

Revision Total Hip Arthroplasty – What Are We to Expect?

Igor I. Shubnyakov¹, Andrey A. Korytkin², Alexey O. Denisov¹, Alisagib A. Dzhavadov¹, Aymen Riahi¹, Maksim S. Guatsaev¹, Abdula M. Chililov³, Rashid M. Tikhilov¹

¹ Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia

² Tsivyan Novosibirsk Research Institute of Traumatology and Orthopedics, Novosibirsk, Russia

³ Vishnevsky National Medical Research Center of Surgery, Moscow, Russia

Abstract

The paper analyzes the local total hip arthroplasty (THA) registry database over 18 years, from 2007 to 2024.

The following questions were posed. Are there any changes in the structure of revision THA? What are the current trends in revision THA in recent years? What revision technologies are being utilized?

A total of 11,201 cases of revision procedures were analyzed, which accounted for 12.4% of all registered THAs. Compared to previous analyses, the share of early revisions has increased – 42.2% of initial revisions and 87.6% of subsequent re-revisions are performed within the first five years after the previous surgery.

This analysis revealed several important trends:

1. The significant increase in both the absolute number and proportion of infection-related revisions (40.7%). This share is significantly higher for re-revisions (72.5%) compared to 20.2% for initial revisions.
2. Rejuvenation of revision – the average age is 60.7 years for aseptic revisions and 58.5 for infection-related ones.
3. The increase in proportion of trabecular metal constructs and other revision acetabular components, as well as a significant increase (up to 11.9%) of custom-made acetabular implants produced via 3D printing.
4. For femoral component revision, there is a steady trend towards using Wagner-type tapered fluted titanium components. Their share increased from 39.4% in 2019 to 61.7% in 2024.

There is a sharp increase in the number of revision procedures, a growing proportion of complex revisions requiring advanced and costly implants, and an exceptionally rapid rise in the number of infection-related revisions. It is therefore clear that the challenges of revision arthroplasty may soon affect all surgeons performing primary total hip arthroplasty – initially through the need to manage infectious complications, and later due to the gradual accumulation of patients requiring other types of revisions, including repeat procedures.

Keywords: revision total hip arthroplasty, arthroplasty registries.

Cite as: Shubnyakov I.I., Korytkin A.A., Denisov A.O., Dzhavadov A.A., Riahi A., Guatsaev M.S., Chililov A.M., Tikhilov R.M. Revision Total Hip Arthroplasty – What Are We to Expect? *Traumatology and Orthopedics of Russia*. 2025;31(2):132-152. (In Russian). <https://doi.org/10.17816/2311-2905-17697>.

✉ Igor I. Shubnyakov; e-mail: shubnyakov@mail.ru

Submitted: 26.03.2025. Accepted: 17.04.2025. Published online: 19.05.2025.

© Shubnyakov I.I., Korytkin A.A., Denisov A.O., Dzhavadov A.A., Riahi A., Guatsaev M.S., Chililov A.M., Tikhilov R.M., 2025

Ревизионное эндопротезирование тазобедренного сустава — что нас ждет?

И.И. Шубняков¹, А.А. Корыткин², А.О. Денисов¹, А.А. Джавадов¹, А. Риахи¹,
М.С. Гуацаев¹, А.М. Чилилов³, Р.М. Тихилов¹

¹ ФГБУ «Национальный медицинский исследовательский центр травматологии и ортопедии им. Р.Р. Вредена» Минздрава России, г. Санкт-Петербург, Россия

² ФГБУ «Новосибирский научно-исследовательский институт травматологии и ортопедии им. Я.Л. Цивьяна» Минздрава России, г. Новосибирск, Россия

³ ФГБУ «Национальный медицинский исследовательский центр хирургии им. А.В. Вишневского» Минздрава России, г. Москва, Россия

Реферат

Работа представляет собой анализ локальной базы регистра эндопротезирования тазобедренного сустава (ТБС) за 18 лет с 2007 по 2024 г.

Были поставлены следующие вопросы. Отмечаются ли какие-либо изменения в структуре ревизионного эндопротезирования ТБС? Какие тенденции в ревизионном эндопротезировании ТБС наблюдаются в последние годы? Какие применяются технологии ревизии?

Всего проанализирован 11 201 случай ревизии эндопротеза ТБС, что составило 12,4% от общего числа зарегистрированных операций. В сравнении с предыдущими анализами увеличилась доля ранних ревизий — 42,2% первых ревизий и 87,6% последующих ре-ревизий выполняются в первые пять лет после предшествующего вмешательства.

Отмечен ряд важных трендов:

1. Интенсивный рост в структуре ревизий абсолютного числа и доли инфекционных ревизий (40,7%). Эта доля значительно выше в группе ре-ревизий (72,5%) в сравнении с 20,2% в группе первых ревизий.
2. Омоложение ревизии — средний возраст 60,7 года при асептических ревизиях и 58,5 года при инфекционных.
3. Увеличение доли конструкций из трабекулярного металла и других ревизионных вертлужных компонентов, а также значительная доля (до 11,9%) индивидуальных вертлужных имплантатов, изготовленных методом 3D-печати.
4. В ревизионной замене бедренных компонентов отмечается устойчивый тренд на увеличение титановых конических ребристых компонентов типа Wagner. Их доля выросла с 39,4% в 2019 г. до 61,7% в 2024 г. Интенсивное увеличение числа ревизионных операций с нарастанием числа случаев сложных ревизий, требующих использования сложных и дорогостоящих имплантатов, а также чрезвычайно быстрое увеличение числа случаев инфекционных ревизий свидетельствует о том, что проблемы ревизионного эндопротезирования очень скоро могут коснуться всех хирургов, выполняющих первичную замену ТБС, сначала через необходимость лечить инфекционные осложнения, а затем за счет постепенного накопления пула пациентов, нуждающихся в других вариантах ревизий, в том числе повторных.

Ключевые слова: ревизионное эндопротезирование тазобедренного сустава, регистры эндопротезирования.

 **Для цитирования:** Шубняков И.И., Корыткин А.А., Денисов А.О., Джавадов А.А., Риахи А., Гуацаев М.С., Чилилов А.М., Тихилов Р.М. Ревизионное эндопротезирование тазобедренного сустава — что нас ждет? *Травматология и ортопедия России*. 2025;31(2):132-152. <https://doi.org/10.17816/2311-2905-17697>.

 Шубняков Игорь Иванович; e-mail: shubnyakov@mail.ru

Рукопись получена: 26.03.2025. Рукопись одобрена: 17.04.2025. Статья опубликована онлайн: 19.05.2025.

© Шубняков И.И., Корыткин А.А., Денисов А.О., Джавадов А.А., Риахи А., Гуацаев М.С., Чилилов А.М., Тихилов Р.М., 2025

INTRODUCTION

In modern orthopedic literature, publications based on arthroplasty registry data provide the most comprehensive overview of trends in the use of various implants and perioperative technologies, as well as their short- and long-term effectiveness in different patient populations [1, 2, 3, 4, 5, 6, 7]. The vast accumulated datasets of registries make it possible to evaluate the survival of different implants depending on multiple factors simultaneously – for example, the type of prosthetic components' fixation, bearing surface used, and patient age¹, or the survival of a specific femoral component model in combination with a particular acetabular component model². Registry data analysis also enables long-term healthcare budgeting and supports organizational decision-making regarding patient routing and the scope of specialized care [8, 9].

Despite numerous efforts by individual institutions and healthcare authorities to establish a national hip arthroplasty registry in the Russian Federation, a comprehensive database covering all total hip arthroplasty (THA) procedures is still lacking. Only local databases are available, which fail to fully reflect the processes occurring across various regions and healthcare institutions under different jurisdictions. These databases do not allow for even a basic estimate of the total number of procedures performed, let alone insights into the underlying indications, complication rates, revision surgery patterns, or outcomes [10, 11].

Based on individual studies [12] and taking into account the overall upward trend in the number of operations, it is estimated that no fewer than 100,000 primary THA procedures are currently performed annually in Russia. The proportion of revision arthroplasty accounts for approximately 6% [12]. On the one hand, this number is comparable to that of other countries; on the other hand, it represents several thousand procedures per year, whose outcomes are significantly worse than those of primary arthroplasty. A substantial proportion of these patients will require further specialized care

[13, 14]. In fact, revision surgery may pose a life-threatening risk – statistics show that 1 in 145 patients undergoing revision dies [15]. Furthermore, the revision workload varies significantly across arthroplasty centers, likely necessitating adjustments to the financial coverage of such procedures, as international experience highlights the importance of periodically revising reimbursement tariffs. Otherwise, healthcare institutions may begin to “adapt” to existing tariffs by using less effective technologies, thereby increasing the subsequent burden on the healthcare system [16].

In recent years, numerous organizational changes have occurred in the field of THA: the procedure has shifted from being categorized as a high-tech intervention to a routine one covered by the Obligatory Medical Insurance (OMI) system. This transition allows for the performance of such operations in all Russian medical institutions that provide specialized trauma and orthopedic care. Naturally, this has had a significant positive impact on the availability of specialized care for Russian citizens. However, the widespread performance of primary THA inevitably leads to an increase in the number of patients requiring revision surgery. Currently, revision arthroplasty is not performed in all medical facilities, and waiting lists for such procedures tend to grow. At the same time, the need for revision surgery is often more urgent than for primary procedures, as patients with complications such as infection, recurrent dislocation, or periprosthetic fracture require immediate attention but may face prolonged delays due to long waiting lists.

The absence of a national THA registry in the Russian Federation hinders the collection of comprehensive data on the prevalence, structure, and actual effectiveness of both primary and revision THA procedures performed in domestic healthcare facilities. Consequently, only isolated publications based on large datasets, including local databases, offer approximate insights into the population characteristics of Russian patients and current trends in this area of trauma and orthopedic surgery [10, 17, 18]. The most

¹ National Joint Registry. 21st Annual Report, 2024. <https://reports.njrcentre.org.uk>

² The Australian Orthopaedic Association National Joint Replacement Registry. Annual Report 2024. <https://aoanjrr.sahmri.com/home>

recent analysis of revision surgery structure, based on the data from the local registry of the Vreden National Medical Research Center of Traumatology and Orthopedics, was conducted in 2019 and revealed an almost twofold increase in the proportion of early revisions following primary total THA – from 19.6 to 37.4% [11, 17].

The continued accumulation of registry data allows new research questions to be formulated, which are addressed in the present study:

1. Are there any changes in the structure of revision THA?
2. What are the current trends in revision THA in recent years?
3. What revision technologies are being utilized?

METHODS

The cleaned dataset of the local THA registry contains information on 90.427 THA cases performed between 2007 and 2024, of which 11.201 (12.4%) represent various revision procedures (Figure 1).

