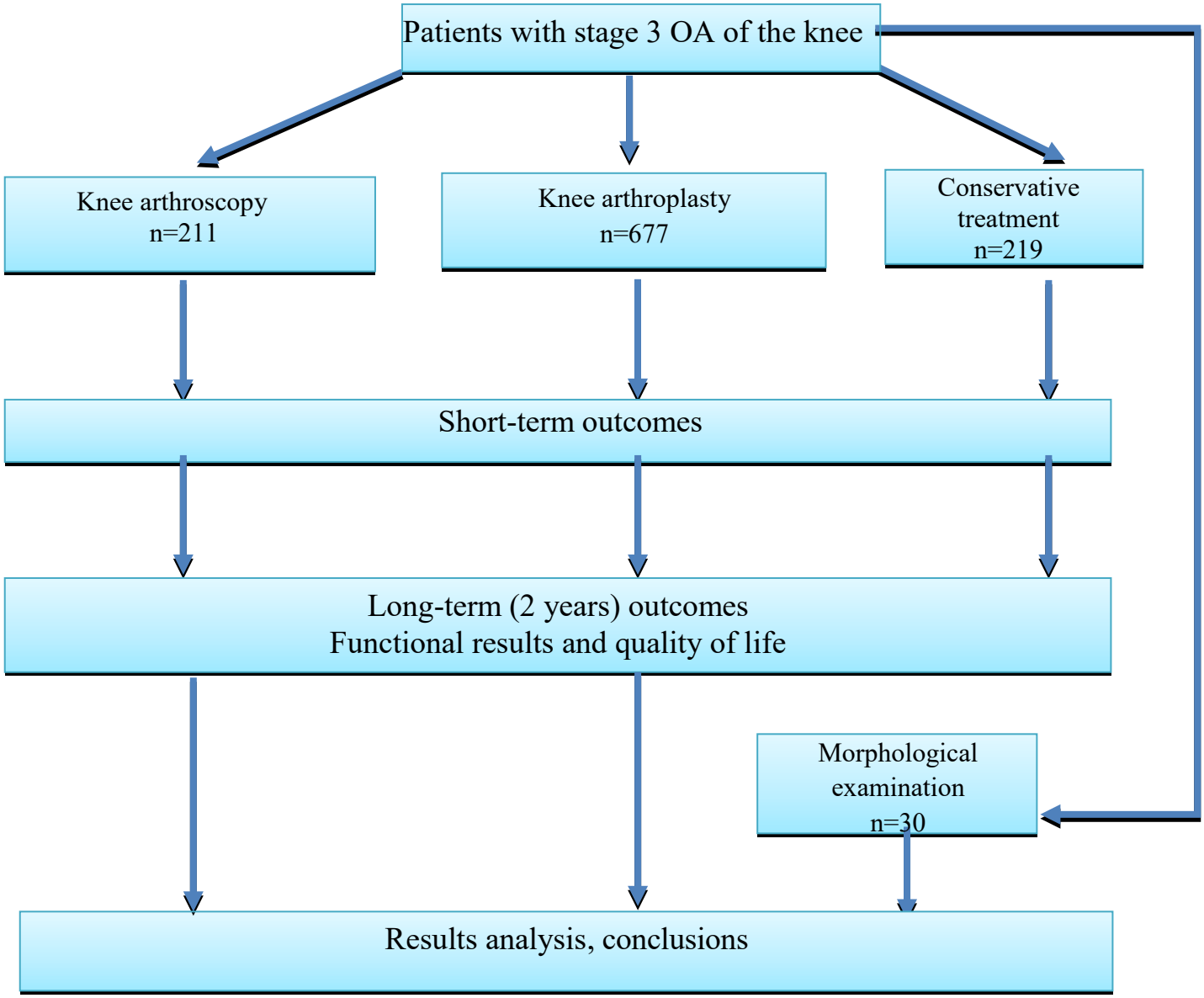


Figure 2.1 Study design: The role of arthroscopy in the treatment of knee OA

From 01.01.2022 to 15.12.2022, total knee replacement was performed in 187 patients with knee OA at the Clinic. Materials for intravital patho-morphological examination were taken randomly from 30 patients aged from 40 to 76 years (19 females and 11 males). All the patients had a valgus/varus deviation of 20° or less (femorotibial angle), which corresponded to grade I-II (Ranawat A.S. et al., 2005; Chang C.B. et al., 2011).

The study presents the data on several groups of patients analyzed with the required number of observations (Table 2.4). Thus, the data are considered sufficient to provide a representative sample and reliable results.

2.2. Study Methods

All patients hospitalized for different treatments of knee OA to the Clinic from 2019 to 2021 underwent a standard clinical examination.

Heart rate was measured. Tachycardia was diagnosed in case of the heart rate of more than 90 beats per min, bradycardia was diagnosed in case of that of 60 or less beats per min (Murashko V.V., Strutynsky A.V., 1991).

Arterial hypertension was diagnosed in case of repeatedly elevated diastolic blood pressure (BP) of above 90-95 mmHg or systolic BP of above 140-160 mmHg. Arterial hypotension was diagnosed in case of the BP of less than 105/65 mmHg, (Morgan-Ml J.E., Michael M.S., 2000).

Body mass index (BMI), kg/m2, was calculated using the formula:

$$I = \frac{m}{h^2}$$

where, m is body mass in kg; h is height in m. Normal BMI is from 18.5 to 25 kg/m^2. BMI values between 25 and 29.9 kg/m^2 were considered as overweight, while those of 30 kg/m^2 and more obesity were considered as obesity. BMI values between 16.5 and 18.49 kg/m^2 were considered as underweight, while those of less than 16 kg/m^2 were considered as severely underweight (Report of the WHO, 1997).

Laboratory Investigations

Biological fluids of the treated patients were tested in the clinical laboratory department (Table 2.5).

Table 2.5 - Laboratory investigations in patients planned for knee arthroscopy

Material	Test	Test method
Blood	Hematology	DxH 800 Hematology Analyzer (USA)
	Coagulation (clotting time, fibrinogen level in combination with fibrinolytic activity, pro-thrombin activity, plasma recalcitrance time)	STACompact Coagulation Analyzer (France)
	Blood chemistry (glucose, urea, total protein, bilirubin, ALT, AST, amylase, alkaline phosphatase, creatinine, electrotrolites: K+, Na+)	ROCHE COBASINTEGRA 400+ Analyzer (Austria, Switzerland); KONELAB 20 Analyzer (Finland)
	Blood loss	Gravimetry determining the amount of blood in the intraoperative surgical aspirator (Lebedeva M.N. et al., 2015)
Urine	Urine microscopy, urine chemistry	IRIS IQ 200 Elite Urine Microscopy Analyzer (Japan); Aution Max 4030 Urine Chemistry Analyzer (Japan)

Instrumental Investigations

All patients with knee OA underwent radiological examination prior to knee arthroscopy. When indicated, esophagogastroduodenoscopy (EGD), Doppler ultrasonography, knee ultrasound, abdomen ultrasound, computed tomography (CT) or magnetic resonance imaging (MRI) were performed (Table 2.6).

Table 2.6 – Instrumental investigations in patients planned for knee arthroscopy

Object	Investigation	Investigation method
Bones and joints, chest	Radiography	AXIOM Luminos dRF radiography system (Siemens, Germany); Shimadzu radiography system (Shimadzu corporation, Japan)
Heart	12 lead ECG at rest; functional tests, if necessary	Nihon Konden ECG 1350K 6-channel electrocardiograph (NIHON KOHDEN Corporation, Japan)
Abdominal organs, joints, lower limb vessels, neoplasms, soft tissues, surgical area	Ultrasound	Ysio Max ultrasound (Siemens, Germany)
Vessels	Lower limb venous duplex ultrasound	Vivid E95 (General Electric, Israel)
Hollow Organs	EGD, fibrocolonoscopy, fibrobronchoscopy	Olympus GIF-Q165 gastroscope, Olympus PCF-H290ZL/I diagnostic colonoscope EVIS LUCERA ELITE, Olympus BF-TE2 bronchoscope 2.8 mm with working channel (all Olympus Corporation, Japan)
Bones, joints, soft tissues	CT, MRI	SOMATOM Force CT scanner, MAGNETOM Symphony TIM 1.5T MRI scanner (all Siemens, Germany)
Knee	Arthroscopy	Stryker Endoscopy Arthroscope (Stryker, USA)

Radiological examination allowed assessing the OA stage, the joint gap changes, and revealing osteophytes, subchondral osteosclerosis, subchondral cysts, marginal bone defect, or intra-articular calcified chondromas. The clinical and radiological classification by N.S. Kosinskaya (1961) was used to determine the stage of knee OA.

In the group of patients who underwent knee arthroplasty, the implant-bone ratio, the implant placement correctness, the implant stability, bone resorption degree, and possible debris syndrome were assessed with radiological examination in the postoperative period. In case of periprosthetic infection the bones and soft tissues were

examined, and a fistulography was performed if indicated.

To clarify the nature and severity of comorbidity, additional examinations could be performed.

Diagnostic and Debridement Knee Arthroscopy

Knee arthroscopy was performed in the supine position. The surgical site was treated three times from the inguinal crease to the tips of the toes. To prevent the limb from slipping, it was fixed with a support block. The tibia was hanging down in a free position to provide the maximum opening of the joint gap (Irzhansky A.A. et al., 2018).

The knee was flexed at about 90°, the accesses were marked, after which two longitudinal skin incisions no longer than 5 mm were made. First, the fibrous capsule and synovial membrane were perforated with a trocar with a sharp obturator. Next, the trocar was inserted into the knee superior recess with the tibia extended. The obturator was replaced with an arthroscope, and a 0.9% NaCl pump was connected. Often synovial fluid was copiously released into the joint cavity during access, and the joint was flushed with the fluid.

The joint examination was always started from the superior recess, followed by the other structures of the knee. The synovial membrane and articular cartilage changes, scars and adhesions, loose bodies if any, and marginal bone and cartilage overgrowths were visualized. The meniscus was thoroughly examined as well including its shape, color, gloss, tissue density, surface structure, horns and bodies vascular changes, fat pad inflammatory or scarring changes if any.

Rational debridement included the resection of unstable articular cartilage flaps, medial and lateral menisci damaged areas, and intermuscular notch bone and cartilage overgrowths, as well as the removal of loose bodies. In case of meniscus injuries, only unstable fragments that were excessively displaced into the joint were removed using specific arthroscopic instruments. Since sharp meniscus edges made by partial meniscectomy may be subject to tears later on, the contour of the edge was made smooth, without sharp areas. In case of anterior cruciate ligament partial damage, ablation of its atonic damaged fibers was performed.

Multiple tunneling (microfracturing) of the subchondral bone with an awl, spoke

or 2 mm drill was performed in patients with condyle cartilage defects. After these surgical manipulations, abundant lavage of the joint cavity with saline solution was performed. The course of surgery was photographed for further entering the database (Baranovsky A.A. et al., 2023).

Postoperative Complications Assessment

Postoperative complications could develop both in the early postoperative period and in the distant period after the knee arthroscopy or arthroplasty. To diagnose those, various procedures were performed including patient physical examination, blood and urine laboratory tests, wound discharge bacteriological examination with antibiotic sensitivity test.

The instrumental methods included: ECG-study, radiography; tomographic studies (ultrasound of soft tissues of the area of surgical intervention, CT, MRI), puncture examination (in case of suspected surgical site infection, SSI), and others. The bacteriological examination of surgical site tissues or fluids was performed (Mansurov D.Sh. et al., 2022).

Knee OA Treatment Results Assessment

Goniometry

Goniometry, a method of measuring the range of motion, allows independent examination of joint abduction, adduction, flexion, extension, and rotation. In 1538, the Dutch physician Regnier Gemma Frisius first developed the goniometer, an instrument derived from the astrolabe, a device used to determine heights or hollows (cited in Cantor M., 1878).

Range of motion is measured with goniometers with two arms, one of which has a graduated scale (in degrees). The arms are placed along the longitudinal axis of the joint.

The fulcrum of the goniometer is set above the joint gap projection.

Normal goniometry parameters of the knee are extension of 180° and flexion of 50°. Joint function disorder as per goniometry includes stage I, i.e. preserved range of motion of at least 50° of the functional position; stage II, i.e. preserved range of motion

of 45-20°; stage III, i.e. the range of motion of 15° or less or ankylosis in the functional position. The functional position of the knee is extension with a small range of preserved motion.

Pain Assessment

Pain levels were assessed using an adapted Visual Analogue Scale (VAS), which uses both visual and verbal scoring from 0 to 10 points, where 0 is no pain at all and 10 is the worst possible pain (Fig. 2.2).

Visual Analogue Pain Rating Scale

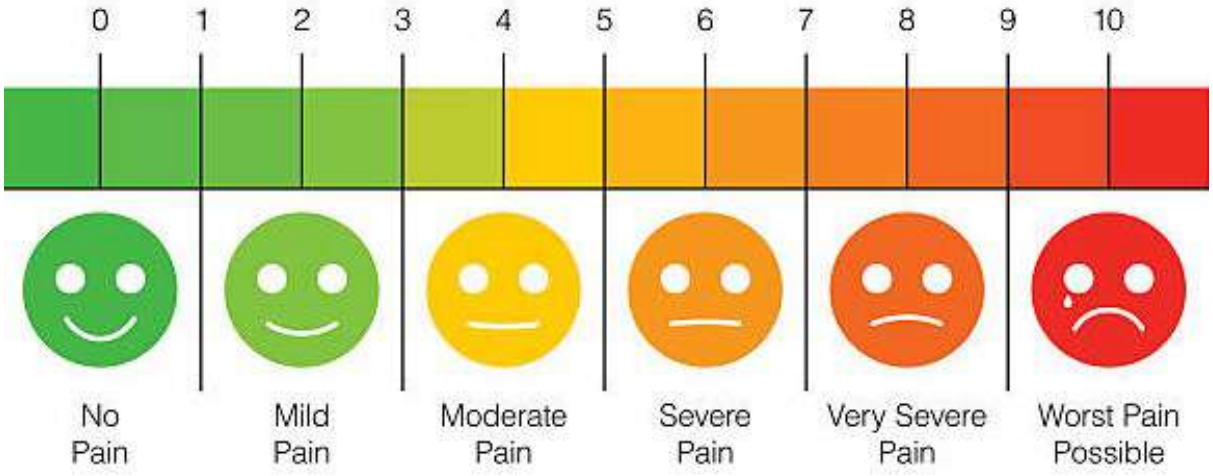


Figure 2.2 - Adapted Visual Analogue Pain Rating Scale

Functional Outcomes Assessment

Clinical assessment of the results of conservative and surgical (arthroscopy or arthroplasty) treatments of knee OA including pain, stiffness, function, and health status was performed using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) (Bellamy N. et al., 1988). The WOMAC is a self-administered questionnaire consisting of 24 items divided into the 3 following subscales. Pain (5 items): during walking, using stairs, in bed, sitting or lying, and standing upright. Stiffness (2 items): after first waking and later in the day. Physical Function (17 items): using stairs, rising from sitting, standing, bending, walking, getting in/out of a car, shopping, putting on/taking off socks, rising from bed, lying in bed, getting in/out of bath, sitting, getting

on/off toilet, heavy domestic duties, light domestic duties (Irzhansky AA et al., 2018).