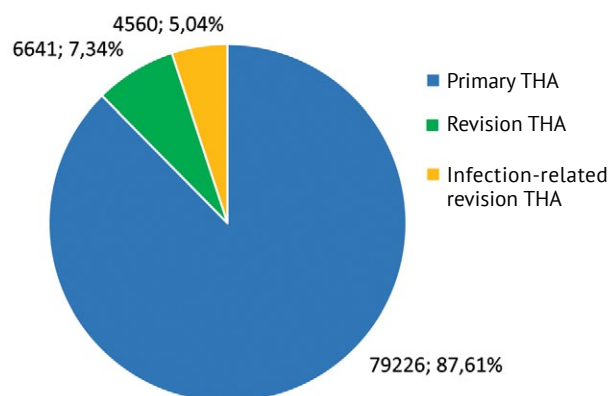


Figure 1. Distribution of patients by type of arthroplasty performed

The following categories of procedures were identified.

1. “Primary THA” is addressed in this study only in a general context.
2. “Revision THA” includes several aseptic indications for re-operation:
 - “aseptic loosening of prosthetic components” – loss of fixation of one or both components;
 - “dislocations” – recurrent and irreducible dislocations requiring surgical intervention on the prosthetic joint;

- “periprosthetic fractures” – fractures in the region of the prosthesis requiring surgical management;

- “polyethylene liner/cement cup wear and associated osteolysis”;

- “other causes” – included pain syndrome, malposition of components, mechanical damage to prosthetic components, muscular insufficiency, and heterotopic ossification.

3. “Infection-related revision THA” includes various types of revision procedures performed in patients diagnosed with periprosthetic joint infection (PJI) according to the 2018 International Consensus Meeting on Musculoskeletal Infection criteria [19]:

- “debridement procedures for prosthesis retention (DAIR³)”;

- “one-stage revision” – removal of prosthetic components, debridement, and reimplantation during a single surgical procedure;

- “two-stage revision” (each stage considered as a separate case):

- first stage – removal of the prosthesis and debridement;

- second stage – removal of the temporary spacer and implantation of a new prosthesis;

- prosthesis removal with various soft-tissue grafting or resection arthroplasty;

- implantation of a new prosthesis following muscular or resection arthroplasty;

- “other” – use of external fixation to restore limb weight-bearing function without prosthesis, or creation of a permanent fistula to reduce bacterial load.

The study examined dynamic changes in the structure of revision procedures, reasons for revision, volume of revisions performed, and patient characteristics. In some cases, when data on previous procedures were available (linked records), potential risks of revision or re-revision were analyzed.

Statistical Analysis

Calculations were performed using Microsoft Excel for Mac (Office 365) and SPSS (version 24.0). Descriptive statistics methods were applied, including presentation of absolute values and proportions. For quantitative variables, mean values, 95% confidence intervals (95% CI), and medians were reported. The Mann-Whitney U

³ DAIR – Debridement, Antibiotic therapy, and Implant Retention.

test was used for comparing means. Proportions were compared using the χ^2 test, and in some cases, odds ratios were calculated.

RESULTS

Proportion of revisions in the overall structure of THA procedures

Between 2007 and 2024, revision procedures accounted for 12.4% of all THAs. Over the years, the proportion of revision operations relative to the total number of THA procedures varied between 8.4 and 20.8%. A distinct trend was observed toward an increasing share of infection-related revisions, ranging from 24.1 to 50.6% (Figure 2).

The considerable fluctuations in the proportion between primary and revision THA procedures are not indicative of changes in actual clinical demand but are instead associated with allocated quotas under different funding streams (e.g., High-Tech Medical Care, High-Tech Medical Care within the Obligatory Medical Insurance system) and the operational capacities of medical facilities, whose data are captured

in the registry. Unfortunately, we lack accurate data on the true population need for revision procedures. However, analysis of our center's waiting list and telemedicine consultation records indicates that the time from problem onset to admission to a specialized facility for many patients in need of revision surgery can range from several months to up to three years. Meanwhile, patients requiring primary THA may undergo surgery almost immediately after consultation at one of the centers that provide this service.

Demographic and geographic characteristics of patients

There was a statistically significant difference in the gender distribution between patients undergoing primary and aseptic revision THA ($p < 0.001$) (Figure 3). The odds ratio (OR) for undergoing aseptic revision was higher among women (OR = 1.242; 95% CI 1.179-1.308), whereas the risk of infection-related revision was higher among men (OR = 1.284; 95% CI 1.211-1.361).

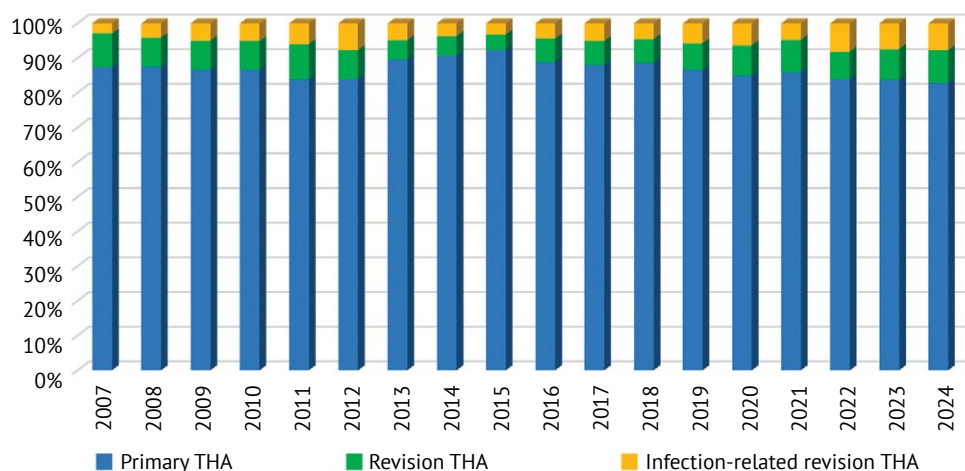


Figure 2. Ratio of surgery types by year

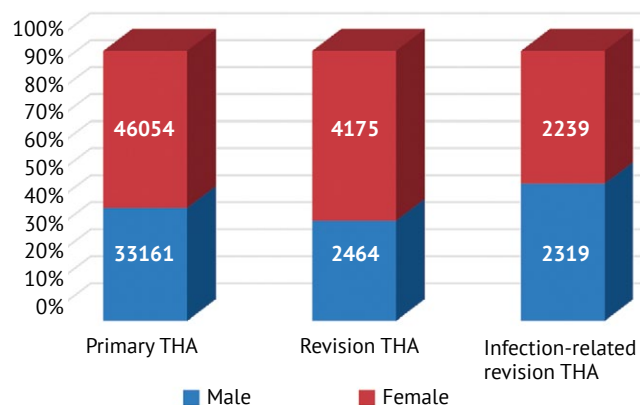


Figure 3. Gender composition of the patient cohort who underwent primary aseptic revision THA and revision THA due to infection from 2007 to 2024

The mean age at the time of aseptic revision THA was 60.7 years (95% CI 60.4-61.0; median 62 years), which is slightly older than patients undergoing primary THA – 58.0 years (95% CI 58.0-59.1; median 60 years), and those undergoing infection-related revision – 58.5 years (95% CI 58.1-58.8; median 60 years).

Unfortunately, information about the specific medical facilities where primary THA was performed is very limited and could not be analyzed. No substantial gender differences were observed among patient groups from different regions in our study.

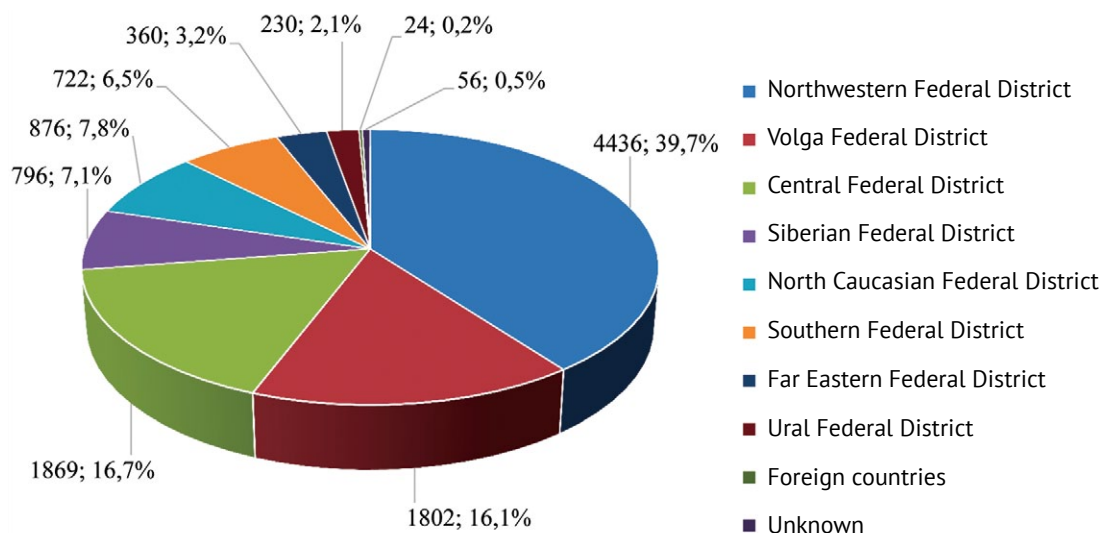


Figure 4. Geographic distribution by place of residence of patients who underwent revision or re-revision

The majority of patients undergoing revision procedures recorded in the registry are residents of the Northwestern Federal District. The Central Federal District ranks second, followed closely by the Volga Federal District. Residents of other federal districts are represented in smaller numbers (Figure 4).

Timing and causes of revision procedures

Unfortunately, the date of the previous surgery was not available in all cases; only 5.962 observations were accessible for this study. As shown in two earlier analyses, the majority of revision operations are performed within the first few years after the initial procedure [11, 17]. The structure of the chart in Figure 5 remains virtually unchanged, demonstrating that by the second year, the number of revisions is reduced by more than half, followed by a gradual decline with a minor spike at 9-10 years, likely due to the accumulation of delayed complications. However, when aseptic revisions and those performed

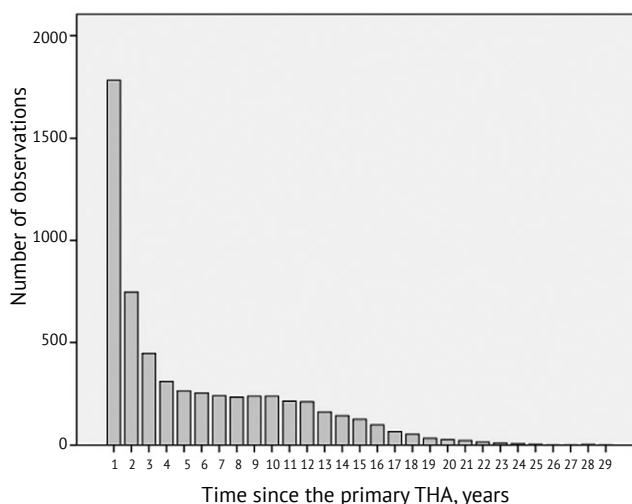


Figure 5. Distribution of revisions by time since the previous surgery

due to infectious complications are considered separately, the pattern of the graphs changes significantly. Still, in all cases, the majority of revisions occur within the first three years (Figure 6).

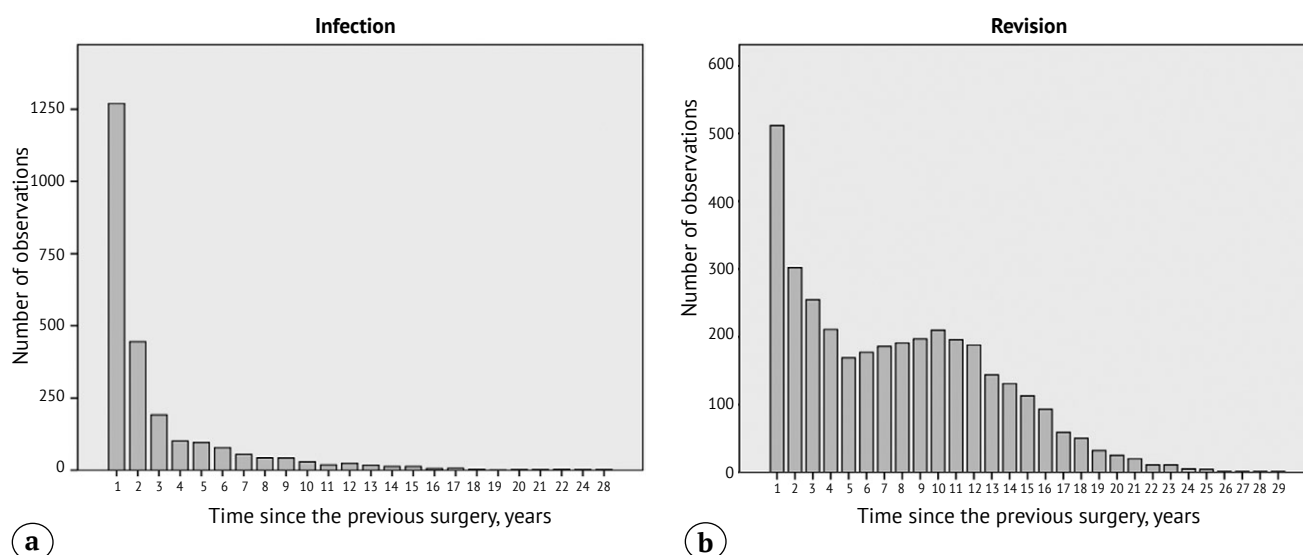


Figure 6. Distribution of revisions due to infection (a) and aseptic loosening (b) by time since the previous surgery

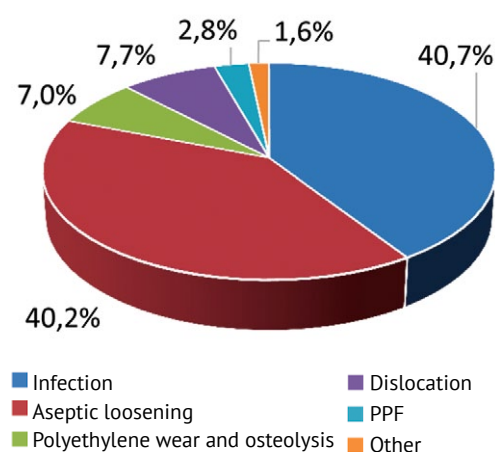


Figure 7. Proportion of different causes of revision THA

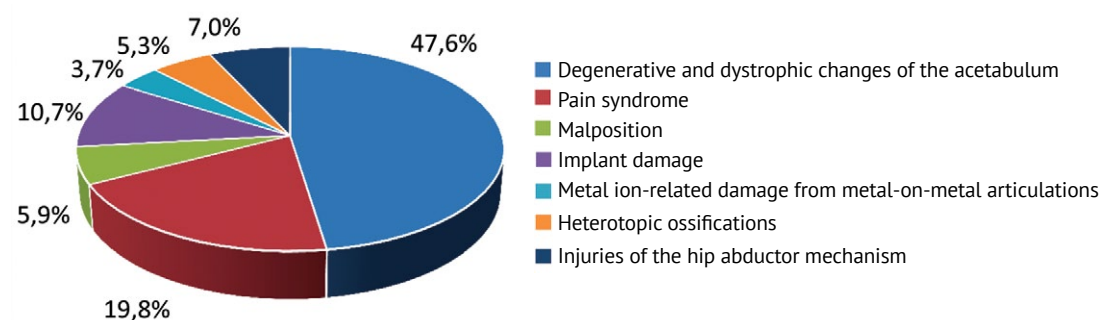


Figure 8. Structure of causes for hip prosthesis revisions in the “Other” category

The main causes of all revisions were infection (40.7%) and aseptic loosening of prosthetic components (40.2%). Dislocations accounted for 7.7%, while polyethylene wear and osteolysis represented 7.0%. Periprosthetic fractures (PPFs) and other causes made up 2.8% and 1.6%, respectively (Figure 7). Among the 187 aseptic revisions classified under “Other”, 89 (47.6%) were due to degenerative and dystrophic changes of the acetabulum in monopolar or bipolar arthroplasties, 37 (19.8%) were attributed to pain syndrome of various etiologies, 11 (5.9%) to malposition of components, 20 (10.7%) to fractures of femoral stems or modular necks (implant damage), 7 (3.7%) to metal ion-related damage from metal-on-metal articulations, 10 (5.3%) to heterotopic ossifications requiring excision, and 13 (7.0%) to injuries of the hip abductor mechanism (Figure 8).

As in previous analyses, the structure of initial revisions significantly differed from that of re-revisions. When the previous surgery was a primary THA, the proportion of revisions due to infection was substantially lower (20.2%), with the leading cause being aseptic loosening (54.9%). Other causes included polyethylene wear and osteolysis (9.1%), dislocations (8.9%), PPFs (4.1%), and other reasons (2.8%) (Figure 9a). In re-revisions, most interventions (72.5%) were performed for patients diagnosed with orthopedic infections at various stages. Aseptic loosening accounted for 17.4%, dislocations 6.8%, PPFs 1%, and other causes 0.7% (Figure 9b). The annual distribution of revisions vs re-revisions lacked a consistent pattern, but there was a clear trend toward an overall increase in the number of operations.

Within the group of aseptic revisions, the share of aseptic loosening decreased from 86.4% in 2007 to 57.6% in 2024, while the proportion of polyethylene wear rose from 0.6% in 2007 to 19.6% in 2023, with a slight decline to 18.3% thereafter (Figure 10). The share of dislocations increased from 8.4 to 16.4%. The proportion of PPFs varied from 1.9 to 8.4%. Other causes showed minimal fluctuation.

Interestingly, the proportion of combined loosening of both components steadily declined (Figure 11). In the early years of the registry, loosening of both components was recorded in 47.7-52.1% of cases; in recent years, this figure fell to 14.7-16.2%. It is unclear whether this reflects diagnostic practices or a true decrease in such cases. Meanwhile, the frequency of isolated femoral component loosening increased from 7.5-12.7% to 31.2-33.5%, and acetabular component loosening ranged from 33.3 to 55.4% across the years.

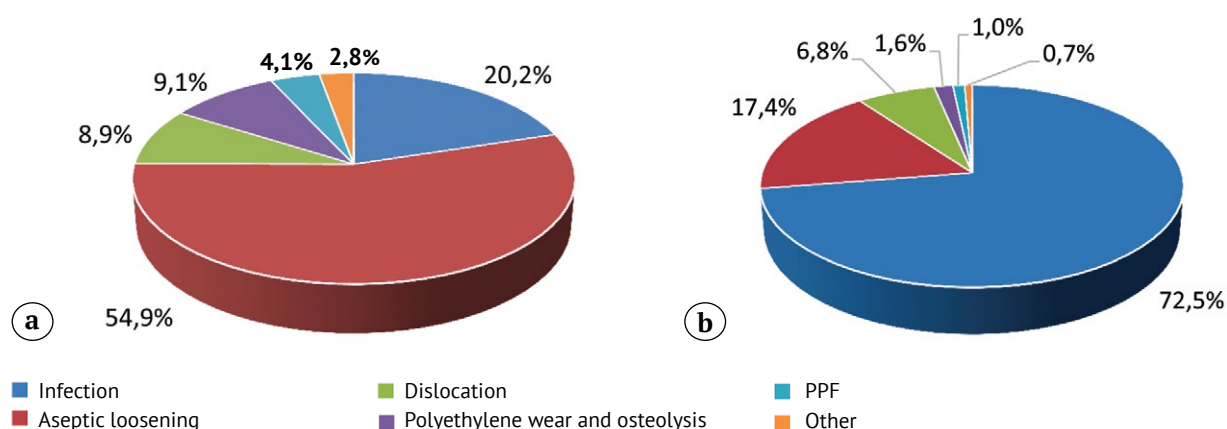


Figure 9. Proportion of different causes of revision: a – after primary THA; b – after re-revisions