The patient chooses answers from the provided list based on their condition during the previous 2 days on a five-point scale: None (0), Mild (1), Moderate (2), Severe (3), and Extreme (4). The scores for each subscale are summed up, with a possible score range of 0-20 for Pain, 0-8 for Stiffness, and 0-68 for Physical Function. The maximum possible total score of 96 indicates the worst pain, stiffness and functional limitation of knee joint function.

Higher scores on the WOMAC indicate worse pain, stiffness, and functional limitations. A score of about 96 indicates the worst pain, stiffness and functional limitation of knee joint function. Interpretation of the questionnaire results:

Outcomes: 0-14 = Excellent

15-28 = Good

29-38 = Satisfactory

more than 38 points = Unsatisfactory

The minimum possible total score of 0 indicates the absence of pain, stiffness and functional limitations of the knee joint (Irzhansky A.A. et al., 2018; Giesinger J.M. et al., 2015).

Quality of Life Assessment

Limitation of functioning was assessed according to the International Classification of Functioning, Disability and Health 2001 (World Health Organization, 2001) using a scoring system with subsequent coding (Table 2.7).

Table 2.7 – Limitation values (%) depending on their characteristics

Score	Limitation qualifier	Limitation value (%)
0	No	0-4
1	Mild	5-24
2	Moderate	25-49
3	Severe	50-95
4	Complete	96-100

To assess the quality of life in patients undergone primary total knee replacement, the categories of functioning was listed (Table 2.8).

Table 2.8 - Possible limitations of functioning in elderly patients undergone arthroscopy or arthroplasty of the knee

Functioning category	Limitation code
Sensation of pain	b280.0.1
Mobility of joint functions	b710.0.1
Stability of joint functions	b715.0.1
Mobility of bone functions	b720.0.1
Structure of pelvic region	s 740.0.1
Structure of lower extremity	s 750.0.1
Undertaking a single task	d 210.0.1
Undertaking multiple tasks	d 220.0.1.2.3
Carrying out daily routine	d 230.0.1
Changing basic body position	d 410.0.1
Maintaining a body position	d 415.0.1
Transferring oneself	d 420.0.1
Lifting and carrying objects	d 430.0.1
Moving objects with lower extremities	d 435.0.1
Walking	d 450.0.1.2
Moving around using equipment	d 465.0.1.2
Caring for body parts	d 520.0.1
Toileting	d 530.0.1.2
Dressing	d 540.0.1.2
Doing housework	d 640.0.1.2

The limitation of each function was scored as 1 (if it corresponded to the selected range), and the scores were summed up. Quality of life was considered as Excellent with the total score of 16-20, Good with the total score of 11-15, and Satisfactory with the total score of 6-10. The score of 0-5 corresponded to Unsatisfactory quality of life.

Morphological Examination

After the operation, the fragments of femoral condyle were fixed in 10% buffered formalin solution for 24 hours. Then, bone material was cut out using a set of saws for subsequent histological examination.

Histological samples were prepared according to the standard technique for bone preparation including decalcification (Sarkisov D.S., Perov Y.L., 1996). Bone fragments were decalcified in the electrolyte decalcifying solution (Biovitrum, Russia) at the ratio

of the object volume to the decalcifying liquid volume 1:50 for 8 hours, the degree of decalcification was controlled with a needle. Upon the decalcification completion, the specimens were washed out with tap water for 60 min. Histological processing, embedding, and microtomy at a slice thickness of 5 μm were performed according to standard techniques. The sections were stained with haematoxylin and eosin, and safranin O.

The changes in cartilage, subchondral bone, and intertrabecular tissue were assessed by microcopy.

The Osteoarthritis Research Society International (OARSI) Cartilage Histopathology Assessment System (OOCHAS) was used to assess the damage of the articular surface and subchondral bone (Table 2.9) (Custers R.J. et al., 2007; Tkachenko A.N. et al., 2023).

Table 2.9 – OOCHAS grading methodology

Grade	Subgrade	Associated criteria
Grade 0: surface intact, cartilage intact	-	Intact, uninvolved cartilage
Grade 1: surface intact	1.0 Cells intact	Matrix: superficial zone intact, edema and/or fibrillation
	1.5 Cell death	Cells: proliferation (clusters), hypertrophy
Grade 2: surface discontinuity	2.0 Fibrillation through superficial zone	As above
	2.5 Surface abrasion with matrix loss within superficial zone	+ Discontinuity at superficial zone
		± Cationic stain matrix depletion (Safranin O or Toluidine Blue) upper 1/3rd of cartilage (mid zone)
		± Disorientation of chondral columns
Grade 3: vertical fissures	3.0 Simple fissures	As above
	3.5 Branched/complex fissures	± Cationic stain depletion (Safranin O or Toluidine Blue) into lower 2/3rd of cartilage (deep zone)
		± New collagen formation (polarized light microscopy, Picro Sirius Red stain)

Grade 4: erosion	4.0 Superficial zone delamination	Cartilage matrix loss, cyst formation within cartilage matrix
	4.5 Mid zone excavation	
Grade 5: denudation	5.0 Bone surface intact	Surface is sclerotic bone or reparative tissue including fibrocartilage
	5.5 Reparative tissue surface present	
Grade 6: deformation	6.0 Joint margin osteophytes	Bone remodeling. Deformation of articular surface contour (more than osteophyte formation only)
	6.5 Joint margin and central osteophytes	Includes: microfracture and repair

Statistical Methodology

First, a statistical analysis plan was created. Next, data for further analysis were collected. At this stage, a model examination chart was developed for a patient with knee OA admitted for conservative or surgical treatment (knee arthroscopy or primary total knee arthroplasty) (Appendix 1). The chart is a record and statistical document and included both short- and long-term results. Then, the data were grouped and analyzed. For that, a database was created and processed statistically using the methods of variation statistics.

The results were analyzed using conventional statistical processing carried out in the STATISTICA 10 program (GraphPad Prism 5). The data were presented and analyzed using arithmetic mean (X), standard deviation (δ), standard error (m), true mean 95% confidence interval (I_x) (p=0.05). To test the differences between values Student's t-test and confidence coefficient (p) were used within the Neiros©2024 program. The mean difference was considered significant at $p < 0.05$.

Text editing and graphic design were performed using Microsoft® Word 2010 and Microsoft® Office Excel 2010 in the WINDOWS XPpro system (Microsoft®, USA). To examine the data on patients with knee OA undergone conservative or surgical treatment, the primary medical records (outpatient records, medical histories, survey forms, and questionnaires) were used. All data were entered into the database. An intermediate formalized chart was created to form a comprehensive database. The chart included 85

items from both retrospective and prospective phases of the study.

By methods used the study be considered an active dynamic retrospective-prospective single-Centre unblinded open-label non-randomized clinical study for the evaluation of therapeutic and diagnostic effects in randomly assigned groups of subjects using modern approaches of medical variation statistics.

CHAPTER 3. TREATMENT OF PATIENTS WITH KNEE OSTEO-ARTHRITIS: MAIN RESULTS

3.1. Overall Treatment Results in Patients with Knee OA

The data on 1107 patients with stage 3 knee OA treated in the Clinic from 2019 to 2021 were analyzed. The patients were examined per three groups: 1) 677 patients undergone primary total knee replacement; 2) 219 patients undergone conservative inpatient treatment; 3) 211 patients undergone arthroscopy.

Knee arthroplasty was performed mostly in elderly (65 years and older) patients (n=402, 59.3%); fourteen (2.1%) patients of young age (18 - 44 years) were operated (Fig. 3.1). The female:male ratio was 2:1 (Fig.3.2).

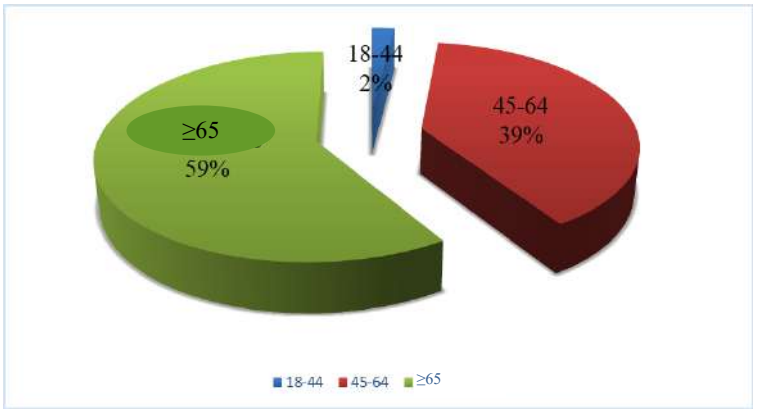


Figure 3.1. Distribution of patients undergone primary total knee replacement for OA by age (%)

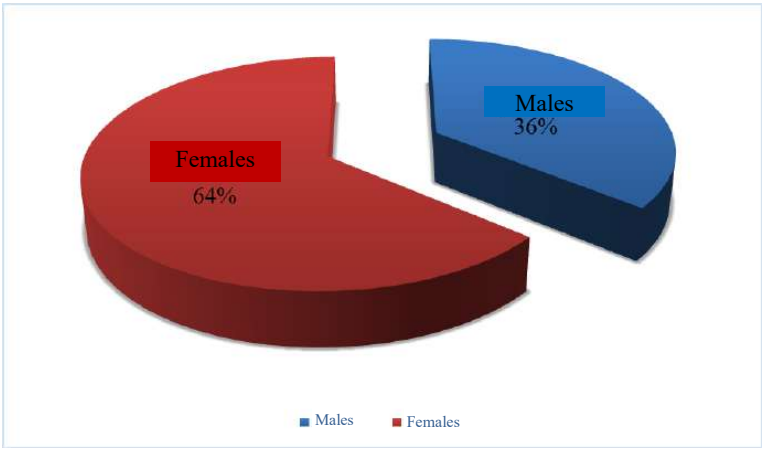


Figure 3.2. Distribution of patients undergone primary total knee replacement for OA by gender (%)

The retrospective data examination revealed that most of the patients (n=261, 38.6%) with knee OA were self-treated occasionally before hospitalization for arthroplasty. Nearly every third patient (n=122) was hospitalized for arthroplasty immediately after their initial visit to an outpatient specialist. Knee OA treatment was performed outpatienlty in 334 (49.3) patients. With this, only 82 (12.1%) patients received conservative treatment inpatiently (Fig. 3.3).

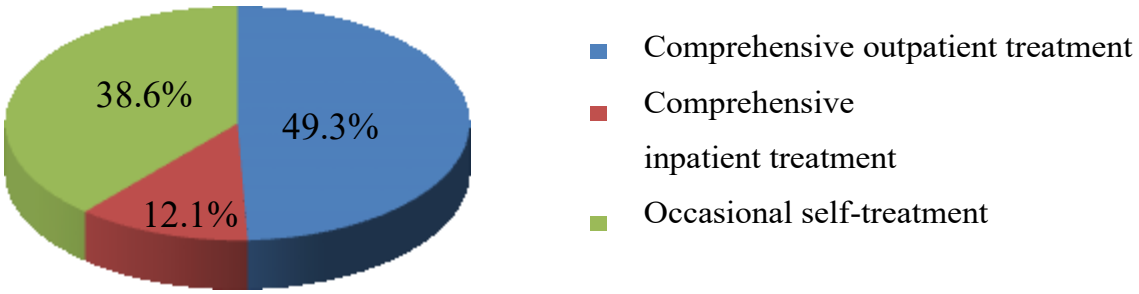


Figure 3.3. Distribution of knee OA conservative treatments (%)

Various conservative treatments were administered inpatiently in 219 patients with knee OA. Most of the patients (n=114, 52%) were of 45 to 64 years of age comprising the middle-age group. There were 8 (3.7%) young patients. The gender composition of the conservative treatment group was the same as that of the arthroscopy group: 141 (64.4%) patients were females and 78 (35.6) were males (Fig. 3.4 and Fig. 3.5).

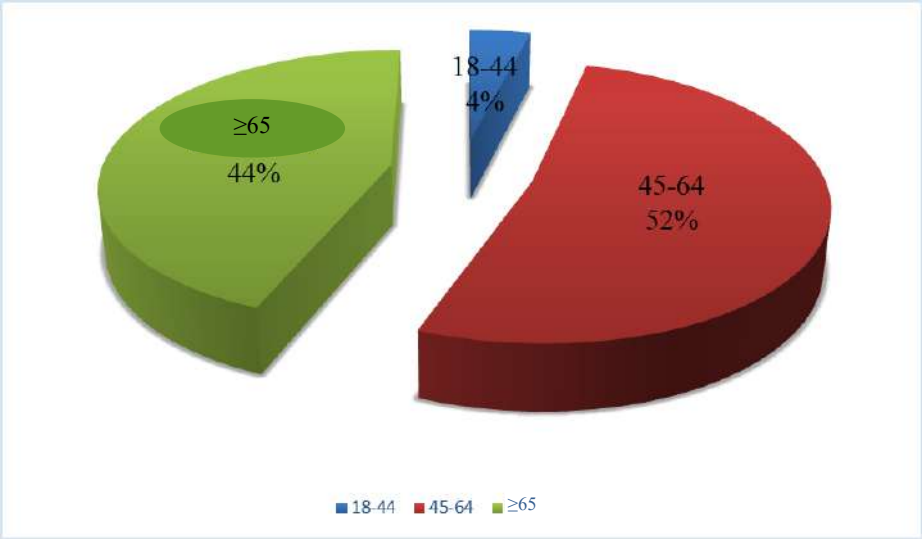


Figure 3.4. Distribution of patients undergone inpatient conservative treatment for knee OA by age (%)

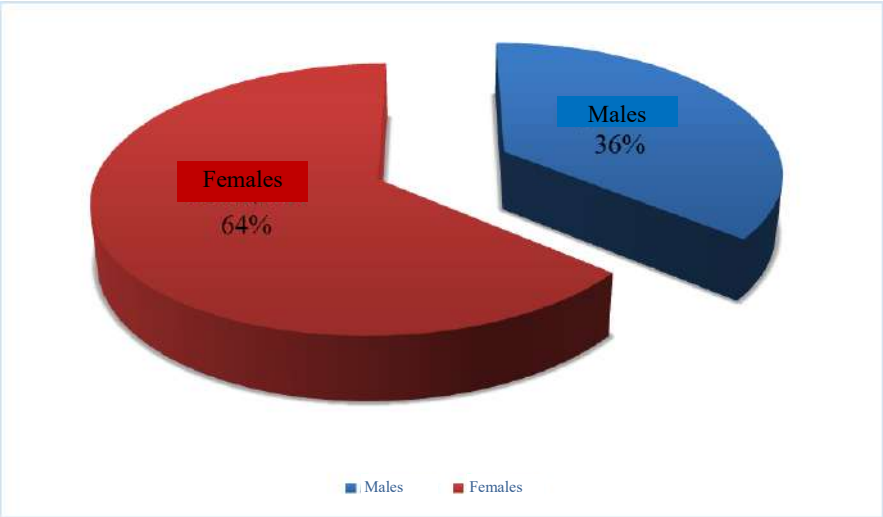


Figure 3.5. Distribution of patients undergone inpatient conservative treatment for knee OA by gender (%)

In contrast with the two previous groups, most of 211 patients who underwent arthroscopy for knee OA were of young age (n=84, 39.8%). There were 37 (17.5%) older patients. The gender composition of the arthroscopy group also differs from those of the conservative treatment and the arthroscopy group: there were 99 males (46.9%) and 112 females (53.1%), which is 1:1 ratio (Fig. 3.6 and Fig. 3.7).