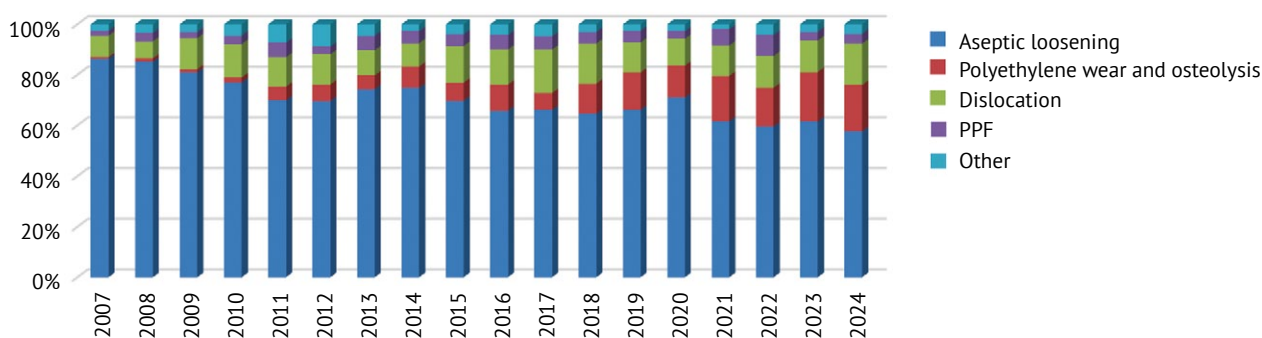


Figure 10. Dynamic changes in the structure of aseptic revision causes by year

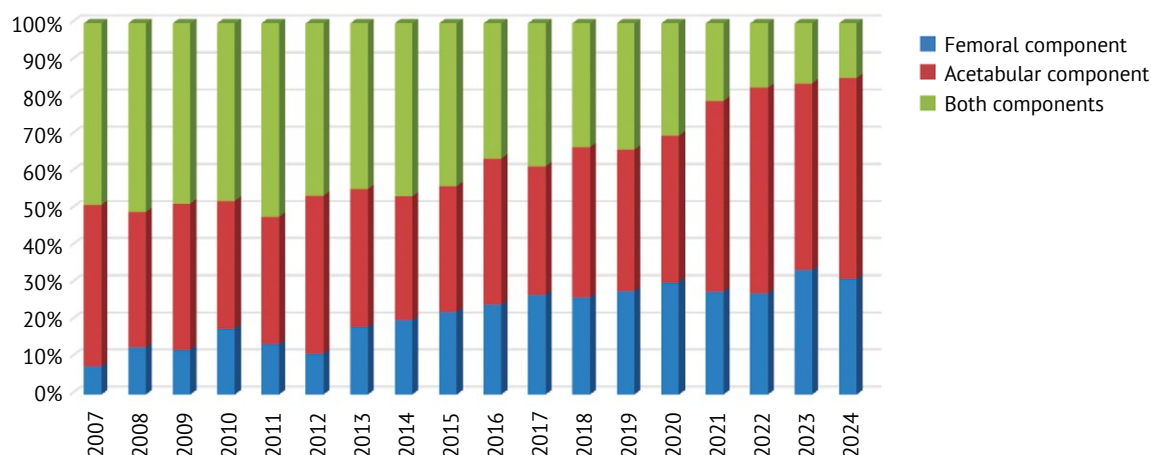


Figure 11. Proportion of aseptic loosening of prosthetic components by year

Beyond the prevalence of revision causes, their temporal distribution post-primary surgery and their relation to whether the revision was initial or repeat are of great interest. As shown in Figure 12, in the first year after primary THA, infection was the leading cause (38.2%), followed by aseptic loosening (24.0%) and recurrent dislocations (22.0%). PPFs accounted for 12.8%, and other causes – 3.3%. From the second year onward, aseptic loosening became the predominant cause, ranging from 51.0% in year 3 to 78.9% after 15 years of follow-up. The share of infections declined over time but remained relevant throughout the follow-up. The share of dislocations and PPFs dropped significantly after the second year and became negligible by year four (12.8% and 4.8%, respectively). From the sixth year onward, polyethylene wear and osteolysis began to rise in frequency, ranging from 5.2 to 12.3%.

The average time to revision due to infection was 2.4 years (95% CI 2.2-2.5; median: 1 year), ranging from 2 weeks to 28 years, possibly

reflecting infection superimposed on aseptic loosening. For aseptic loosening, the mean time was 7.9 years, varying by subgroup: combined component loosening had a mean of 8.3 years (95% CI 8.0-8.8; median: 8 years, range: from 1 month to 29 years), isolated acetabular loosening was similar at 8.5 years (95% CI 8.1-8.8; median: 8 years, range: from 1 month to 27.5 years), while isolated femoral loosening occurred earlier at 6.1 years (95% CI 5.8-6.6; median: 5 years, range: from 1 month to 21 years) ($p < 0.001$). Recurrent dislocations had a mean revision time of 2.7 years (95% CI 2.4-3.0; median: 1 year, range: from 1 week to 18 years), and revisions for polyethylene wear and osteolysis occurred after a mean of 10.6 years (95% CI 10.1-11.1; median: 11 years, range: from 6 years to 28 years). PPFs occurred mainly in the early years post-primary THA (mean: 3.1 years; 95% CI 2.6-3.6; median: 1.5 years, range: from 1 month to 18 years). Other causes had a mean revision time of 5.2 years (95% CI 3.9-6.4; median: 3.5 years, range: from 6 months to 14.5 years).

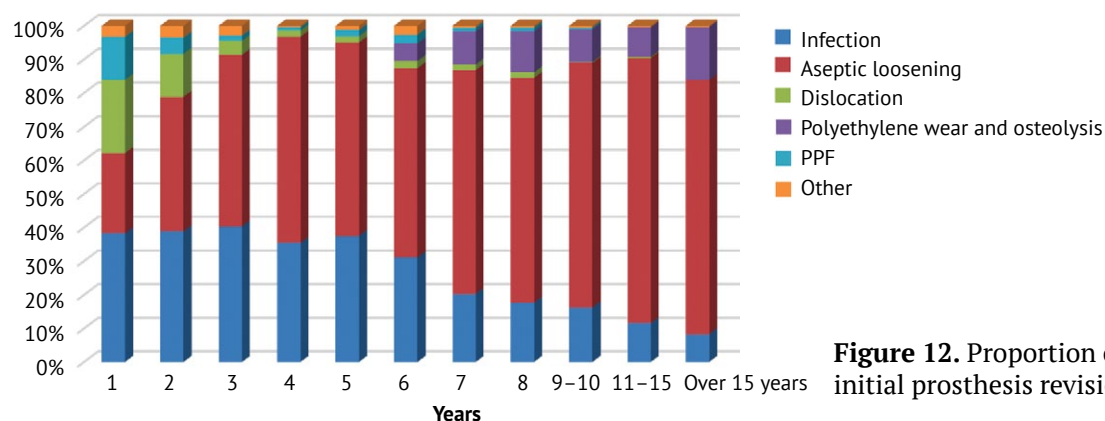


Figure 12. Proportion of causes for initial prosthesis revisions by year

In the structure of first revisions, 13.6% occurred in the first year after primary THA, 9.1% in the second year, 8.2% in the third, 6.1% in the fourth, and 5.3% in the fifth, with 57.7% occurring later. Among re-revisions, 56.8% occurred in the first year, 18.1% in the second, 6.3% in the third, 3.8% in the fourth, 3.0% in the fifth, and 12.4% beyond.

Infections were the dominant cause of re-revisions, accounting for 85.6% of all cases, with 86.0% of infection-related re-revisions occurring

within the first two years. Infection remained the leading cause throughout the follow-up (Figure 13). The share of aseptic loosening among re-revision causes increased gradually from 4.5 to 33.3% in the long term. Dislocations and PPFs were more evenly distributed over time compared to initial revisions, but still occurred mostly within the first five years postoperatively. Polyethylene wear, similar to initial revisions, became more prominent after year five, peaking around 9-10 years.

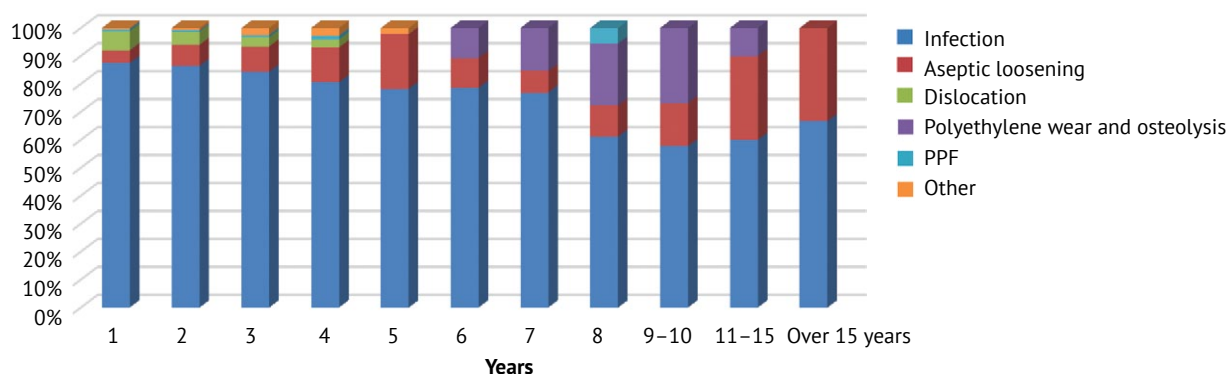


Figure 13. Proportion of causes for hip prosthesis re-revisions by year

Of 2,272 re-revisions, 1,521 (66.9%) were first re-revisions, 560 (24.6%) were second, 102 (4.5%) were third or fourth, and 89 (3.9%) were between the fifth and ninth. The average time to revision after primary THA was 7.0 years (95% CI 6.8-7.1; median: 6 years), to first re-revision 3.3 years (95% CI 3.1-3.5; median: 1 year), to second re-revision 2.9 years (95% CI 2.5-3.2; median: 1 year), and subsequent re-revisions occurred within an average of under 2 years, though some intervals extended to 20 years. The average age at revision after primary THA was 60.0 years (95% CI 59.5-60.4; median: 61 years), while for first re-revisions it was lower – 58.1 years (95% CI 57.6-58.7; median: 59 years), suggesting that younger patients are at higher risk for earlier and repeated revisions.

Extent of revisions after primary THA depending on causes and timing of their performance

Aseptic revisions

In 546 patients (8.2%) who underwent aseptic revisions, the extent of the procedure was either

not specified or unclear; therefore, these cases were excluded from the analysis. As shown in Figure 14, the most frequently performed procedure was isolated acetabular component replacement, followed by total replacement of the entire prosthesis. Isolated femoral component replacement and replacement of modular components were less common, while various types of osteosynthesis and other revision procedures were performed rarely.

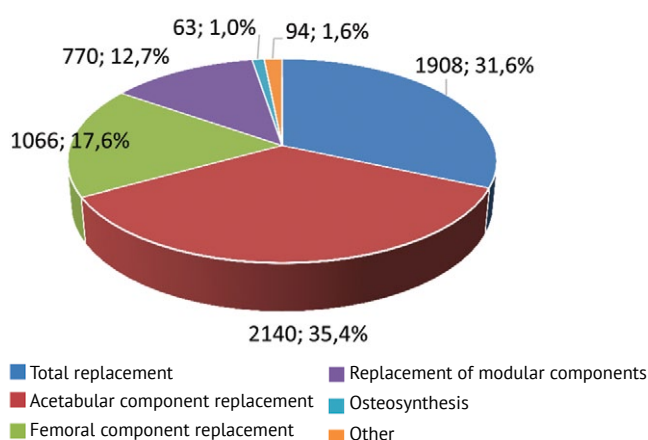


Figure 14. Volume of aseptic revision surgery

The most common cause of aseptic revisions was aseptic loosening of one or both prosthetic components, accounting for 4.491 cases (67.7% of all aseptic revisions). Among these, isolated replacement of the acetabular component was performed in 39.5% of cases, isolated femoral component replacement in 19.5%, and total prosthesis replacement in 40.9% of cases (Figure 15).

In revisions performed due to polyethylene wear and osteolysis, the most common approach – observed in 488 cases (65.9%) – was the replacement of one or both modular components. In 141 cases (19.0%), the acetabular cup was replaced. Total replacement of both components and isolated femoral component replacement were performed in 63 (8.5%) and 47 (6.3%) cases, respectively. No statistically significant differences were observed in the timing of the different types of revision procedures for polyethylene wear.

In patients with recurrent dislocations, the most common procedure – performed in 293 cases (38.8%) – was replacement of the acetabular component, including implantation of a cemented dual mobility cup into the existing acetabular shell. Slightly less frequently, modular components of the

prosthesis – such as the liner, head, or both – were replaced, accounting for 262 cases (34.7%). Total prosthesis replacement was carried out in 118 patients (15.6%), and femoral component revision was performed in 42 cases (5.6%). In 31 patients (4.1%), the management of recurrent dislocation involved other techniques, primarily various forms of muscle reconstruction.

Periprosthetic fractures requiring revision were observed only in the region of the femoral component, likely because fractures involving the acetabular component were always associated with loss of fixation and thus classified as aseptic loosening. Accordingly, the most common procedure in these cases was isolated femoral component replacement, performed in 178 cases (65.9%). In 52 cases (19.3%), it was possible to perform osteosynthesis without replacing any prosthetic components, while in 41 cases (15.2%), replacement of both components was required.

The extent of revision in patients categorized as “Other” included isolated acetabular revision in 11.8% of cases, total joint revision in 9.8%, isolated femoral component replacement in 4.1%, replacement of modular components in 6.9%, osteosynthesis in 3.2%, and various soft-tissue procedures in 13.9% of patients.

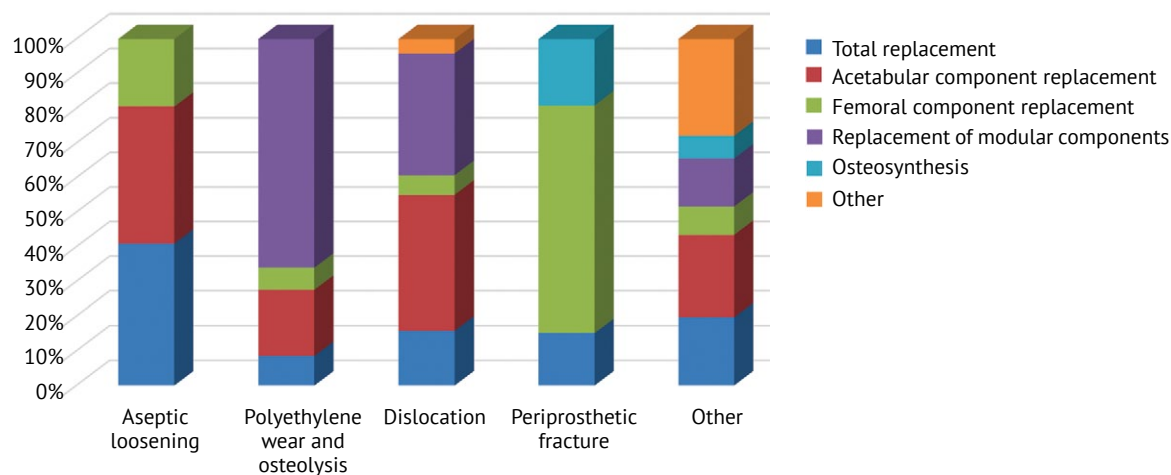


Figure 15. Surgical options for aseptic revisions after primary THA

Infection-related revisions

In hip prosthesis revisions performed due to infection, the distribution of surgical intervention types was as follows: debridement with implant retention and polyethylene liner exchange (DAIR) – 4.9%, removal of prosthetic components with spacer implantation – 39.4%, one-stage prosthesis removal and re-implantation (one-stage revision arthroplasty) – 3.9%, and removal of prosthetic components followed by muscle flap coverage or resection arthroplasty – 3.6%. The most common procedure was the second stage of infection-related revision – implantation of a new prosthesis after spacer removal – accounting for 45.4% of cases. The least frequent approach was implantation of a new prosthesis following prior prosthesis removal combined with muscle reconstruction, resection arthroplasty, or a combination of both, observed in only 0.9% of cases (Figure 16). The timing of the first stage of PJI treatment (spacer implantation) varied widely – from 2 weeks to 28 years – with a mean of 3.6 years (95% CI 3.3-3.8; median: 2 years). Although this is significantly shorter than in the previous analysis (5.4 years; median: 4 years), it still reflects a substantial proportion of chronic PJI cases. Given the extended waiting times, it remains unclear how many of these cases might have been managed with alternative methods if the infection had been identified and patients hospitalized in a timely manner.

In the vast majority of cases (74.8%), articulating spacers were used, while block-type spacers were employed in the remaining cases.

In cases of acute PJI (within 30 days of primary THA), the DAIR procedure was performed in 72.4% of cases, while the remaining patients underwent a two-stage revision with spacer implantation.

For one-stage revision arthroplasty, the average time to surgery was the same as for the first stage of two-stage revision – 3.6 years (95% CI 3.0-4.4; median: 2 years); the difference lay only in the clinical conditions that determined the choice of procedure. The second stage of two-stage revision was performed on average 1.2 years after spacer implantation (95% CI 1.1-1.3; median: 7 months), which reflects the prolonged waiting times for revision surgeries.

Total removal of the prosthesis is traditionally performed only in cases with the most unfavorable prognosis for infection treatment, often combined with muscle grafting in especially severe cases or performed without it, and usually after several previously unsuccessful interventions (81.2% of cases). The average time from the previous procedure was relatively short – 2.3 years (95% CI 1.4-3.1; median: 6 months). However, the average time since the primary THA was significantly longer – 7.2 years (95% CI 6.8-7.6; median: 6 years). This choice of intervention is likely explained by the prolonged duration of chronic infection.

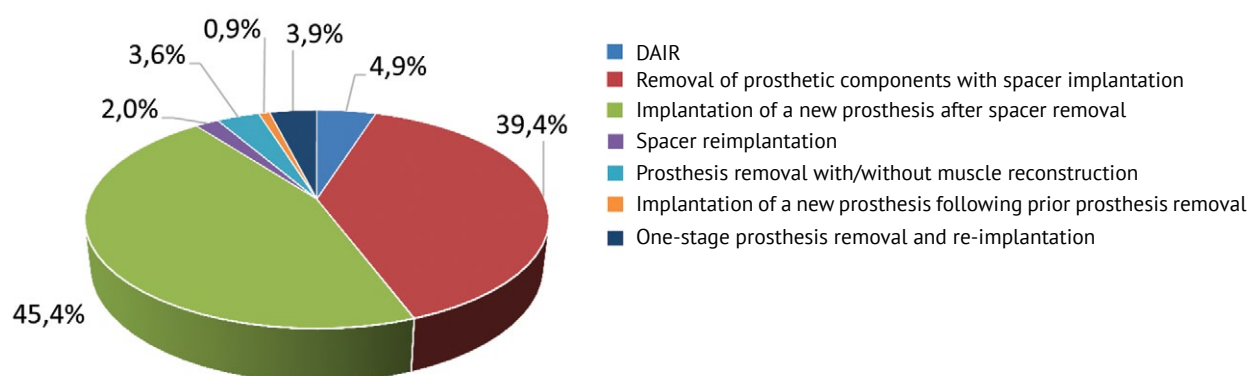


Figure 16. Surgical options for PJI-related revisions after primary THA

Technologies employed in revision THA

Revision of the acetabular component is primarily based on the use of cementless hemispherical cups, which are widely used in primary THA but, in revision cases, are typically (in 78.0% of cases) equipped with multiple screw holes. Up to and including 2015, the most commonly used revision components were cups with porous coatings or rough surfaces, such as Trilogy (Zimmer), Duraloc (DePuy), Plasmacup (Aesculap), and several others (Figure 17).

From 2012 to 2020, a gradual replacement of the component lineup occurred – mainly featuring Trilogy IT (Zimmer-Biomet), Plasmacup (Aesculap), Pinnacle (DePuy), R3 (Smith & Nephew), and Continuum (Zimmer-Biomet). The proportion of acetabular components of this type varied over the years from 20.4 to 73.7%. In 8.2% of cases, the use of hemispherical components was combined with the implantation of metal augments.

Since 2016, there has been wider use of specialized revision hemispherical cups, such as TM Modular (Zimmer-Biomet), TM Revision (Zimmer-Biomet), Pinnacle Revision (DePuy), and others, including in combination with metal augments in 42.2% of cases. Their share in the revision component structure gradually increased from 8.8% in 2007 to 56.5% in 2020, but then decreased to 20.6% in 2024, gradually being replaced by custom-made components

and fully porous titanium Tuberlock Multi-hole cups (Logeeks, Novosibirsk), manufactured using 3D printing technology. The proportion of patient-specific implants in the overall structure ranged from 1.9 to 11.9%. The new Tuberlock Multi-hole cups (Logeeks, Novosibirsk, Russia) were combined with porous metal augments in 34 out of 79 cases (43.6%) and were used as part of complex revision systems, including cemented dual mobility cups. Overall, the use of dual mobility implants shows a clear trend of increasing share in the revision component structure; however, tracking all cases of their use is challenging due to their combination with other acetabular components. It is also difficult to determine the proportion of cases in which cemented dual mobility cups were implanted without removal of a well-fixed existing acetabular component.

In 2007, the combined share of Wagner- and Zweymüller-type femoral components in revision THA was 25.8%. At that time, the most commonly used femoral components were fully porous-coated types such as AML (DePuy), Solution (DePuy), and Malory-Head (Biomet) (Figure 18). Subsequently, the proportion of Zweymüller-type components increased significantly, represented by models like Alloclassic (Zimmer), SL-Plus (Smith & Nephew), with later additions including CBH (Mathys), TRJ (Aesculap), SL-Plus MIA (Smith & Nephew), and YAR-TEZ

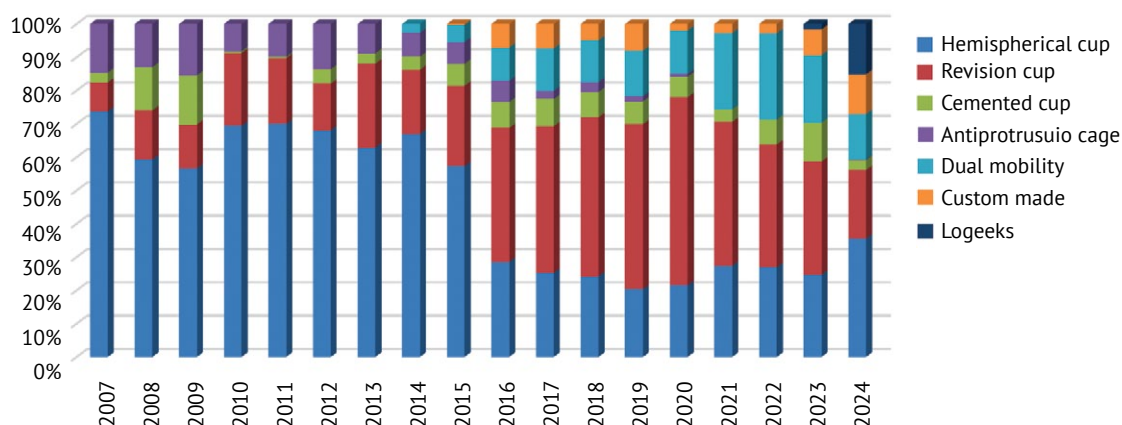


Figure 17. Dynamics of the use of different acetabular systems in hip prosthesis revisions