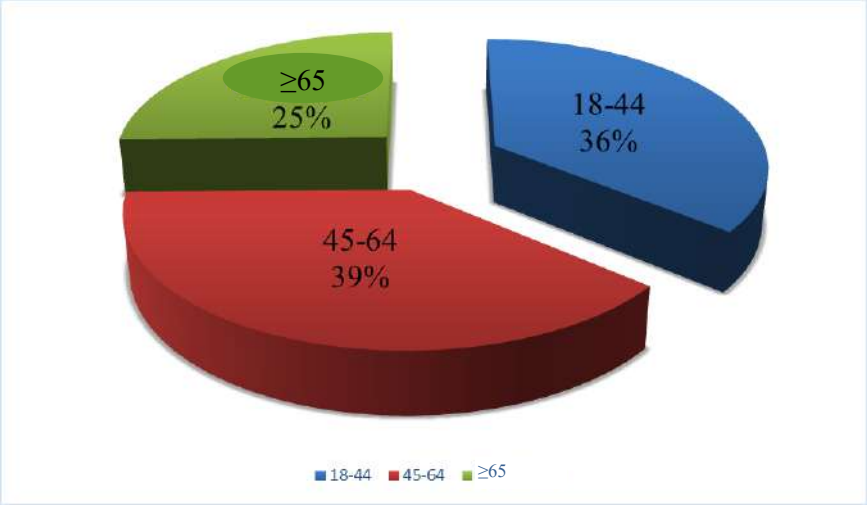


Figure 3.6. Distribution of patients undergone arthroscopy for knee OA by age (%)

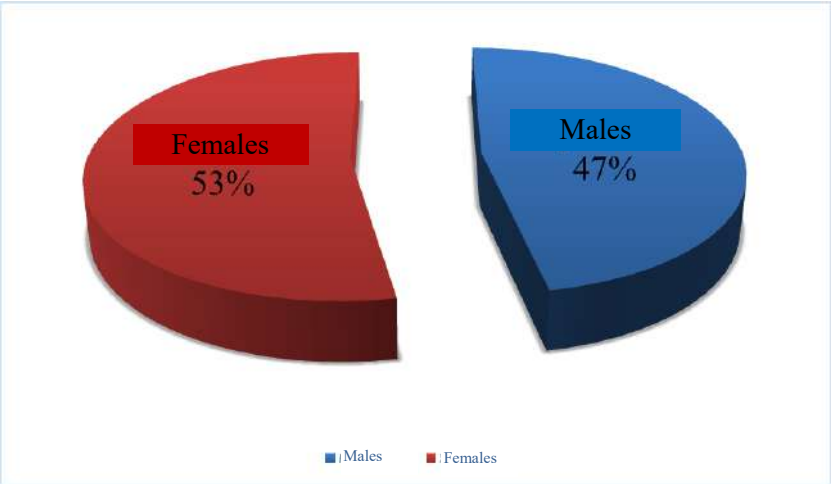


Figure 3.7. Distribution of patients undergone arthroscopy for knee OA by gender (%)

It should be noted that arthroscopy was not performed in case of the OA of end-stage (including valgus or varus deformity of greater than 20°, knee instability due to ligaments destruction, articular cartilage destruction, or technical inability to perform the procedure) due to its obvious futility.

The structure and frequency of comorbidities in patients with knee OA are presented in Table 3.1.

Table 3.1 – Concomitant diseases in patients undergone different treatments for OA

Concomitant disease	Arthroscopy	Arthroplasty	Conservative
	n (%)	n (%)	n (%)
Cardiovascular disorders (arterial hypertension, angina I-III FC, rhythm and conduction disorders, acute myocardial infarction, history of varicose veins, etc.)	78 (40.0)	457 (67.5)	118 (53.9)
Respiratory system disorders (chronic obstructive pulmonary disease, bronchial asthma, etc.)	7 (3.3)	67 (9.9)	28 (12.8)
Nervous system disorders (spine osteochondrosis, transient ischemic attack or acute cerebral circulatory failure in history, etc.)	54 (25.6)	268 (39.6)	56 (25.6)
Urinary system disorders (urinary stone disease, stage I-III chronic kidney disease, chronic pyelonephritis, etc.)	26 (12.3)	159 (23.5)	34 (15.5)

Digestive system disorders (chronic gastro-duodenitis, gastric or duodenal ulcer in remission, biliary stone disease out of exacerbation, etc.)	48 (22.7)	278 (41.0)	68 (31.1)
Obesity	25 (11.8)	398 (58.8)	73 (33.3)
Diabetes mellitus	17 (8.0)	239 (36.3)	13 (5.9)
Total number of patients with concomitant diseases	78 (40.0)	602 (88.9)	169 (77.2)
Total number of patients	211 (100)	677 (100)	219 (100)

As shown in Table 3.1, the patient who underwent arthroscopy had fewer comorbidities than those who underwent arthroplasty (40% and 88.9%, respectively).

Various complications developed during surgical treatment of knee OA. The structure and frequency of the complications are shown in Table 3.2.

Table 3.2 - Complications identified during knee arthroscopy or arthroplasty

Complication	Operation		p-value
	Arthroscopy	Arthroplasty	
Intraoperative	5 (2.4)	45 (6.6)	p=0.02
Local		20 (2.9)	
lig. collaterale tibiale injury		7 (1.0)	
lig. collaterale fibulare injury		4 (0.6)	
posterior cruciate ligament injury		3 (0.4)	
major vessel haemorrhage		6 (0.9)	
articular cartilage damage	5 (2.4)		
Systemic		25 (3.7)	
respiratory complication		7 (1.0)	
cardiovascular failure		10 (1.5)	
central nervous system complication		4 (0.6)	
vascular complication		4 (0.6)	
Postoperative	18 (8.5)	93 (13.7)	p=0.05
Local	18 (8.5)	68 (10.0)	p<0.001
lymphorrhoea		13 (3.4)	
hematoma	8 (3.8)	24 (3.5)	p=0.87
synovitis	8 (3.8)		
superficial SSI	2 (0.9)	13 (1.9)	p=0.34
deep SSI		12 (1.8)	
implant dislocation, aseptic loosening		6 (0.9)	
Systemic		25 (3.7)	
respiratory complication		8 (1.2)	
cardiovascular complication		10 (1.5)	
central nervous system complication		2 (0.3)	
Other		5 (0.7)	
Total number of complications	23 (10.9)	138 (20.4)	p<0.001
Total number of patients with complications	16* (7.6)	106** (15.7)	p<0.001
Total number of patients	211 (100)	677 (100)	

* 6 patients had 2 or more complications ** 106 patients had 2 or more complications

As shown in Table 3.2, that surgery-related complications occurred 2 times less frequently during arthroscopy than during arthroplasty: 16 (7.6%) and 106 (15.7%), respectively.

Only 5 (2.4%) cases of cartilage injury were observed within local intraoperative complications of arthroscopy. There were no systemic intraoperative complications during the operation. During arthroplasty, the medial collateral ligament injury was the most common local complication occurred in 7 (1.0%) patients. The most common systemic intraoperative complications of arthroplasty were cardiovascular failure occurred in 10 (1.2%) patients and respiratory complications in 7 (1.0%) patients.

There were 2 (0.9%) patients undergone arthroscopy who experienced SSI as a postoperative complication. Both cases were superficial infections. In the patients undergone arthroplasty, 25 (3.7%) cases of SSI were observed. Deep infection was reported in 12 (1.8%) patients.

Systemic complications of arthroplasty were observed in 25 (3.7%) patients. Cardiovascular and respiratory system complications were the most common reported in 10 (1.5%) patients and 8 (1.2%) patients, respectively.

Conservative treatment was conducted inpatiently in 219 patients. All treatments were assigned by a physician. The patients were also examined by physical rehabilitation specialists, physiotherapists, and other specialists according to comorbidity. The types of OA conservative treatments are presented in Table 3.3.

Table 3.3 - Conservative treatment in patients with knee OA

Conservative treatment	Number of patients (%)
Therapeutic exercise (isometric and isotonic muscle strengthening exercises, range of motion exercises, aerobic exercises)	153 (69.9)
Physiotherapeutic methods (ultra-high and high frequencies electromagnetic therapy, ultrasound therapy, anti-inflammatory drugs electrophoresis, laser therapy, heat-carrier applications, hydrotherapy)	174 (79.5)
Radiotherapy	23 (10.5)
Medications – nonsteroidal anti-inflammatory drugs (combined with gastroprotectors)	212 (96.8)
– B vitamins	160 (73.0)
– systemic enzymes (vobenzyme, flogenzyme)	29 (13.3)

– vasodilators (pentoxifylline, dipyridamole)	145 (66.2)
– antioxidatives (α–tocopherol acetate - vitamin E)	37 (16.9)
– antihistamines (suprastin, tavegil)	43 (19.6)
– Symptomatic Slow-Acting Drug in Osteoarthritis (SYSADOA)	61 (27.9)
– Platelet rich plasma (PRP)	112 (51.2)
Total number of patients	219 (100)

All patients with OA used different conservative treatments. In all patients, except for those with intolerance, nonsteroidal anti-inflammatory drugs (combined with gastroprotectors) were used (n=212, 96.8%). According to the physician's recommendations, other products were prescribed in some cases: B vitamins in 160 (73.0%) patients; vasodilators (pentoxifylline, dipyridamole) in 145 (66.2%) patients; antihistamines (suprastin, tavegil) in 43 (19.6%) patients. Some patients n=153, 69.9%) were also prescribed therapeutic exercises including isometric and isotonic muscle strengthening exercises, range of motion exercises, stretching, and aerobics.

Physiotherapeutic treatments were prescribed to 174 (79.5%) patients. Those included ultrahigh and high frequency electromagnetic therapy, ultrasound therapy, anti-inflammatory drugs electrophoresis, laser therapy, heat carrier applications, hydrotherapy and others used alone or in combinations.

Intra-articular injection of platelet rich plasma (PRP) was performed in 112 (51.2%) patients during hospitalization. In addition, 31 (17.8%) patients received the basic chondroprotective Symptomatic Slow-Acting Drug in Osteoarthritis (SYSADOA) treatment in combination with non-medication therapy including daily walking and an individual exercise program while inpatient.

Previous reports discussed the possible slowing of the disease progression with SYSADOA treatment (Lila A.M. et al., 2019; Bishnoi M. et al., 2016).

Functional outcomes were assessed using the WOMAC scale at the predefined time points (Table 3.4, Fig. 3.8).

Table 3.4 - Functional outcomes in patients undergone conservative treatment

Years of follow-up	On admission	After treatment completion	1 year after treatment completion	2 years after treatment completion
Number of patients (%)	219 (100)	219 (100)	209 (95.0)	203 (93.6)
Outcome: excellent or good (%)	103 (47.0)	157 (71.7)	142 (67.9)	129(63.5)
Outcome: satisfactory or unsatisfactory (%)	116 (53.0)	62 (28.3)	67 (32.1)	74 (36.5)

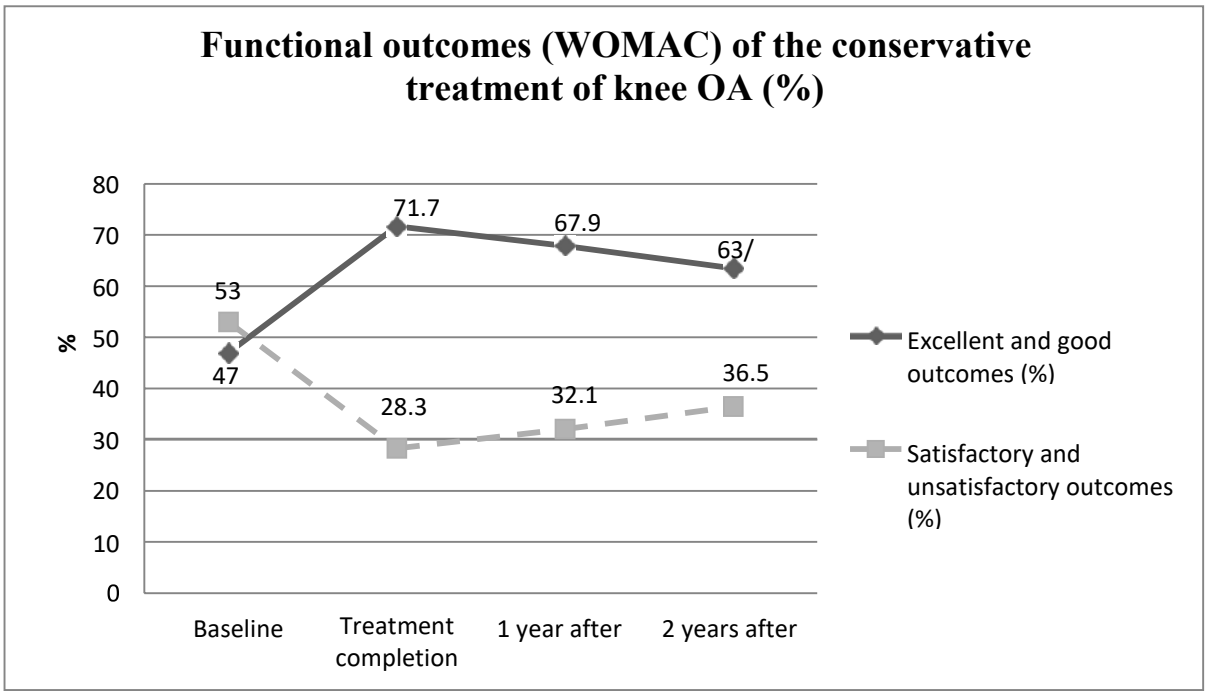


Figure 3.8. Functional outcomes (WOMAC) of the conservative treatment of knee OA (%)

As shown in Figure 3.8 and Table 3.4, the number of patients with excellent and good functional outcomes increased after a course of conservative treatment compared to baseline from 47% to 72%. Satisfactory and unsatisfactory functional outcomes of the knee OA conservative treatment increased by the 3rd year of follow-up from 28% to 37% compared to baseline, however, the difference was not statistically significant ($p > 0.05$), still, a trend of improvement was identified.