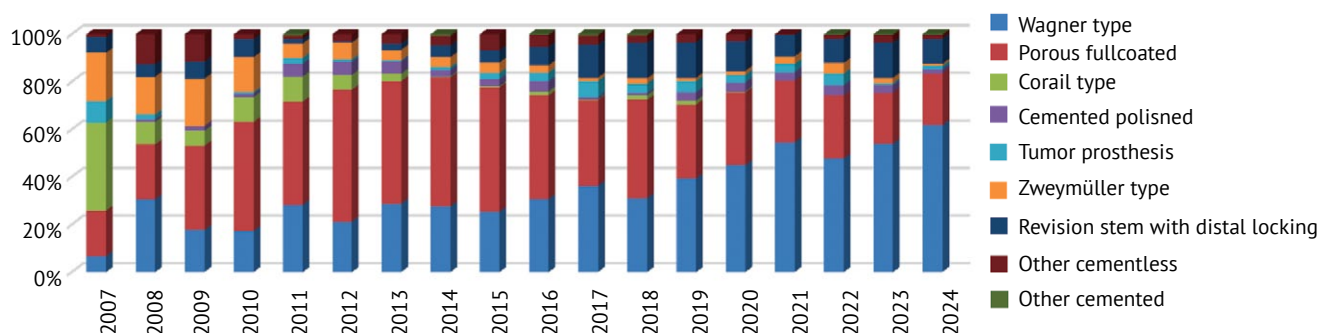


Figure 18. Dynamics of the use of different femoral component types in hip prosthesis revisions

(Rybinsk, Russia). Alloclassic (Zimmer) and SL-Plus (Smith & Nephew) components were more frequently (69.5%) used in their revision versions – Alloclassic SLL and SLR-Plus. Up until 2018, this type of femoral stem remained the most commonly used option for femoral revision. Since 2019, the vast majority (ranging from 39.4 to 61.7%) of revisions have been performed using Wagner-type stems, represented by Wagner SL Revision (Zimmer-Biomet), Redapt (Smith & Nephew), and Wagner Cone (Zimmer-Biomet) components.

DISCUSSION

As a result of the rapid increase in the number of primary surgeries and the gradual accumulation of a patient pool experiencing various complications following THA, revision THA is becoming an increasingly common surgical procedure in our country [20, 21, 22, 23, 24, 25]. Although this analysis of the local registry database does not provide a complete picture of the structure of revision THA across the Russian Federation as a whole, the large number of cases allows us to identify the main trends in joint revision surgery, especially considering that the majority of patients were initially operated on in various regions throughout the country.

The first point to note is the significant number of early revisions (42.2% of primary revisions and 87.6% of subsequent re-revisions) are performed within the first five years after

the previous surgery. The five-year cutoff for defining early revision was adopted in line with other studies [17, 26, 27]; however, it may be more accurate to consider interventions performed within the first two or three years after the prior operation as early revisions. Within the first two years, 22.6% of initial revisions and 74.5% of re-revisions are performed, while within the first three years, these figures increase to 30.1% and 80.1%, respectively. It may be appropriate to define early revisions as those occurring within five years for the first revision, and within two years for re-revisions.

The next important trend is the significant increase in both the absolute number and proportion of infection-related revisions [28]. In recent years, nearly half of all THA revision cases have been performed in patients with a documented history of PJI. These findings correspond with data from the New Zealand registry⁴, where not only the proportion but also the absolute number of PJI cases tripled since 2011-2012, making infection the leading cause of revision. A similar situation is observed in Australia, where according to the national arthroplasty registry⁵ data, infection also became the number one cause for THA revision in 2022 and remained so in 2023.

Finnish colleagues have reported that the incidence of early infection cases increased from 0.11 per 100 primary medical consultations in 2008 to 1.09 in 2021 [29]. During one-year follow-up, 26.6% (95% CI 22.2-31.2)

⁴ New Zealand Joint Registry. www.nzoa.org.nz/nzoa-joint-registry

⁵ The Australian Orthopaedic Association National Joint Replacement Registry. Annual Report 2024. <https://aoanjrr.sahmri.com/home>

of patients underwent repeat surgery, and 7.9% (95% CI 5.4-10.9) died. The risk of re-operation was highest after DAIR (36.6%, 95% CI 28.5-44.7) and lowest after one-stage revision (20.2%, 95% CI 13.4-28.0) [30]. The overall success rate of DAIR in terms of component retention and infection eradication at two years was 68% [31]. Defining the true incidence of PJI remains an extremely important task, as numerous publications report a rapid increase in infection cases due both to the overall rise in the number of joint arthroplasty procedures and the growing number of difficult-to-recognize infectious processes. Based on an epidemiological study, Taiwanese colleagues anticipate a 4.79-fold increase in the incidence of infectious periprosthetic complications by 2035, with treatment costs rising 4.86-fold, which may become a serious economic burden for the healthcare system [32]. A cohort study using data from the German Joint Arthroplasty Registry (Endoprothesenregister Deutschland – EPRD) showed that the cumulative mortality rate within the first year after septic hip revision was 14%, increasing to 40% over seven years. In cases of multiple prior revisions, the rate of repeat revisions due to septic causes exceeds 40%. The critical period for the likelihood of repeat revision after septic revision has been identified as the first 6 months [33]. Our registry data on the extremely high infection rate in cases of multiple revisions fully correspond with these findings, and the focus of future research should be on determining the mortality rate resulting from these interventions.

Another significant problem is the exceptionally young average age of patients undergoing revisions, which was demonstrated previously [11] and is especially evident in re-revisions, as shown by the current analysis. Dutch colleagues, based on data from their national registry, noted that revision outcomes in patients younger than 55 years are significantly worse than in the general patient population. The rate of all failures requiring repeat revision surgery was 22% (95% CI 19-25) at 5 years and

28% (95% CI 24-33) at 10 years. The cumulative incidence of infectious complications after revision procedures over 10 years was 7.8% (95% CI 6.1-9.7), aseptic loosening of the acetabular component – 7.0% (95% CI 4.1-11.0), dislocation – 3.8% (95% CI 2.6-5.2), and loosening of the femoral stem – 2.7% (95% CI 1.6-4.1). Notably, if the revision was performed due to infection, the rate of subsequent revisions within 10 years accounted for 45% (95% CI 37-55) [34].

In our country, this problem is exacerbated by the characteristics of the general population undergoing primary THA [10]. Patients under 50 years old constitute 22.7% of our registry database for primary THA, which is almost twice as high as in the populations of Australia or the United Kingdom⁶. A large population-based study published in *The Lancet* demonstrated that men under 50 years have a lifetime revision risk of 35% [35]. Considering the historically widespread use of conventional ultra-high molecular weight polyethylene until recently [18], and current trends showing an increase in revisions related to the wear of the prosthesis friction unit and progressive osteolysis, we can expect a significant rise in such revision surgeries in the coming years. This issue is also typical for other countries. In particular, in the United States, an upcoming increase in revisions related to younger patient age and infectious complications has been emphasized [36]. Given the specific characteristics of our patient population, the correct choice of implants becomes especially important [37].

However, another issue arises – a marked shift in the spectrum of implants used. In our study, complete replacement of all prosthetic components was performed in 31.6% of all aseptic revisions, with a clear trend toward a decreasing proportion in recent years. According to the literature, retaining one of the components is considered a safe procedure with a low rate of re-revision [38], and partial revision appears to be a common trend. For example, in Germany, replacement of only one component is performed in 75% of cases; however, there are no available statistics on the year-by-year changes in the

⁶ National Joint Registry. 21st Annual Report, 2024. <https://reports.njrcentre.org.uk>

proportion of isolated component revisions [39]. A significantly higher need for total replacement of all components in previous years may have been associated with the problem of osteolysis, the incidence of which has markedly decreased following the near-complete transition to cross-linked polyethylene [40, 41]. However, in our country, there is a substantial replacement of well-established prosthesis models from leading global manufacturers with models produced in China, India, Turkey, and other countries, as well as a gradual shift toward domestically manufactured implants. Data on these models are insufficient in the national registries of other countries, which makes the establishment of our own registry especially important for the timely identification of potentially hazardous artificial joint models. A local registry would be able to detect potentially unfavorable trends no sooner than 10-12 years, whereas a national registry could identify problematic implants within 7-8 years, potentially sparing hundreds of thousands of patients from premature revision surgeries related to insufficient implant wear resistance.

An interesting trend is the increase in the number and proportion of revision acetabular components made of trabecular metal, which peaked in 2020, followed by a noticeable decline. Revision systems made of trabecular metal have well-documented efficacy in reducing the risk of aseptic loosening and decreasing the incidence of infectious complications [25, 42, 43, 44]. On the other hand, they are significantly more expensive than standard porous-coated, multi-hole hemispherical cups. It is always challenging to assess the justification for using more costly constructs given the substantial variety of implants and the equally diverse opinions regarding their potential effectiveness [45, 46, 47]. For instance, data from a recent meta-analysis by Chinese colleagues showed no statistically significant difference between the use of trabecular metal acetabular components and other acetabular systems [48]. However, any meta-analysis cannot account for the complexity of the included clinical cases or the rationale behind choosing a particular implant to address a specific problem. Moreover, according to other researchers, this meta-analysis was conducted

with certain methodological flaws that limit its value [49]. Regarding our analysis, the significant increase in the share of trabecular metal components in 2019-2020 is most likely explained by the growing proportion of revision procedures that require the use of augments and extended screw fixation to achieve adequate implant stability. In such cases, the possibility of placing additional screws precisely where needed – enabled by the design features of trabecular metal implants – becomes a decisive factor that outweighs even their higher cost. Subsequently, the declining interest in these implants can be attributed to the increased availability of alternative revision systems suitable for managing severe bone defects. These include custom triflange cups, individualized augments, and the emergence of domestically produced serial acetabular components manufactured using 3D printing, the rising use of which was especially notable in 2023-2024. Currently, titanium acetabular components produced by 3D printing, when combined with cemented polyethylene liners or dual mobility systems, offer an effective [43, 50, 51] and relatively cost-efficient option for revision arthroplasty in the presence of substantial bone loss. This is particularly relevant given that implant selection during the preoperative stage, based on modern imaging capabilities, is becoming the standard in revision surgery [20, 52, 53]. Nevertheless, it should be noted that the planning, production, and implantation of patient-specific prostheses is an exceptionally complex process in revision surgery, and the risk of various errors associated with their use remains considerable [50, 54, 55, 56]. Therefore, such implants should be reserved for cases with strict indications. It is also important to highlight the trend toward the more widespread use of dual mobility acetabular components, which are increasingly employed in cases of recurrent dislocation and other revisions in the setting of muscular insufficiency, as they offer the highest level of dislocation resistance [57, 58, 59].

The trend toward the use of Wagner-type femoral components in revision surgery is explained by the high effectiveness of these designs in the presence of even extensive

femoral bone defects, their reliable fixation, and the relative simplicity of the surgical technique. Additionally, they are compatible with the extended trochanteric osteotomy approach [60]. As demonstrated by mechanical studies, these implants maintain stability under cyclic loading exceeding 200% of body weight, and bone failure occurs only at loads above 400% [61]. It is not surprising that most orthopedic implant manufacturers include such revision stems in their product lines. However, in cases of extremely severe bone defects, even long Wagner-type femoral components may fail to achieve reliable fixation. In such scenarios, there remains an important role for distal locking constructs and custom-made implants produced via 3D printing. Although their overall number is still limited, they are also reflected in the registry database [62].