The number of patients with excellent and good functional outcomes increased after an arthroscopy for OA treatment c from 30% to 91% compared to baseline,

decreasing to 83% during the 2-year follow-up (Table 3.5, Fig. 3.9).

Table 3.5 - Functional outcomes in patients undergone knee arthroscopy

Years of follow-up	On admission	After surgery	1 year after surgery	2 years after surgery
Number of patients (%)	211 (100)	211 (100)	199 (95.0)	174 (82.3)
Outcome: excellent or good (%)	64 (30.3)	192 (91.0)	178 (89.4)	144 (82.8)
Outcome: satisfactory or unsatisfactory (%)	147 (69.7)	19 (9.0)	21 (10.6)	30 (17.2)

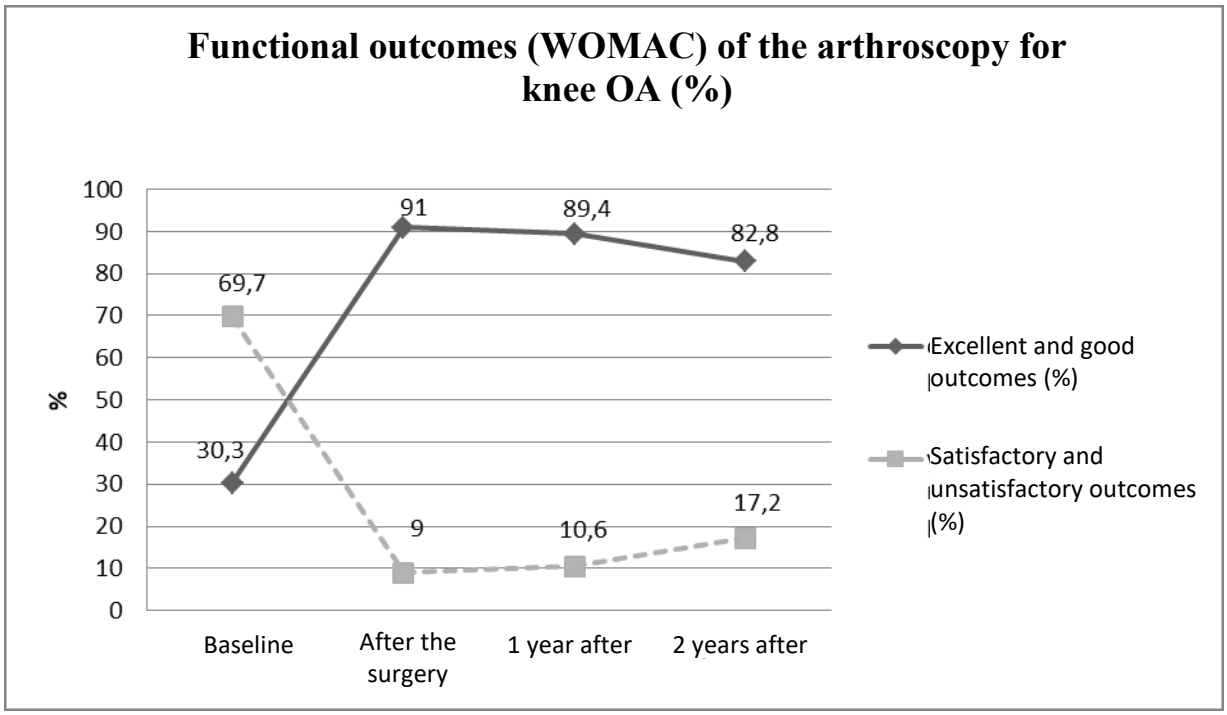


Figure 3.9. Functional outcomes (WOMAC) of the arthroscopy for knee OA (%)

Before arthroplasty, knee function was considered as satisfactory or unsatisfactory in 667 (98.5%) patients. Only 10 (1.5%) patients had good knee function. In the first year after the knee arthroplasty the assessment of functional outcomes inverted. There were 0.6% of patients with satisfactory and unsatisfactory outcomes and 99.4% of patients with excellent and good functional outcomes (Table 3.6, Fig. 3.10).

Table 3.6 - Functional outcomes in patients undergone knee arthroplasty

Years of follow-up	On admission	After surgery	1 year after surgery	2 years after surgery
Number of patients (%)	677 (100)	677 (100)	650 (96.0)	634 (93.6)
Outcome: excellent or good (%)	10 (1.5)	673 (99.4)	629 (96.8)	591 (93.2)
Outcome: satisfactory or unsatisfactory (%)	667 (98.5)	4 (0.6)	21 (3.2)	43 (6.8)

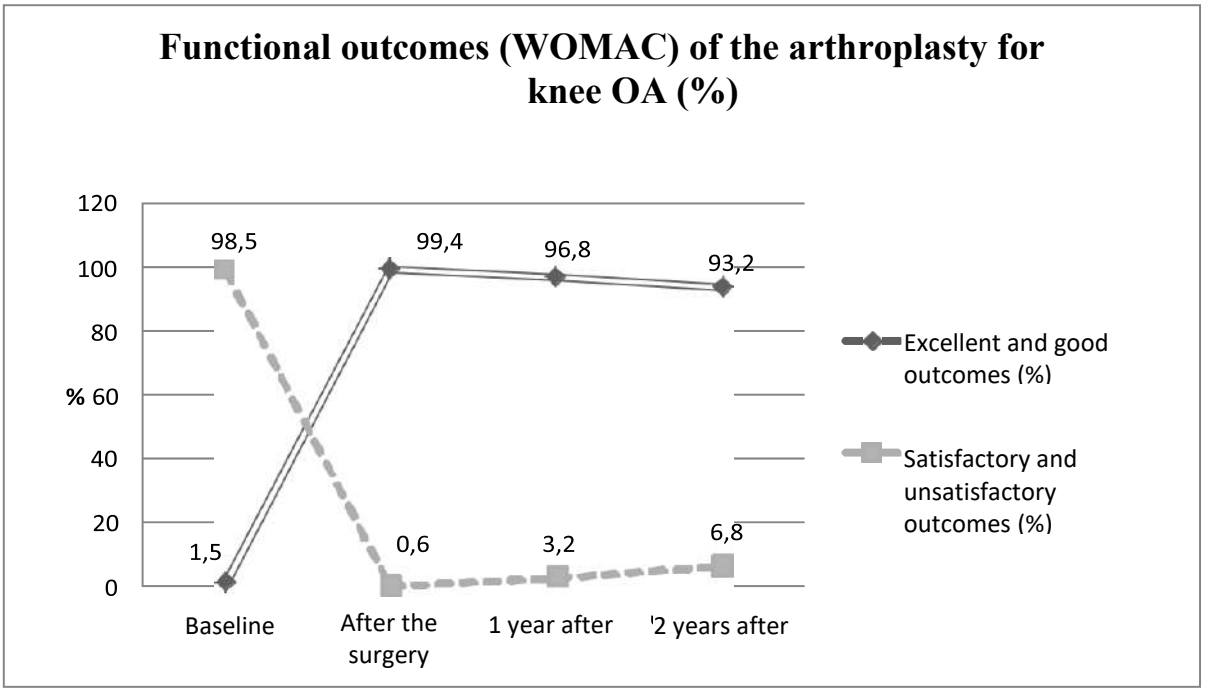


Figure 3.10. Functional outcomes (WOMAC) of the arthroplasty for knee OA (%)

The WOMAC score also showed a tenfold increase from 0.6% satisfactory and unsatisfactory results of the knee arthroplasty 1-year post-surgery to 6.8% of those in the 3rd year (Fig. 3.9). There were no statistically significant differences either with conservative treatment or knee arthroplasty. However, the trend of increasing number of patients with satisfactory and unsatisfactory results was more pronounced in the arthroplasty group. Probably, the assessments of arthroplasty functional outcomes and conservative treatment outcomes in knee OA would grow equal in 5-7 years. Further prognosis requires a comprehensive study of the OA treatment results both conservative and surgical (organ-preserving, as well as organ replacement) in terms of 10 and 15 years.

Based on the analysis of the conservative treatment results in patients with knee OA, excellent and good functional outcomes were observed in 64% of cases (Table 3.4). Three-year functional outcomes were satisfactory or unsatisfactory in 36% of cases. The frequency of those outcomes increased from 28% to 36% over three years (Fig. 3.7).

The study demonstrated that the negative changes of functional outcomes are less pronounced in patients systematically undergoing conservative treatment than in those undergone arthroplasty alone.

Thus, in each of the study groups (conservative treatment, knee arthroscopy, and knee arthroplasty), there was a convincing increase in the number of patients with excellent and good functional outcomes of the treatment for OA. Moreover, in each group there was a prominent tendency of decrease in the number of patients excellent and good outcomes, and of increasing in the number of patients with satisfactory and unsatisfactory outcomes over three years. However, joint replacement with an implant cannot be considered an organ-preserving intervention. According to many researchers, the results of repeated operations on the prosthetic joint cannot be recognized as absolutely positive due to changes in the bone structure. This allows considering arthroplasty to be the final stage of knee OA treatment.

Unlike arthroplasty, arthroscopy as an organ-preserving intervention and conservative treatments can be repeated more than once. Arthroplasty is advisable when the other methods are ineffective. Despite this, many researchers report premature use of knee arthroplasty, in advance of the potentially effective conservative treatments and organ-preserving surgeries. The validity of knee joint replacement with an implant will be discussed in the next section taking to account morphological examination results (Mansurov D.Sh. et al., 2021; Spichko A.A. et al., 2021; Tkachenko A.N. et al., 2022; Khaidarov V.M. et al., 2021).

3.2. Validity of Total Knee Replacement in OA: Morphological Examination

Osteoarthritis affects about 300 million people worldwide (Allen K.D. et al., 2022). As for the Russian Federation, OA is verified in 4% of the adult population, and the older the age, the more often the disease occurs. At the same time, there has been a steady trend

of the disease incidence increasing in the adult population in recent years (Balabanova R.M., Dubinina T.V., 2019). The most common localization of idiopathic OA is the knee joint. The results of the study were published in the article by Mazurov V.I. et al. (2021).

Treatment of knee OA is performed by various specialists: orthopedic traumatologists, rheumatologists, physicians, rehabilitation specialists, therapeutic exercise specialists, physiotherapists, and others. Currently, arthroplasty is recognized by many orthopedists as the operation of choice in the treatment of advanced stages of OA. Although, the results of the intervention are not always favorable.

The adverse consequences of arthroplasty include early and late postoperative complications, unsatisfactory operation results, premature knee replacement, inadequate physical recovery, etc. Deciding on an arthroplasty for the treatment of a patient with OA, the doctor is considering the following factors: pain syndrome persistence, clinical and radiological stage, comorbidities, the patient's consent, etc. Histological examination is performed right after joint replacement with an implant.

On this stage of our study, the histological part of the process was examined, and the validity of arthroplasty was determined retrospectively. The results of the study were published in the article by Tkachenko A.N. et al (2023).

A total of 187 knee replacements were performed in patients with knee OA in the Clinic from 01 Jan 2022 to 15 Dec 2022. Materials from random 30 patients aged 40 to 76 years (19 females and 11 males) were assigned for intravital histological examination (Fig. 3.11).

Figure 3.11. Tissue material withdrawn during the knee arthroplasty and assigned for histological examination

After the operation, the fragments of femoral condyle were fixed in 10% buffered formalin solution for 24 hours. Then, bone material was cut out using a set of saws for subsequent histological examination.

Histological samples were prepared according to the standard technique for bone preparation including decalcification. Bone fragments were decalcified in the electrolyte decalcifying solution (Biovitrum, Russia) at the ratio of the object volume to the decalcifying liquid volume 1:50 for 8 hours, the degree of decalcification was controlled with a needle.

Upon the decalcification completion, the specimens were washed out with tap water for 60 min. Histological processing, embedding, and microtomy at a slice thickness of 5 μm were performed according to standard techniques. The sections were stained with haematoxylin and eosin, and safranin O. The OOCHAS and the clinical and radiological classification by N.S. Kosinskaya (Kosinskaya N.S.,1961; Custers R.J., 2007) were used for staging of OA.

The changes in cartilage, subchondral bone, and intertrabecular tissue were assessed by microcopy.

The records of 187 patients who underwent arthroplasty for knee OA at the Clinic during 2022 were analyzed.

The mean±SD age of patients was 59.3±6.7 years (ranged from 40 to 76 years). The patients distribution by age and gender are shown in Table 3.7.

Table 3.7 - Distribution of patients undergone primary total arthroplasty for OA by age and gender

Age group, years	Number of patients (%)					
	Males		Females		Total	
	abs.	%	abs.	%	abs.	%
18–44	8	4.3	15	8.0	23	12.3
45–64	32	17.1	57	30.5	89	47.6
≥65	22	11.8	53	28.3	75	40.1
Total	62	33.2	125	66.8	187	100

As shown in Table 3.7, there were more females (n=15, 8%) than males (n=8, 4.3%) in the younger age group. There were also more female patients in the middle age and older age groups. The male/female ratio was 1:2 in young and elderly patients, and 1:3 (11.8% and 28.3%, respectively) in middle-aged patients (45 to 64 years).

Based on disease history, only 48 (25.7%) patients received inpatient conservative treatment or organ-preserving surgical treatment for knee OA at least once before undergoing arthroplasty. In addition, 139 (74.3%) patients received occasional conservative treatment outpatiently.

Prior to arthroplasty, knee radiography was performed in 187 patients. MRI was performed in 84 (44.9%) patients. The diagnosis of stage 3 knee OA was verified in 123 (65.8%) patients after the examination. In 64 (34.2%) patients, OA of stage 2-3 was diagnosed.

The results of arthroplasty were favorable in the majority of cases. Local and systemic complications were observed in 18 (9.6%) patients during arthroplasty and in the early postoperative period.

As for the intraoperative complications, the knee ligaments injury was detected in

4 (2.1%) patients (two cases of the lateral ligament injury and two cases of the quadriceps injury). Among the postoperative complications, 2 (1.1%) cases of superficial SSI were registered. Among the systemic complications, cardiac disorders were the most common (n=4, 2.1%).