CONCLUSIONS

Despite the lack of comprehensive data on the structure of primary and revision arthroplasty in the Russian Federation, this analysis revealed several important trends: a sharp increase in the number of revision procedures, a growing proportion of complex revisions requiring advanced and costly implants, and an exceptionally rapid rise in the number of infection-related revisions. It is therefore clear that the challenges of revision arthroplasty may soon affect all surgeons performing primary total hip arthroplasty – initially through the need to manage infectious complications, and later due to the gradual accumulation of patients requiring other types of revisions, including repeat procedures.

DISCLAIMERS

Author contribution

All authors made equal contributions to the study and the publication.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

Funding source. This study was not supported by any external sources of funding.

Disclosure competing interests. The authors declare that they have no competing interests.

Ethics approval. Not applicable.

Consent for publication. Not required.

REFERENCES

1. Brüggemann H., Dalen I., Bache-Mathiesen L.K., Fenstad A.M., Hallan G., Fosse L. Incidence and risk factors of intraoperative periprosthetic femoral fractures during primary total hip arthroplasty: 218,423 cases reported to the Norwegian Arthroplasty Register between 1987 and 2020. *Acta Orthop.* 2022;93:405-412. doi: 10.2340/17453674.2022.2431.
2. Dale H., Børsheim S., Kristensen T.B., Fenstad A.M., Gjertsen J.E., Hallan G. et al. Perioperative, short-, and long-term mortality related to fixation in primary total hip arthroplasty: a study on 79,557 patients in the Norwegian Arthroplasty Register. *Acta Orthop.* 2020;91(2):152-158. doi: 10.1080/17453674.2019.1701312.
3. Groot L., Latijnhouwers D.A.J.M., Reijman M., Verdegaal S.H.M., Vliet Vlieland T.P.M., Gademán M.G.J. et al. Recovery and the use of postoperative physical therapy after total hip or knee replacement. *BMC Musculoskelet Disord.* 2022;23(1):666. doi: 10.1186/s12891-022-05429-z.
4. Kuijpers M.F., Hannink G., van Steenbergen L.N., Schreurs B.W. A significant change towards cemented fixation in revision total hip arthroplasty in patients younger than 55 years in the Netherlands: results of an observational cohort study in the Dutch Arthroplasty Register in 28,516 primary hip replacements and 1285 revision procedures. *Hip Int.* 2023;33(2):288-297. doi: 10.1177/11207000211020002.
5. Lutro O., Tjørhom M.B., Leta T.H., Gjertsen J.E., Hallan G., Bruun T. et al. How many doses and what type of antibiotic should be used as systemic antibiotic prophylaxis in primary hip and knee arthroplasty? A register-based study on 301,204 primary total and hemi- hip and total knee arthroplasties in Norway 2005-2023. *Acta Orthop.* 2025;96:217-225. doi: 10.2340/17453674.2025.43003.
6. Mikkelsen R.T., Overgaard S., Pedersen A.B., Kärrholm J., Rolfson O., Fenstad A.M. et al. Does choice of bearings influence the survival of cementless total hip arthroplasty in patients aged 20-55 years? Comparison of 21,594 patients reported to the Nordic Arthroplasty Register Association dataset 2005-2017. *Acta Orthop.* 2023;94:266-273. doi: 10.2340/17453674.2023.13384.

7. Springer B.D., Mullen K.P., Donnelly P.C., Tucker K., Caton E., Huddleston J.I. Is American Joint Replacement Registry Data Consistent With International Survivorship in Hip and Knee Arthroplasty? A Comparative Analysis. *Arthroplasty*. 2024;39(9S1):S46-S50. doi: 10.1016/j.arth.2024.02.055.
8. Rasmussen M.B., El-Galaly A., Daugberg L., Nielsen P.T., Jakobsen T. Projection of primary and revision hip arthroplasty surgery in Denmark from 2020 to 2050. *Acta Orthop*. 2022;93:849-853. doi: 10.2340/17453674.2022.5255.
9. Premkumar A., Kolin D.A., Farley K.X., Wilson J.M., McLawhorn A.S., Cross M.B. et al. Projected Economic Burden of Periprosthetic Joint Infection of the Hip and Knee in the United States. *J Arthroplasty*. 2021;36(5):1484-1489.e3. doi: 10.1016/j.arth.2020.12.005.
10. Shubnyakov I.I., Tikhilov R.M., Nikolaev N.S., Grigoricheva L.G., Ovsyankin A.V., Cherny A.Z. et al. Epidemiology of Primary Hip Arthroplasty: Report from Register of Vreden russian research institute of traumatology and orthopedics. *Traumatology and Orthopedics of Russia*. 2017;23(2):81-101. (In Russian). doi: 10.21823/2311-2905-2017-23-2-81-101.
11. Shubnyakov I.I., Tikhilov R.M., Denisov A.O., Akhmedilov M.A., Cherny A.Z., Totoev Z.A. et al. What Has Changed in the Structure of Revision Hip Arthroplasty? *Traumatology and Orthopedics of Russia*. 2019;25(4):9-27. (In Russian). doi: 10.21823/2311-2905-2019-25-4-9-27.
12. Sereda A.P., Kochish A.A., Cherny A.A., Antipov A.P., Aliev A.G., Veber E.V. et al. Epidemiology of Hip And Knee Arthroplasty and Periprosthetic Joint Infection in Russian Federation. *Traumatology and Orthopedics of Russia*. 2021;27(3):84-93. (In Russian). doi: 10.21823/2311-2905-2021-27-3-84-93.
13. Yenigul A.E., Dikici A.E., Eken G., Bilgen M.S. Comparison of patients undergoing revision total hip arthroplasty and patients undergoing re-revision. *Eur Rev Med Pharmacol Sci*. 2023;27(11):5053-5058. doi: 10.26355/eurrev_202306_32622.
14. Brown T.S., McLaughlin R.J., Berry D.J., Lewallen D.G., Trousdale R.T., Sierra R.J. What Is the Survivorship of Revision Surgery Performed for the Chronically Dislocated THA? *Clin Orthop Relat Res*. 2019;477(2):374-379. doi: 10.1097/CORR.0000000000000392.
15. Rullán P.J., Orr M.N., Emara A.K., Klika A.K., Molloy R.M., Piuze N.S. Understanding the 30-day mortality burden after revision total hip arthroplasty. *Hip Int*. 2023;33(4):727-735. doi: 10.1177/11207000221094543.
16. Ashkenazi I., Christensen T., Oakley C., Bosco J., Lajam C., Slover J. et al. Trends in Revision Total Hip Arthroplasty Cost, Revenue, and Contribution Margin 2011 to 2021. *J Arthroplasty*. 2023;38(7S):S34-S38. doi: 10.1016/j.arth.2023.03.088.
17. Tikhilov R.M., Shubnyakov I.I., Kovalenko A.N., Totoev Z.A., Lyu B., Bilyk S.S. The structure of early revisions after hip replacement. *Traumatology and Orthopedics of Russia*. 2014;20(2):5-13. (In Russian). doi: 10.21823/2311-2905-2014-0-2-5-13.
18. Shubnyakov I.I., Riahi A., Denisov A.O., Korytkin A.A., Aliev A.G., Veber E.V. et al. The Main Trends in Hip Arthroplasty Based on the Data in the Vreden's Arthroplasty Register from 2007 to 2020. *Traumatology and Orthopedics of Russia*. 2021;27(3):119-142. (In Russian). doi: 10.21823/2311-2905-2021-27-3-119-142.
19. Proceedings of the Second international consensus meeting on musculoskeletal infection. Ed. by R.M. Tikhilov, S.A. Bozhkova, I.I. Shubnyakov. St. Petersburg: RNIITO im. R.R. Vredena, 2019. 314 p. (In Russian).
20. Bazlov V.A., Mamuladze T.Z., Golenkov O.I., Efimenko M.V., Pronskikh A.A., Kharitonov K.N. et al. Effects of 3D Imaging on Surgical Tactics in Primary and Revision Hip Arthroplasty. *Traumatology and Orthopedics of Russia*. 2020;26(2):60-70. (In Russian). doi: 10.21823/2311-2905-2020-26-2-60-70.
21. Golnik V.N., Fedorova N.V., Larichkin A.Yu., Boyko S.V., Panchenko A.A., Kosinov A.M. et al. Impaction Bone Grafting for Acetabular Bone Defects Replacement in Revision Hip Arthroplasty: Biomechanical Aspects. *Traumatology and Orthopedics of Russia*. 2024;30(4):101-113. (In Russian). doi: 10.17816/2311-2905-17564.
22. Rykov A.G., Schebenkov B.V., Kozhevnikova S.Yu., Volovik V.E., Korshnyak V.Yu., Palshin G.A. Experience in revision hip arthroplasty using modular systems. *Public Health of the Far East*. 2020;3(85):59-63. (In Russian). doi: 10.33454/1728-1261-2020-3-59-63.
23. Tsed A.N., Mushtin N.E., Dulaev A.K. Causes of Revision Hip Arthroplasty After Hemiarthroplasty for Femoral Neck Fracture. *Traumatology and Orthopedics of Russia*. 2024;30(4):25-37. (In Russian). doi: 10.17816/2311-2905-17545.
24. Kaminskiy A.V., Matveyeva E.L., Gasanova A.G., Luneva S.N., Spirkina E.S., Ermakov A.M. Analysis of Biochemical Parameters of Blood Serum in Patients with Revision Hip Arthroplasty and Disorder of Carbohydrate Metabolism. *Science of the Young (Eruditio Juvenium)*. 2023;11(1):5-14. (In Russian). doi: 10.23888/HMJ20231115-14.
25. Korytkin A.A., Novikova Ya.S., Kovaldov K.A., Korolev S.B., Zykin A.A., Gerasimov S.A. et al. Mid-Term Outcomes of Revision Hip Arthroplasty with Acetabular Augments. *Traumatology and Orthopedics of Russia*. 2019;25(1):9-18. (In Russian). doi: 10.21823/2311-2905-2019-25-1-9-18.
26. Melvin J.S., Karthikeyan T., Cope R., Fehring T.K. Early failures in total hip arthroplasty – a changing paradigm. *J Arthroplasty*. 2014;29(6):1285-1288. doi: 10.1016/j.arth.2013.12.024.
27. Jafari S.M., Coyle C., Mortazavi S.M., Sharkey P.F., Parvizi J. Revision hip arthroplasty: infection is the most common cause of failure. *Clin Orthop Relat Res*. 2010;468(8):2046-2051. doi: 10.1007/s11999-010-1251-6.