There were no deaths during surgery and in the early postoperative period. Of 187 patients, 30 patients were randomly assigned for postoperative histological examination. Conventionally, the femoral condyle and knee joint capsule were examined.

Both the signs of initial stage (Fig. 3.12) and stage 2-3 (Figs. 3.13 and 3.14) of knee OA were identified during the sectioned slides examination.

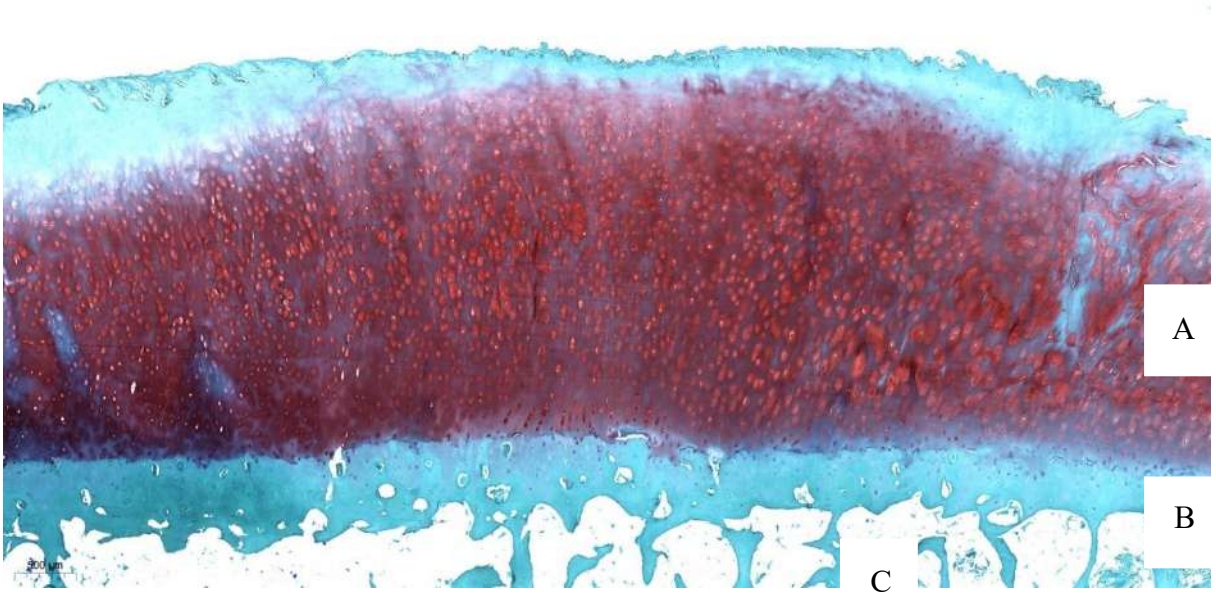


Figure 3.12. Articular cartilage (A) and subchondral bone (B) of the medial femoral condyle of a patient undergone arthroplasty: OOCHAS stage 2 OA; stage I as per N.S. Kosinskaya. A - hyaline cartilage; B - subchondral lamellar bone; C - intertrabecular spaces of the epiphysis filled with bone marrow fat. Staining: safranin-O

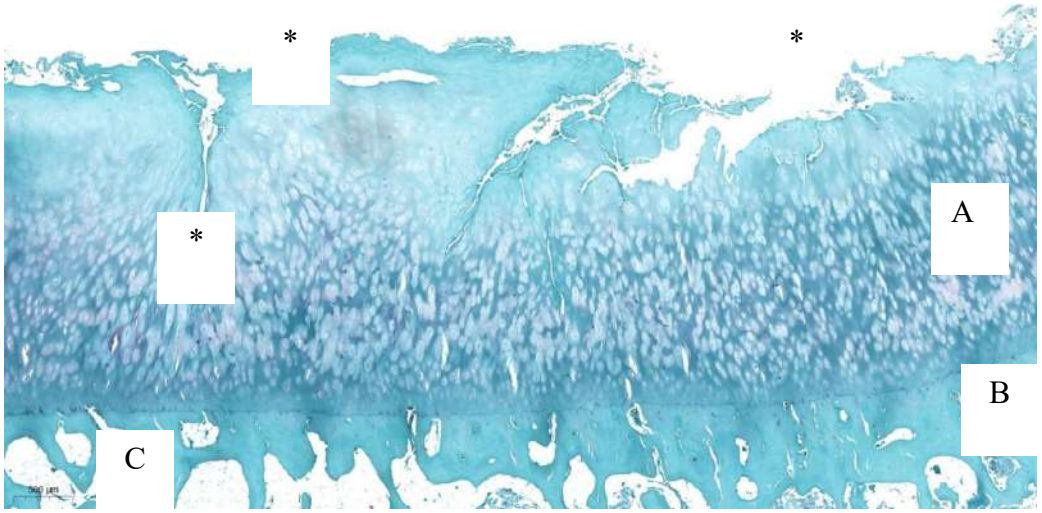


Figure 3.13. Articular cartilage (A) and subchondral bone (B) of the medial femoral condyle of a patient undergone arthroplasty: OOCHAS stage 4 OA; stage II as per N.S. Kosinskaya. A - hyaline cartilage with biochemically altered matrix; B - subchondral lamellar bone with signs of osteosclerosis; C - intertrabecular spaces of the epiphysis filled with bone marrow fat; * - vertical and horizontal cracks, and erosions (defect) of the cartilage. Staining: safranin-O

Figure 3.14. Articular cartilage (A) and subchondral bone sclerosis (B) of the medial femoral condyle of a patient undergone arthroplasty: OOCHAS stage 4-5 OA; stage III as per N.S. Kosinskaya. A - fibrous cartilage tissue; B - subchondral lamellar bone sclerosis and microcysts (*); red line indicates a border between the remaining cartilage and the underlying bone. Staining: haematoxylin and eosin; ×100 magnification

The slides examination revealed different morphological stages of OA: from initial

manifestations to stage 3 of the disease. Of 30 histological examinations performed, stage I knee OA as per N.S. Kosinskaya was determined in 3 (10%) patients (Fig. 3.12); stage II OA in 8 (26.7%) patients (Fig. 3.13), and stage III OA in 19 (63.3%) patients (Fig. 3.14).

Deciding on knee arthroplasty, orthopedic traumatologists were considering both the data of radiological or tomographic examinations showing the presumed stage of OA, and the clinical characteristics of the disease (including disease duration, pain intensity, and the conservative treatment effectiveness). The results of the examinations of knee joint stability and ligaments changes were also taken to account. It should be noted, that in the majority of patients with knee OA (139 out of 187 patients, 74.3%) the first inpatient treatment was total knee replacement.

Arthroplasty is not an organ-preserving operation. It may be accompanied by intra- or postoperative complications up to death as any other surgery. After an arthroplasty, patients sometimes violate the recommendations for the restriction of movement in the operated joint, which can lead to various complications. Indications for arthroplasty are periodically revised, usually resulting in a more restricted list. Based on the morphological examination data, it can be concluded that the knee arthroplasty was performed prematurely in 11 (36.7%) patients with stage I-II OA (as per N.S. Kosinskaya), and no potentially effective conservative treatments or minimally invasive surgical interventions were used in advance.

Thus, the histological examination of the removed knee joint fragments showed that every third patient had no stage 3 OA, which is an arthroscopy indication. This can be explained by some discrepancy between the radiological and morphological data, as well as by the flaws of the conventional technique of examination the only medial femoral condyle but not the other parts of the knee joint. The obtained data warrant a scientific study aimed at improving and objectivizing OA diagnosis and developing a treatment strategy for patients with knee OA, including conservative treatment, minimally invasive surgical intervention, knee arthroplasty (as a last-resort treatment), and rehabilitation (Tkachenko A.N. et al., 2023).

The number of publications on premature arthroplasty in OA is increasing

worldwide including Russia. Many researchers emphases that the potentially effective conservative treatments and minimally invasive surgical interventions are utilized insufficiently. The next chapter describes the algorithm of knee OA treatment and defines the place of arthroscopy.

CHAPTER 4. RATIONALE FOR THE OSTEOARTHRITIS TREATMENT STRATEGY: KNEE ARTHROSCOPY PRIOR TO ARTHROPLASTY

Several factors were taken into account when developing a comprehensive treatment strategy for knee OA.

A plenty of publications appeared in the recent years on the effectiveness of conservative treatments and minimally invasive surgical interventions in patients with stage 3 knee OA. However, no treatment strategy, which would include outpatient examination and treatment, inpatient conservative treatment, minimally invasive surgical interventions, a last-resort treatment with knee replacement, and rehabilitation, for such patients was established neither in Russia nor in other countries.

To optimize the treatment of patients with stage 3 knee OA, a medical care strategy was developed (Fig. 4.1). The keystone of the proposed strategy is to consider knee arthroplasty as the final stage of OA treatment, which should be applied only after conservative treatment and minimally invasive surgical interventions have been conducted.

The strategy was tested using retrospective data for ethical reasons. Since all the patients of a potential prospective group agreed to undergo arthroscopy in order to preserve the joint after being informed on the study purpose and objectives.

It should be noted that the strategy does not provide for knee arthroscopy if the knee valgus/varus deviation exceeds 20° (grade 3) or there is knee ligaments instability.

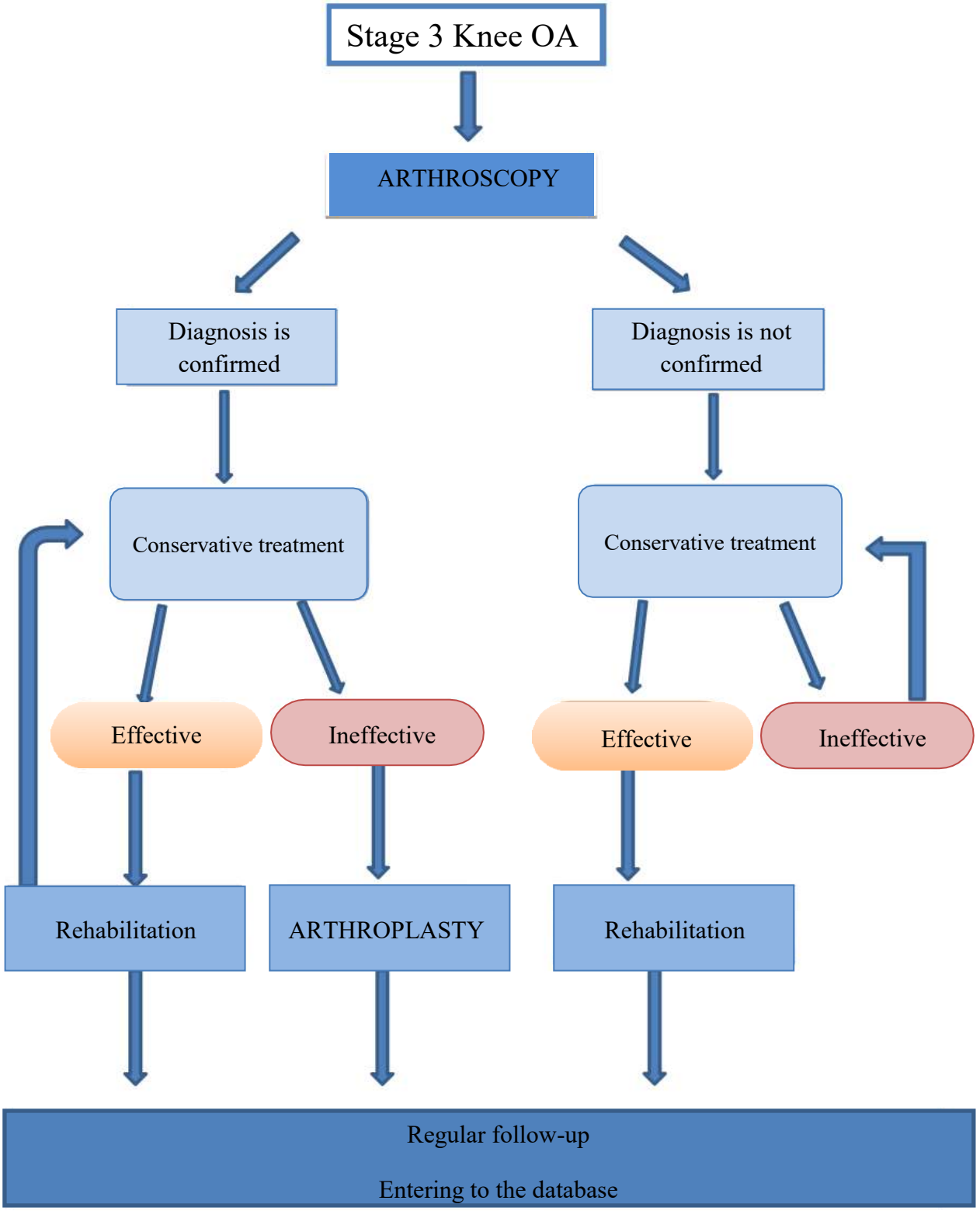


Figure 4.1. Treatment strategy in a patient with stage 3 knee OA

Arthroscopy is also not performed in case of pronounced changes in the joint, which exclude the technical possibility of the procedure. In general, the strategy is applicable in patients with radiological signs of stage 3 OA, except for the end-stage.

The proposed strategy can be a part of the comprehensive treatment in patients with knee OA, which includes outpatient examination and treatment, inpatient conservative treatment, minimally invasive surgical interventions, a last-resort treatment with knee arthroplasty, and rehabilitation (Tkachenko A.N. et al., 2023).

The retrospective observations demonstrating the effectiveness of the strategy are presented below.

***

Patient K., 56 years old, chart #19647/5. Came to the clinic on 22 Dec 2021 with complaints of pain in the right knee at the end of the working day for 3 years. In the last 2 months the pain intensity had increased. Joint stiffness in the morning. Pain when going downstairs. Did not remember any injury.

The patient was self-treated with paracetamol. Occasionally was followed-up by a polyclinic surgeon; right knee arthroplasty was recommended. The patient was hospitalized at the Clinic.

Height 168 cm, weight 74 kg, BMI 26.2 kg/m2. Goniometry: flexion 135°, extension 180° (2 degree). Pain of 7 per VAS. Knee OA of the stage 3 was diagnosed (Fig. 4.2 A, B).

The patient was proposed to undergo organ-preserving intervention - arthroscopic joint debridement with meniscus resection.

A

B

Figure 4.2 A, B. Patient K., 56 years old, right knee MRI: right knee OA of stage 2-3; aged damage of the medial meniscus Stoller III A; synovitis

A therapeutic and diagnostic arthroscopy of the right knee was performed, and the medial meniscus was resected (Fig. 4.3 A, B, C). Subsequently, conservative treatment was provided. Physiotherapy was provided quarterly, and the patient performed home exercises recommended by the doctor daily for two years. Once a year the patient received hyaluronic acid intra-articular injection. The patient also received SYSADOA treatment regularly.

Figure 4.3. Patient K., 56 years old, right knee arthroscopy: A - a defect in the medial femoral condyle articular cartilage; B - aged bucket-handle tear of the medial meniscus; C - a partial meniscectomy and debridement were performed

The patient came back for follow-up in 2 years. Radiological signs of right knee OA of stage 2-3 were verified (Fig. 4.4 A, B). Pain was observed only during prolonged physical activity and weather changes. Goniometry: flexion 105°, extension 180° (1 degree). Pain of 3 per VAS. No negative dynamics during the follow-up period. Functional outcomes (WOMAC) are good (20 points), quality of life is good (13 points).

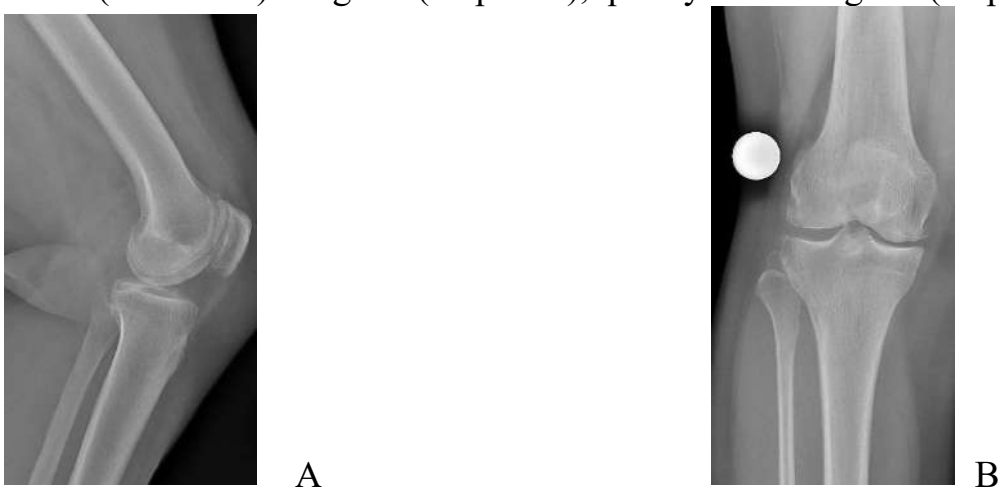


Figure 4.4 A, B. Patient K., 58 years old, right knee radiography: right knee OA of stage 2-3

***

Patient I., 29 years old, chart #10791/5. The patient complained of the pain in the left knee, increasing after exertion. A history of a knee injury 3 years ago, no medical care provided. Pain and restriction of motion appeared with time in the left knee. Goniometry: flexion 140°, extension 180° (2 degree). Pain of 8 per VAS.

The patient was diagnosed with a stage 3 post-traumatic OA of the left knee in a polyclinic. Loose bodies in the joint were detected. It was recommended to hospitalize the patient in the Clinic to decide on the knee arthroplasty. Additional examination was carried out. MRI showed a defect of the left femur medial condyle, two loose bodies in the joint cavity, degenerative changes of the anterior cruciate ligament, and stage 3 OA of the knee (Fig. 4.5 A, B, C). Minimally invasive surgery was applied. Therapeutic and diagnostic arthroscopy + tunneling was performed. Loose bodies were removed from the joint cavity (Fig 4.6 A, B, C). Further, the patient underwent conservative treatment outpatiently and was scheduled for a chondroplasty.

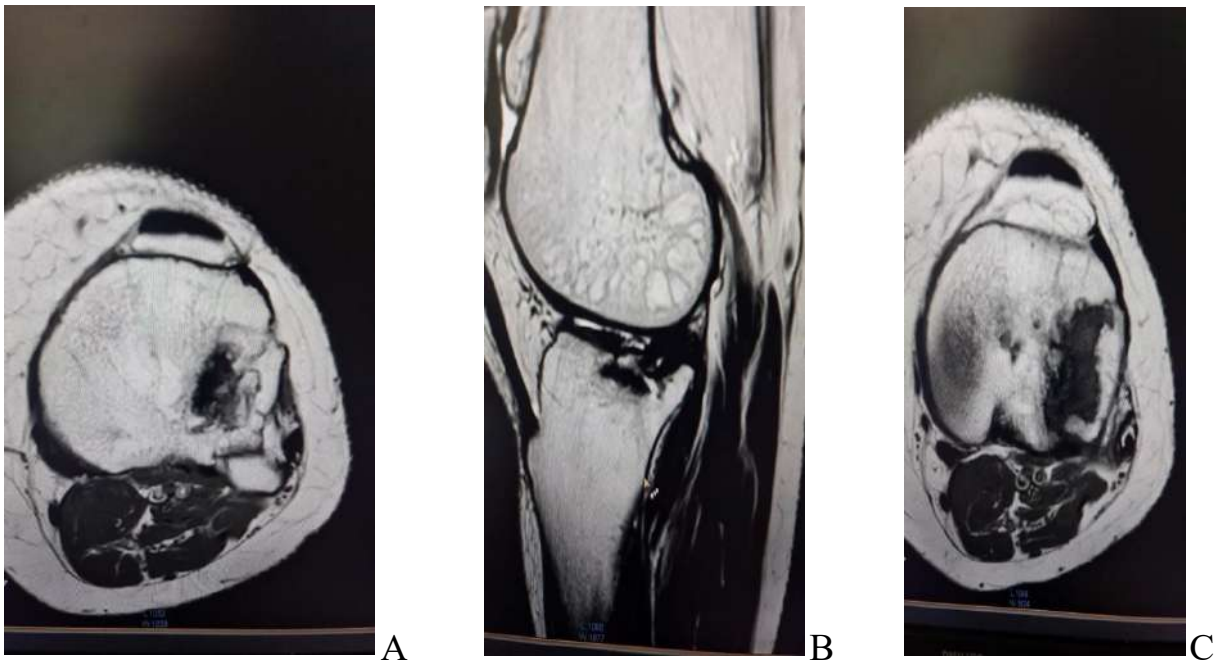


Figure 4.5 A, B, C. Patient I., 29 years old, left knee MRI: A - damage of the tibial condyles; B - damage of the femoral condyles; C - loose bodies in the joint cavity; synovitis

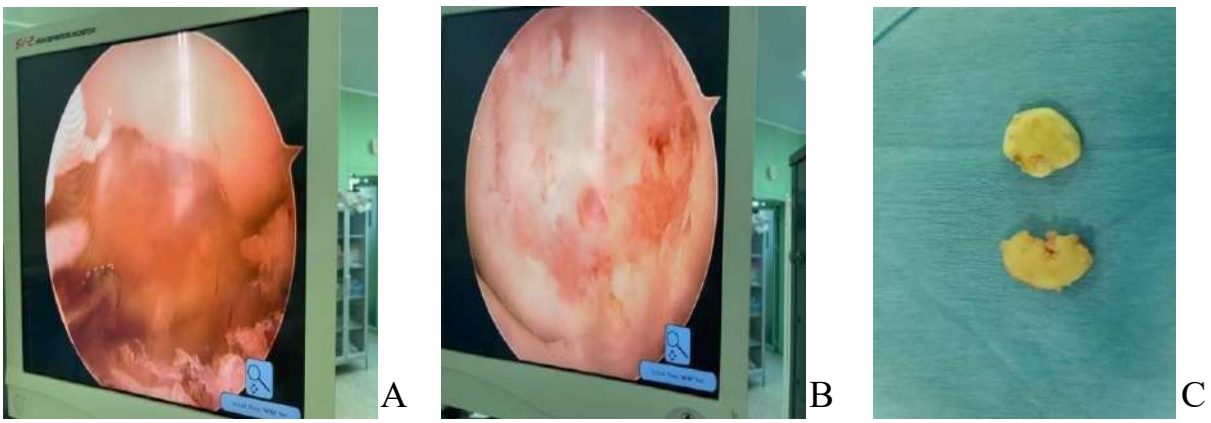


Figure 4.6 A, B, C. Patient I., 29 years old, left knee arthroscopy: A - the largest femoral condyle defect was visualized during debridement; B - tunneling with a 2-mm drill; C - large fragments of the condyles, the loose bodies

Two years after the chondroplasty (Fig. 4.7 and Fig. 4.8), the patient reported no

pain and no motion restriction. Goniometry: flexion 70°, extension 180. Pain of 1 per VAS. High-impact physical exercises for knees were contraindicated, however, swimming pool and gym activities were allowed with minor restrictions.

Figure 4.7. Patient I., 30 years old, left knee MRI: one-year result of the chondroplasty

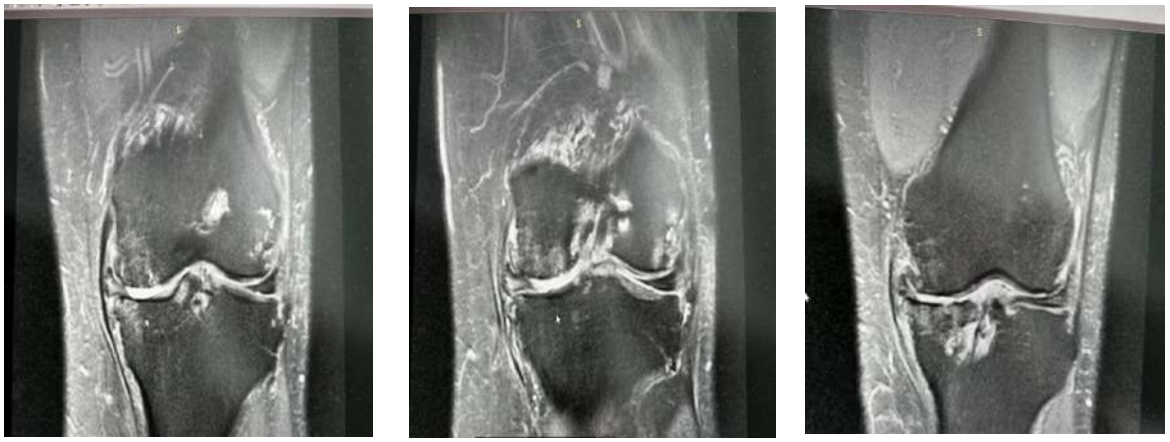
A

B

Figure 4.8. Patient I., 31 years old, left knee MRI: two-years result of the chondroplasty

***

Patient S., 76 years old, chart # 5055/5. Complaints of constant aching pain in the left knee. Restriction of motion from 6 months ago. The patient was self-treated with NSAIDs and physical therapy exercises by her own. Joint stiffness of at least 15 min. The discomfort was associated with intensive physical exertion at the workplace while at working age. Now the patient retired. The joint function of 37 per WOMAC. Range of motion: flexion - 107, extension - 163. Pain of 6 per VAS. MRI of the left knee joint showed degenerative changes of the posterior horn and body of both menisci (Stoller II), synovitis, partial damage of the anterior cruciate ligament, and stage 3 OA (Fig. 4.9 A, B, C).

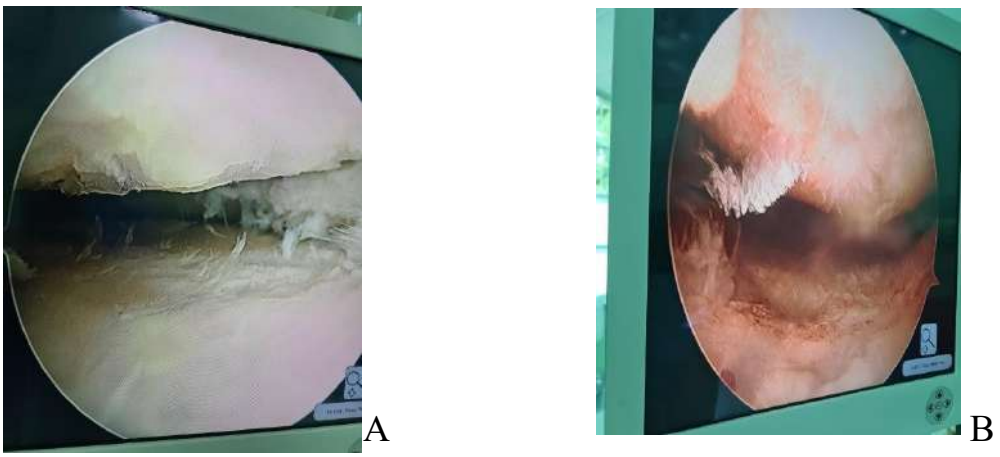


A B C

Figure 4.9 A, B, C. Patient C., 76 years old, left knee MRI: degenerative changes of the posterior horn and body of both menisci (Stoller II), synovitis, partial damage of the anterior cruciate ligament, gonarthrosis stage 3

Due to restricted motion in the knee, pain, synovitis, damages in menisci, and lack of conservative treatment in the history, therapeutic and diagnostic arthroscopy of the left knee was recommended in the patient (Fig. 4.10 A, B). Early activation of the patient 1.5 hours after the surgery was performed. The patient was discharged 3 days post-surgery for outpatient treatment.

The patient underwent conservative treatment without physiotherapeutic procedures. At 3 months of follow-up, the patient complained of pain in the arthroscopy ports sites. The patient described the pain as periodic and aching. The knee range of motion had increased: flexion - 85, extension - 175. Pain of 3 per VAS. Stiffness persisted, however the duration did not exceed 5 min.



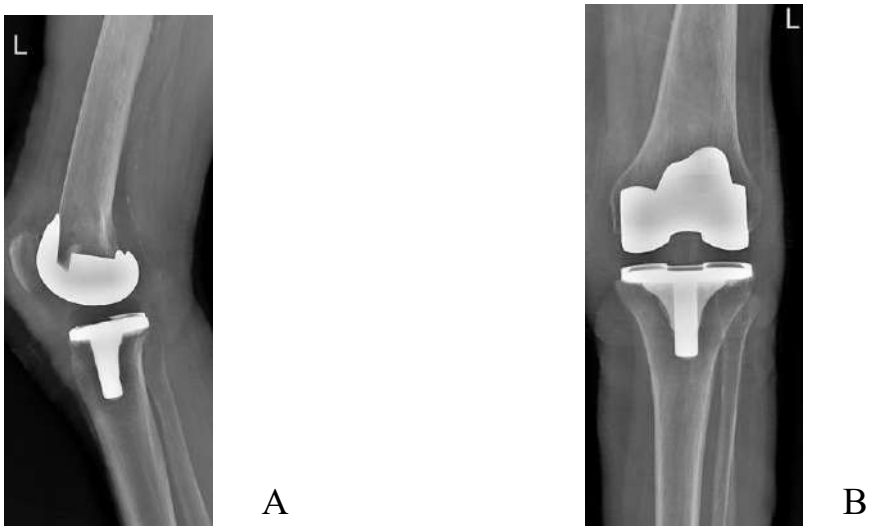
A B

Figure 4.10 A, B. Patient C., 76 years old, left knee arthroscopy: A - defects of the femoral and tibial condyles articular cartilage; B - after all necessary manipulations were performed (lavage, debridement, and partial meniscectomy)

The patient was re-admitted to the traumatology and orthopedics department for inpatient conservative treatment. Physiotherapy was contraindicated due to a history of

oncological disease. The treatment included PRP, hyaluronic acid injections, NSAIDs, and therapeutic exercises. The joint function of 25 per WOMAC. Range of motion: flexion - 67, extension - 173. The effect of the conservative treatment was maintained for 18 months, after which the pain returned, and the patient was assigned for knee arthroplasty.

In 1.5 years, patient S., 79 years old underwent the surgery. Total cemented left knee replacement was performed (Fig. 4.11 A, B).



A B

Figure 4.11 A, B. Patient C., 76 years old, left knee radiography: after total knee replacement

The provided cases demonstrated that the long-term arthroscopy results may vary; however, the personification of treatment in these patients could prevent or delay arthroplasty. In some cases, conservative or organ-preserving surgical treatments could improve the quality of life and prevent unacceptable results of arthroplasty (Balgley A.G. et al., 2022; Tkachenko A.N. et al., 2023).

The strategy (Fig. 4.1) was tested using retrospective data. Long-term 2-year results were available for 174 (82.3%) patients of those (n=211) undergone knee arthroscopy between 2019 and 2021 (Table 4.1).

Table 4.1 - Distribution of patients with stage 3 knee OA by age and gender

Age group, years	Number of patients (%)					
	Males		Females		Total	
	abs.	%	abs.	%	abs.	%
18–44	14	8.1	7	4	21	12.1
45–64	43	24.7	49	28.2	92	52.8
≥65	31	17.8	30	17.2	61	35.1

Total	88	50.6	86	49.4	174	100

Within one year after arthroscopy, a knee arthroplasty was performed in 58 (33.3%) of 174 patients (Fig. 4.12). Within two years, an arthroplasty was performed in another 39 (22.4%) patients (Fig. 4.13).

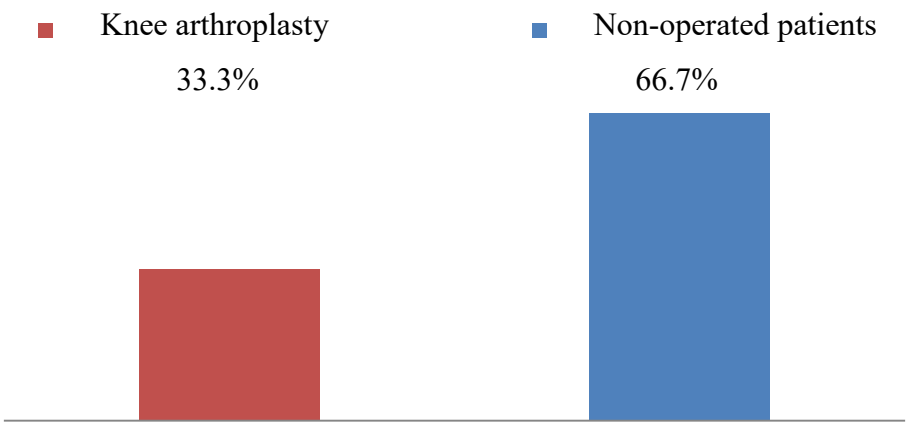


Figure 4.12. Outcomes (%) of comprehensive OA treatment one year after arthroscopy

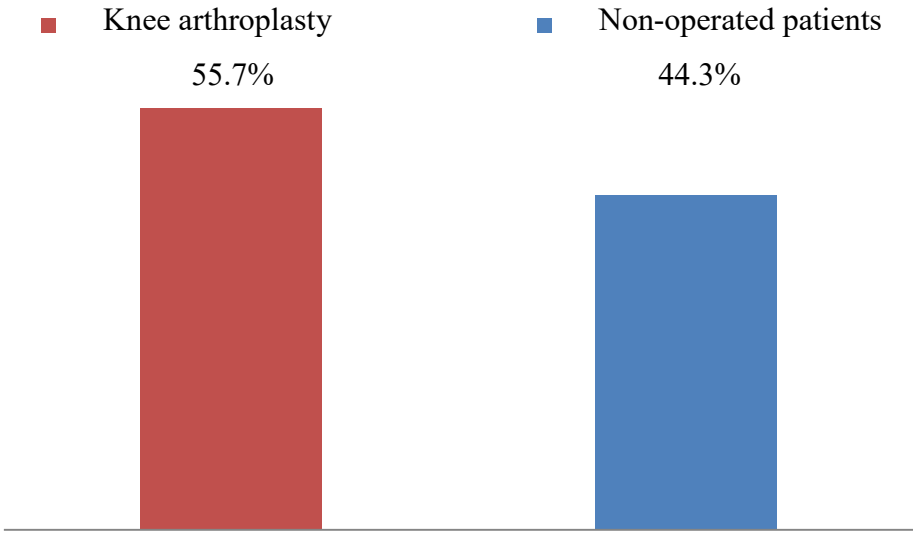


Figure 4.13. Outcomes (%) of comprehensive OA treatment two years after arthroscopy

At present, 77 (44.3%) patients in the observation group did not undergo arthroplasty. Long-term two-year results of treatment in OA patients who underwent arthroscopy are presented in Table 4.2 and Table 4.3.

Table 4.2 – Knee range of motion (degrees) in patients during treatment, Me, (Q1-Q3)

Motion	Baseline	Postoperative period, months			p-value (vs. baseline)
		1	12	24	
Flexion	91 (85-95) n=77	84* (80-90) n=77	83° (80-90) n=77	89^ (85-90) n=77	*p>0.05 ° p>0.05 ^ p>0.05
Extension	168 (163-173) n=77	175* (165-180) n=77	177° (170-180) n=77	173^ (170-180) n=77	*p>0.05 ° p>0.05 ^ p>0.05

Note: p - Wilcoxon's t-test; p-values are provided for comparisons vs baseline within a subgroup; n - number of observations

As shown in Table 4.2, in patients undergone therapeutic and diagnostic arthroscopy, the best range of motion was observed one year after the operation. Later, the knee range of motion returned to baseline, due to the progression of degenerative and dystrophic changes in the joint.

Table 4.3 - Patient assessment of pain per VAS, score, during follow-up period, Me, (Q1- Q3)

Pain per VAS	Postoperative period, months n=77			p-value
Baseline	1	12	24	
8 (7-9)	6° (7-9)	4* (6-9)	4^ (6-9)	°p>0.05 * p>0.05 ^ p>0.05

Note: p - Wilcoxon's t-test; p-values are provided for comparisons vs 6 months value within a subgroup; n - number of observations

The pain was the most intense at baseline before arthroplasty (median of 8 VAS scores). Further the pain intensity decreased, with the median score of 4 at 12 and 24 months after the operation. This provided good knee joint function and quality of life parameters in patients of this group.

During the two-year follow-up period, all these patients received conservative

treatment (medications, therapeutic exercises, physiotherapy, SYSADOA, etc.), including inpatient treatment, which allowed to avoid knee arthroplasty.

In 62 (80.5%) of 77 patients, a decrease in the pain intensity and a slight restriction of the knee motion were observed 2 years after the arthroscopy, which provided excellent and good functional outcomes. In 15 (19.5%) patients, the functional outcomes were considered satisfactory by the end of the second year of follow-up. Of those, 4 (5.2%) patients could not be assigned for arthroplasty due to the pronounced concomitant pathology resulting in low body functional reserves. Other 11 (14.3%) patients were assigned for arthroplasty.

Thus, the proposed comprehensive strategy, allows to significantly reduce the number of unsatisfactory two-year results of the treatment in knee OA, to improve functional outcomes and patients quality of life, and to postpone or avoid the knee arthroplasty. Knee OA is a widespread degenerative and dystrophic disease. Knee arthroplasty is the operation of choice in the end-stage OA. Nonetheless, experts all over the world state that the operation is performed prematurely or unreasonably in 15-30% of cases. Introduction of the comprehensive treatment strategy including arthroscopy for the knee OA will allow to avoid the premature and unreasonable arthroplasty. Arthroscopy in OA helps the diagnosis verification, synovitis regression, joint inflammation reduction, and thus functional outcomes and patients quality of life improvement. Knee arthroscopy in the OA of end-stage can also be considered as the arthroplasty-preceding procedure.

RESUME

The number of patients with orthopedic and traumatologic pathology in the structure of general morbidity worldwide remains significant, stays on the second place right after cardiovascular diseases. Knee OA is one of the most common diseases in orthopedic practice. WHO experts predict the increase in the number of patients with knee diseases due to demographic aging of the population and prolonged lifespan. Knee arthroplasty is currently considered the operation of choice in the treatment of patients with knee OA. At the same time, the risks of complications, unsatisfactory functional outcomes and quality of life remain even in the long term after knee arthroplasty.

Today arthroscopic treatment for the knee injuries and pathology is widespread and performed routinely. At the same time, the impact of arthroscopy for the treatment of patients with stage 3 knee OA is actively discussed at various medical forums.

Many authors indicate an increase in the number of patients who are not satisfied with the results of arthroplasty both in the short-term (in case of complications) and in the long-term postoperative period due to natural wear of the prosthesis. On the other hand, the indications for arthroplasty are commonly and unreasonably expanded, which is associated with the increased incidence of the poor procedure results and the need for revision. In some patients, knee replacement with an implant is performed without prior conservative treatment and organ-preserving surgical intervention. Some authors suggest arthroscopic debridement combined with intra-articular drug administration as an alternative to knee arthroplasty.

The obtained data warrant a scientific study dedicated to the impact of arthroscopy in the treatment of knee OA.

The purpose of this study was to improve the treatment results in patients with stage 3 knee OA by introducing of a comprehensive strategy using the expanded list of arthroscopy indications. The following study objectives were elucidated. The direct outcomes of arthroscopy and arthroplasty in the treatment of patients with stage 3 knee OA were assessed. The structure of short- and long-term results of the knee OA surgical treatment were evaluated. The validity of knee arthroplasty was determined based on the

retrospective study of the removed joints patho-morphology. The long-term results of arthroscopy in patients with stage 3 knee OA were studied. The comprehensive treatment strategy for the knee OA was developed and justified considering the use of arthroscopy prior to arthroplasty. The improvement in the long-term results of knee OA treatment based on the proposed strategy was demonstrated.

To elucidate the study objectives, the data on several patient groups were analyzed.

A total of 211 patients aged 18 to 72 years (mean±SD 45.4±5.5 years) underwent knee arthroscopy due to OA at the Clinic of Traumatology and Orthopedics of I.I. Mechnikov NWSMU from 2019 to 2021 (inclusive); these patients were considered as the first retrospective group. Comprehensive conservative treatment of knee OA after arthroscopy was performed in 119 (56.3%) patients. Of those, 64 (53.8%) patients returned for repeated inpatient conservative treatment, the remaining 55 (46.2%) patient were outpatiently under the attending physician supervision. Other 92 (43.7%) patients were occasionally self-treated with nonsteroidal anti-inflammatory drugs (NSAIDs).

A total of 219 patients aged 44 to 79 years (mean±SD 59.3±7.3 years) underwent conservative treatment for the knee OA at the Clinic at the same time, from 2019 to 2021; i.e. the second study group.

The third study group consisted of the patients who underwent total knee replacement for OA. A total of 677 total knee replacements were performed due to idiopathic OA at the Peter the Great Hospital of NWSMU from 2019 to 2021. The mean±SD age of the patients was 69.3±7.3 years (from 40 to 88 years).

In general, three study groups (knee arthroscopy, conservative treatment, and arthroplasty) were comparable in age and gender.

In 2022, total knee replacement was performed in 187 patients with knee OA at the Clinic. Materials for intravital patho-morphological examination were taken randomly from 30 patients aged from 40 to 76 years (19 females and 11 males).

The study presents the data on several groups of patients analyzed with the required number of observations. Thus, the data are considered sufficient to provide a representative sample and reliable results.

All patients included in the study underwent a standard clinical examination.

Biological fluids of the treated patients were tested in the central clinical laboratory department of I.I. Mechnikov NWSMU.

All patients with knee OA underwent radiological examination prior to knee conservative or surgical treatment. When indicated, EGD, Doppler ultrasonography, knee ultrasound, abdomen ultrasound, CT or MRI, and surgical site ultrasound were performed (Khaidarov V.M. et al., 2021).

The functional outcomes of conservative and surgical treatments of knee OA was assessed using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) (Bellamy N. et al., 1988). The patient's quality of life was assessed according to the WHO International Classification of Functioning, Disability and Health 2001 (World Health Organization 2001).

Histological samples for morphological examination were prepared according to the standard technique for bone preparation including decalcification (Sarkisov D.S., Perov Y.L., 1996). The changes in cartilage, subchondral bone, and intertrabecular tissue were assessed by microcopy.

The Osteoarthritis Research Society International (OARSI) Cartilage Histopathology Assessment System (OOCHAS) was used to assess the damage of the articular surface and subchondral bone (Tkachenko A.N. et al., 2023; Custers R.J. et al., 2007).

The results were analyzed using conventional statistical processing carried out in the STATISTICA 10 program (GraphPad Prism 5). Text editing and graphic design were performed using Microsoft® Word 2010 and Microsoft® Office Excel 2010 in the WINDOWS XPpro system (Microsoft®, USA).

By methods used the study be considered an active dynamic retrospective-prospective single-center unblinded open-label non-randomized clinical study for the evaluation of therapeutic and diagnostic effects in randomly assigned groups of subjects using modern approaches of medical variation statistics.

The data on 1107 patients with stage 3 knee OA treated in the Clinic from 2019 to 2021 were analyzed. The patients were examined per three groups: 1) 677 patients undergone primary total knee replacement; 2) 219 patients undergone conservative

inpatient treatment; 3) 211 patients undergone arthroscopy.

In general, all three groups were comparable in age and gender. However, there were some peculiarities. In contrast to the conservative treatment and the arthroscopy groups, most of the patients who underwent arthroscopy were of young age (n=84, 39.8%). There were 37 (17.5%) older patients in this group. The gender composition of the arthroscopy group also differs from those of the conservative treatment and the arthroscopy groups: there were 99 males (46.9%) and 112 females (53.1%), which is 1:1 ratio. Patients with fewer comorbidities underwent arthroscopic interventions.

Various complications developed during surgical treatment of knee OA. Surgery-related complications occurred 2 times less frequently during arthroscopy than during arthroplasty: 16 (7.6%) and 106 (15.7%), respectively.

Only 5 (2.4%) cases of cartilage injury were observed within local intraoperative complications of arthroscopy. There were no systemic intraoperative complications during the operation. During arthroplasty, the medial collateral ligament injury was the most common local complication occurred in 7 (1.0%) patients. The most common systemic intraoperative complications of arthroplasty were cardiovascular failure occurred in 10 (1.2%) patients and respiratory complications in 7 (1.0%) patients.

There were 2 (0.9%) patients undergone arthroscopy who experienced SSI as a postoperative complication. Both cases were superficial infections. In the patients undergone arthroplasty, 25 (3.7%) cases of SSI were observed. Deep infection was reported in 12 (1.8%) patients.

Systemic complications of arthroplasty were observed in 25 (3.7%) patients. Cardiovascular and respiratory system complications were the most common reported in 10 (1.5%) patients and 8 (1.2%) patients, respectively.

Conservative treatment was conducted inpatiently in 219 patients. Most often non-steroidal anti-inflammatory drugs were used, in 212 (96.8%) patients. Some patients n=153, 69.9%) were also prescribed therapeutic exercises including isometric and isotonic muscle strengthening exercises, range of motion exercises, stretching, and aerobics. Platelet rich plasma (PRP) was performed in 112 (51.2%) patients during hospitalization. In addition, 31 (17.8%) patients received the basic chondroprotective

Symptomatic Slow-Acting Drug in Osteoarthritis (SYSADOA) treatment in combination with non-medication therapy including daily walking and an individual exercise program during hospitalization.

Functional outcomes were assessed using the WOMAC scale at 3-6 years of follow-up. The scale allows determination of outcomes not only for the knee arthroplasty, but also for conservative treatment of OA. Excellent and good conservative treatment outcomes decreased by the 3rd year of follow-up from 72% to 64%, which was statistically insignificant ($p > 0.05$). WOMAC assessment of knee arthroplasty results also shows a decrease in the number of patients with excellent and good results from 99% in the 1st year of follow-up to 96% in the 3rd year. There were no statistically significant differences either with conservative treatment or knee arthroplasty. However, the trend of decreasing number of patients with excellent and good outcomes was more pronounced in the arthroplasty group. Probably, the assessments of arthroplasty functional outcomes and conservative treatment outcomes in knee OA would grow equal in 5-7 years. Further prognosis requires studying the results of conservative and surgical treatment of osteoarthritis in the long term - in 10 and 15 years. Further prognosis requires a comprehensive study of the OA treatment results both conservative and surgical in terms of 10 and 15 years.

The histological part of the knee OA treatment process was examined, and the validity of arthroplasty was determined retrospectively.

Materials from random 30 patients aged 40 to 76 years (19 females and 11 males), of those 187 patients hospitalized in the Clinic in 2022 were assigned for intravital histological examination.

There were more females (n=15, 8%) than males (n=8, 4.3%) in the younger age group. There were also more female patients in the middle age and older age groups. The male/female ratio was 1:2 in young and elderly patients, and 1:3 (11.8% and 28.3%, respectively) in middle-aged patients (45 to 64 years).

Based on disease history, only 48 (25.7%) patients received inpatient conservative treatment or organ-preserving surgical treatment for knee OA at least once before undergoing arthroplasty. In addition, 139 (74.3%) patients received occasional

conservative treatment outpatiently.

Prior to arthroplasty, knee radiography was performed in 187 patients. MRI was performed in 84 (44.9%) patients. The diagnosis of stage 3 knee OA was verified in 123 (65.8%) patients after the examination. In 64 (34.2%) patients, OA of stage 2-3 was diagnosed.

Both the signs of initial stage (Fig. 3.12) and stage 2-3 (Figs. 3.13 and 3.14) of knee OA were identified during the sectioned slides examination.

The slides examination revealed different morphological stages of OA: from initial manifestations to stage 3 of the disease. Of 30 histological examinations performed, stage I knee OA as per N.S. Kosinskaya was determined in 3 (10%) patients (Fig. 3.12); stage II OA in 8 (26.7%) patients (Fig. 3.13), and stage III OA in 19 (63.3%) patients (Fig. 3.14).

Undoubtedly, deciding on knee arthroplasty, orthopedic traumatologists were considering not only the data of radiological or tomographic examinations showing the presumed stage of OA. They also took into account the clinical characteristics of the disease (including disease duration, pain intensity, and the conservative treatment effectiveness). The results of the examinations of knee joint stability and ligaments changes were also taken to account. However, in the majority of patients with knee OA (139 out of 187 patients, 74.3%) the first inpatient treatment was total knee replacement, which is noteworthy.

Arthroplasty is not an organ-preserving operation. It may be accompanied by intra- or postoperative complications up to death as any other surgery. After an arthroplasty, patients sometimes violate the recommendations for the restriction of movement in the operated joint, which can lead to various complications. An implant does not last forever, and the results of the operation are sometimes inadequate. Besides, indications for arthroplasty are imperfect and are constantly revised, usually resulting in a more restricted list. On the other hand, the health care standards in Russia do not provide for mandatory check-ups in patients with OA; inpatient treatment program warranted by governmental medical insurance for such patients is one of the cheapest. Moreover, the interaction between physicians, orthopedists, rheumatologists, and rehabilitation specialists is not

regulated by a strict algorithm. A similar situation is observed in the USA, the European Union and Asia.

Based on the morphological examination data, it can be concluded that the knee arthroplasty was performed prematurely in 11 (36.7%) patients with stage I-II OA (as per N.S. Kosinskaya), and no potentially effective conservative treatments or minimally invasive surgical interventions were used in advance.

Several factors were taken into account when developing a comprehensive treatment strategy for knee OA.

Most of the patients (n=261, 38.6%) with knee OA were self-treated occasionally before hospitalization for arthroplasty. Nearly every third patient (n=122) was hospitalized for arthroplasty immediately after their initial visit to an outpatient specialist. Only 82 (12.1%) patients received conservative treatment inpatiently.

A plenty of publications appeared in the recent years on the effectiveness of conservative treatments and minimally invasive surgical interventions in patients with knee OA. However, no treatment strategy, which would include outpatient examination and treatment, inpatient conservative treatment, minimally invasive surgical interventions, a last-resort treatment with knee replacement, and rehabilitation, for such patients was established neither in Russia nor in other countries.

The keystone of the proposed strategy is to consider knee arthroplasty as the final stage of OA treatment, which should be applied only after conservative treatment and minimally invasive surgical interventions have been conducted.

The proposed strategy can be a part of the comprehensive treatment in patients with knee OA, which includes outpatient examination and treatment, inpatient conservative treatment, minimally invasive surgical interventions, a last-resort treatment with knee arthroplasty, and rehabilitation.

To optimize the treatment of patients with knee OA, it is also necessary to develop an algorithm of various specialists' interaction including physicians, orthopedists, rheumatologists, and rehabilitation specialists during outpatient and inpatient stages of patient management, as well as sanatorium treatment.

The strategy was tested using among others the data of the prospective study, which

is currently ongoing at the Department of Traumatology, Orthopedics, and Internal Medicine of the I.I. Mechnikov NWSMU. This study is planned to recruit clinical materials for 5 years or more.

Thus, the long-term arthroscopy results may vary; however, the personification of treatment in these patients could prevent or delay arthroplasty. In some cases, conservative or organ-preserving surgical treatments could improve the quality of life and prevent unacceptable results of arthroplasty.

The increasing number of publications worldwide including Russia indicate that arthroplasty is often performed prematurely, and no potentially effective conservative treatments or minimally invasive surgical interventions are used in advance.

Knee arthroplasty with an implant is not an organ-preserving intervention. All components of the joint (articular surfaces, synovial membrane, and joint capsule) are removed, and an implant (which does not last forever) is installed during this operation. In addition, arthroplasty may be accompanied by intra- or postoperative complications up to death as any other surgery. The patients sometimes violate the recommendations for the restriction of movement in the operated joint, which can lead to various complications.

In addition, the indications for arthroplasty are imperfect and are constantly being revised, usually resulting in a more restricted list. On the other hand, the health care standards in Russia do not provide for mandatory check-ups in patients with OA; inpatient treatment program warranted by governmental medical insurance for such patients is one of the cheapest. Moreover, the interaction between physicians, orthopedists, rheumatologists, and rehabilitation specialists is not regulated by a strict algorithm. A similar situation is observed in the USA, the European Union and Asia.

The obtained data warrant a scientific study aimed at improving and objectivizing OA diagnosis and developing a treatment strategy for patients with knee OA, including conservative treatment, minimally invasive surgical intervention, knee arthroplasty (as a last-resort treatment), and rehabilitation.

CONCLUSIONS

1. Among local intraoperative complications of arthroscopy, 5 (2.4%) cases of cartilage damage were observed. In the early postoperative period, hematoma (n=8, 3.8%) and synovitis (n=8, 3.8%) were the most common. Superficial SSI was registered in 2 (0.9%) patients. The local intraoperative complications of arthroplasty were verified in 6.6% of patients. The medial collateral ligament injury was the most common (n=7, 1.0%). During arthroplasty, SSI was observed in 25 (3.7%) patients. Deep infection was observed in 12 (1.8%) patients. Systemic arthroplasty complications were observed only in 25 (3.7%) patients. In general, intra-operative and early postoperative complications were diagnosed in 16 (7.6%) patients after arthroscopy and in 106 (15.7%) after arthroplasty. During 2 years after the operation the number of patients with satisfactory and unsatisfactory functional outcomes after arthroscopy increased 1.9 times (from 9 to 17.2%), while after arthroplasty - 11.3 times (from 0.6 to 6.8%).

2. According to the morphologic examination, stage 3 OA was confirmed in 19 (63.3%) patients. In the other 11 (36.7%) patients who underwent arthroplasty, stage 1-2 OA was verified, which indirectly confirms that the arthroplasty was performed prematurely, and no potentially effective conservative treatment or minimally invasive surgical intervention were used in advance.

3. Of the patients undergone arthroscopy for the stage 3 knee OA, 33.3% needed arthroplasty within the first year after the operation, and 22.4% needed that within the second year. Excellent and good functional outcomes were observed in 80.5% of patients who did not undergo arthroplasty.

4. The ways to improve the treatment results of patients with stage 3 knee OA are diagnosis clarification and the joint debridement using arthroscopy in combination with conservative methods according to the proposed strategy in advance to the joint arthroplasty. The comprehensive treatment strategy for the knee OA introduced to routine practice allowed preserving the joint for at least two years and providing with excellent and good quality of life in 30 % of patients.

PRACTICAL RECOMMENDATIONS

1. Deciding on a treatment for patients with end-stage knee OA, it is recommended to apply the proposed treatment strategy considering the use of arthroscopy.

2. The decision to perform knee arthroplasty should be made after an arthroscopy is performed.

3. In case of clinical and radiologic signs of stage 3 knee OA, it is necessary to keep in mind that the radiology results may be inconsistent with the morphological diagnosis and thus, the worse stage of the disease could be mistakenly determined based on the radiography.

4. Knee arthroplasty should be considered as a last-resort treatment of OA, after which all other methods would be ineffective due to the limited lasting of an implant. The treatment strategy for patients with knee OA, which includes the use of knee arthroscopy, allows to avoid or postpone arthroplasty in a patient.

PROSPECTS FOR FURTHER INVESTIGATIONS

Despite the improvement of the design and technology of arthroplasty, implants do not last forever. The number of patients unsatisfied with the results of the operation increases every year even if no complications occur. In addition, there are still no definite list of arthroplasty indications and contra-indications in OA, and the conservative treatment potential is not taken into account when determining the indications.

The number of patients with excellent and good functional outcomes decreases each year after arthroplasty, while the number of those with satisfactory and unsatisfactory outcomes increases.

At present, a range of modern conservative treatment methods for osteoarthritis have been developed including new pharmacological products, therapeutic exercises, cell therapy, etc. It could be recommended to start treatment with conservative methods in cases of OA without intense pain syndrome or pronounced changes in the joint.

More than 10 years have passed since the introduction of the “Health” national project and increasing of the funding that allowed improvements to the large joints arthroplasty in the Russian Federation. The patient needs in arthroplasty are being effectively met, and more and more institutions are providing this treatment. At the same time, the number of patients receiving comprehensive conservative OA treatment inpatiently is decreasing, whereas the number of patients with unsatisfactory arthroplasty results is increasing.

A prospective study of the proposed treatment strategy for knee OA with at least 10 years of clinical data collection has been started at the Department of Traumatology, Orthopedics, and Internal Medicine of I.I. Mechnikov NWSMU.

Currently, sufficient experience in performing arthroplasty has been obtained in Russia. According to many researchers, the results of knee arthroplasty cannot be recognized as absolutely positive. Arthroplasty should not be the method of choice for the treatment of OA in young and middle-aged patients, as well as for OA of early stages. It is also inappropriate to perform knee arthroplasty without prior comprehensive conservative treatment applied. A large-scale study is needed to specify the patient

selection criteria for knee arthroplasty that would also expand the target population for conservative and organ-preserving surgical treatment of degenerative and dystrophic knee diseases. Such a study will help to clarify the indications for arthroplasty in one of the most common joint diseases, knee OA.

ABBREVIATIONS

AANA - Arthroscopy Association of North America

AAOS - American Academy of Orthopedic Surgeons

ABOS - American Board of Orthopedic Surgery

ACMI - American Cystoscope Makers Inc.

ASA - American Society of Anesthesiologists

BMI – body mass index

BP – blood pressure

CI - confidence interval

CITO - Central Institute of Traumatology

CT – computed tomography

DVT - deep vein thrombosis

ECG – electrocardiography

EGD – esophagogastroduodenoscopy

ESSKA - European Society of Sports Traumatology, Knee Surgery and Arthroscopy

HSS - Hospital for Special Surgery scale

IAA - International Arthroscopy Association

KOOS - Knee injury and Osteoarthritis Outcome Score

MRI - magnetic resonance imaging

NSAIDs – nonsteroidal anti-inflammatory drugs

OA – osteoarthritis

PE – pulmonary embolism

PRP – platelet rich plasma

QALY - quality adjusted life year

SICOT - International Society of Orthopedic Surgery and Traumatology

SSI – surgical site infection

SYSADOA – Symptomatic Slow-Acting Drug in Osteoarthritis

VTE – venous thromboembolism

WHO – World Health Organization

WOMAC – Western Ontario and McMaster University Osteoarthritis Index

OOCHAS – Osteoarthritis Research Society International Cartilage Histopathology Assessment System

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