28. Murylev V.Yu., Parvizi J., Rudnev A.I., Kukovenko G.A., Elizarov P.M., Muzychenkov A.V. et al. The Impact of Extended Preoperative Examination on the Treatment Tactics Choice Before the Second Stage of Revision Hip Arthroplasty. *Traumatology and Orthopedics of Russia*. 2024;30(2):29-39. (In Russian). doi: 10.17816/2311-2905-17510.
29. Liukkonen R.J., Honkanen M., Reito A.P., Skyttä E.T., Karppelin M., Eskelinen A.P. Trends in Revision Hip Arthroplasty for Prosthetic Joint Infection: A Single-Center Study of 423 Hips at a High-Volume Center Between 2008 and 2021. *J Arthroplasty*. 2023;38(6):1151-1159. doi: 10.1016/j.arth.2023.02.061.
30. Liukkonen R., Honkanen M., Skyttä E., Eskelinen A., Karppelin M., Reito A. Clinical Outcomes After Revision Hip Arthroplasty due to Prosthetic Joint Infection – A Single-Center Study of 369 Hips at a High-Volume Center With a Minimum of One Year Follow-Up. *J Arthroplasty*. 2024;39(3):806-812.e3. doi: 10.1016/j.arth.2023.08.078.
31. Veerman K., Raessens J., Telgt D., Smulders K., Goosen J.H.M. Debridement, antibiotics, and implant retention after revision arthroplasty: antibiotic mismatch, timing, and repeated DAIR associated with poor outcome. *Bone Joint J*. 2022;104-B(4):464-471. doi: 10.1302/0301-620X.104B4.BJJ-2021-1264.R1.
32. Chang C.H., Lee S.H., Lin Y.C., Wang Y.C., Chang C.J., Hsieh P.H. Increased periprosthetic hip and knee infection projected from 2014 to 2035 in Taiwan. *J Infect Public Health*. 2020;13(11):1768-1773. doi: 10.1016/j.jiph.2020.04.014.
33. Resl M., Becker L., Steinbrück A., Wu Y., Perka C. Re-revision and mortality rate following revision total hip arthroplasty for infection. *Bone Joint J*. 2024;106-B(6):565-572. doi: 10.1302/0301-620X.106B6.BJJ-2023-1181.R1.
34. Kuijpers M.F.L., Hannink G., van Steenbergen L.N., Schreurs B.W. Outcome of revision hip arthroplasty in patients younger than 55 years: an analysis of 1,037 revisions in the Dutch Arthroplasty Register. *Acta Orthop*. 2020;91(2):165-170. doi: 10.1080/17453674.2019.1708655.
35. Bayliss L.E., Culliford D., Monk A.P., Glyn-Jones S., Prieto-Alhambra D., Judge A. et al. The effect of patient age at intervention on risk of implant revision after total replacement of the hip or knee: a population-based cohort study. *Lancet*. 2017;389(10077):1424-1430. doi: 10.1016/S0140-6736(17)30059-4.
36. Schwartz A.M., Farley K.X., Guild G.N., Bradbury T.L.Jr. Projections and Epidemiology of Revision Hip and Knee Arthroplasty in the United States to 2030. *J Arthroplasty*. 2020;35(6S):S79-S85. doi: 10.1016/j.arth.2020.02.030.
37. Smith L.K., Dures E., Beswick A.D. Systematic review of the clinical effectiveness for long-term follow-up of total hip arthroplasty. *Orthop Res Rev*. 2019;11:69-78. doi: 10.2147/ORR.S199183.
38. Poursalehian M., Zafarmandi S., Razzaghof M., Mortazavi S.M.J. The impact of retaining the femoral stem in revision total hip arthroplasty: a systematic review, meta-analysis, and meta-regression. *Arch Orthop Trauma Surg*. 2024;144(2):947-966. doi: 10.1007/s00402-023-05087-3.
39. Freitag T., Reichel H. Contemporary indications for aseptic revision total hip arthroplasty. *Orthopädie (Heidelb)*. 2022;51(8):609-618. (In German). doi: 10.1007/s00132-022-04272-3.
40. Bildik C., Kahraman H.Ç., Saygı B. Vitamin E-added Highly Cross-Linked Polyethylene Decreases the Risk of Osteolysis in an *in vivo* Arthroplasty Model. *Cureus*. 2023;15(2):e34955. doi: 10.7759/cureus.34955.
41. Prock-Gibbs H., Pumilia C.A., Meckmongkol T., Lovejoy J., Mumith A., Coathup M. Incidence of Osteolysis and Aseptic Loosening Following Metal-on-Highly Cross-Linked Polyethylene Hip Arthroplasty: A Systematic Review of Studies with Up to 15-Year Follow-up. *J Bone Joint Surg Am*. 2021;103(8):728-740. doi: 10.2106/JBJS.20.01086.
42. Matharu G.S., Judge A., Murray D.W., Pandit H.G. Trabecular Metal Versus Non-Trabecular Metal Acetabular Components and the Risk of Re-Revision Following Revision Total Hip Arthroplasty: A Propensity Score-Matched Study from the National Joint Registry for England and Wales. *J Bone Joint Surg Am*. 2018;100(13):1132-1140. doi: 10.2106/JBJS.17.00718.
43. Hitz O., Le Baron M., Jacquet C., Argenson J.N., Parratte S., Ollivier M. et al. Use of dual mobility cup cemented into a tantalum acetabular shell for hip revision with large bone loss can decrease dislocation risk without increasing the risk of mechanical failure. *Orthop Traumatol Surg Res*. 2024;110(2):103739. doi: 10.1016/j.otsr.2023.103739.
44. Mirghaderi P., Eshraghi N., Sheikhabaei E., Razzaghof M., Roustai-Geraylow K., Pouramini A. et al. Does Using Highly Porous Tantalum in Revision Total Hip Arthroplasty Reduce the Rate of Periprosthetic Joint Infection? A Systematic Review and Meta-Analysis. *Arthroplast Today*. 2024;25:101293. doi: 10.1016/j.artd.2023.101293.
45. Voloshin V.P., Shavyrin D.A., Oshukov S.A., Galkin A.G. Variants of replacement of acetabulum defects during revision hip arthroplasty. *Public Health of the Far East*. 2022;2(92):66-67. (In Russian).
46. Tikhilov R.M., Dzhavadov A.A., Kovalenko A.N., Denisov A.O., Demin A.S., Vahramyan A.G. et al. What Characteristics of the Acetabular Defect Influence the Choice of the Acetabular Component During Revision Hip Arthroplasty? *Traumatology and Orthopedics of Russia*. 2020;26(2):31-49. (In Russian). doi: 10.21823/2311-2905-2020-26-2-31-49.
47. Kovalenko A.N., Shubnyakov I.I., Tikhilov R.M., Cherny A.Z. Do new and more expensive implants provide better outcomes in total hip arthroplasty? *Traumatology and Orthopedics of Russia*. 2015;21(1):5-20. (In Russian). doi: 10.21823/2311-2905-2015-0-1-30-36.

48. Shen X., Qin Y., Li Y., Tang X., Xiao J. Trabecular metal versus non-trabecular metal acetabular components for acetabular revision surgery: A systematic review and meta-analysis. *Int J Surg.* 2022;100:106597. doi: 10.1016/j.ijssu.2022.106597.
49. Su Q., Wan X., Wang D., Zhou Z. A commentary on "Trabecular metal versus non-trabecular metal acetabular components for acetabular revision surgery: A systematic review and meta-analysis" (*Int J Surg.* 2022;100:106597). *Int J Surg.* 2022;103:106660. doi: 10.1016/j.ijssu.2022.106660.
50. Golnik V.N., Dzhukhaev D.A., Krasovsky I.B., Pavlov V.V., Peleganchuk V.A. Surgical aspects of positioning individual three-flanged implants in replacement of bone defects in revision hip arthroplasty. *Department of Traumatology and Orthopedics.* 2022;4(50):15-26. (In Russian). doi: 10.17238/2226-2016-2022-4-15-26.
51. Shichman I., Somerville L., Lutes W.B., Jones S.A., McCalden R., Schwarzkopf R. Outcomes of novel 3D-printed fully porous titanium cup and a cemented highly cross-linked polyethylene liner in complex and revision total hip arthroplasty. *Arthroplasty.* 2022;4(1):51. doi: 10.1186/s42836-022-00152-5.
52. Sadovoy M.A., Pavlov V.V., Bazlov V.A., Mamuladze T.Z., Efimenko M.V., Aronov A.M. et al. Potentialities of 3D-Visualization in Preoperative Planning of Primary and Revision Total Hip Arthroplasty. *N.N. Priorov Journal of Traumatology and Orthopedics.* 2017;24(3):37-42. (In Russian). doi: 10.17816/vto201724337-42.
53. Kovalenko A.N., Shubniakov I.I., Dzhavadov A.A., Bilyk S.S., Cherkasov M.A., Ambrosenkov A.V. et al. The role of three-dimensional visualization in revision hip arthroplasty. *Genij Ortopedii.* 2020;26(3):364-369. (In Russian). doi: 10.18019/1028-4427-2020-26-3-364-369.
54. Kovalenko A.N., Tikhilov R.M., Bilyk S.S., Shubnyakov I.I., Cherkasov M.A., Denisov A.O. Positioning of custom-made acetabular components at revision hip arthroplasty: do they really match as "a key and a lock"? *N.N. Priorov Journal of Traumatology and Orthopedics.* 2017;24(4): 31-37. (In Russian). doi: 10.17816/vto201724431-37.
55. Romagnoli M., Zaffagnini M., Carillo E., Raggi F., Casali M., Leardini A. et al. Custom-made implants for massive acetabular bone loss: accuracy with CT assessment. *J Orthop Surg Res.* 2023;18(1):742. doi: 10.1186/s13018-023-04230-5.
56. Weber M., Witzmann L., Wieding J., Grifka J., Renkawitz T., Craiovan B. Customized implants for acetabular Paprosky III defects may be positioned with high accuracy in revision hip arthroplasty. *Int Orthop.* 2019;43(10):2235-2243. doi: 10.1007/s00264-018-4193-3.
57. Unter Ecker N., Kocaoğlu H., Zahar A., Haasper C., Gehrke T., Citak M. What Is the Dislocation and Revision Rate of Dual-mobility Cups Used in Complex Revision THAs? *Clin Orthop Relat Res.* 2021;479(2):280-285. doi: 10.1097/CORR.0000000000001467.
58. Donovan R.L., Johnson H., Fernando S., Foxall-Smith M., Whitehouse M.R. et al. A Meta-Analysis of the Incidence and Temporal Trends of Postoperative Dislocation in Revision Total Hip Arthroplasty Utilizing Constrained Acetabular Components or Dual Mobility Implants. *J Arthroplasty.* 2023;38(5): 957-969.e1. doi: 10.1016/j.arth.2022.11.007.
59. Scholz J., Perka C., Hipfl C. Dual-mobility bearings reduce instability but may not be the only answer in revision total hip arthroplasty for recurrent dislocation. *Bone Joint J.* 2024;106-B(5 Supple B):89-97. doi: 10.1302/0301-620X.106B5.BJJ-2023-0828.R2.
60. Tikhilov R.M., Dzhavadov A.A., Koptsov A.V., Filonov P.V., Kurbanova S.M., Shubnyakov I.I. Which Factors Can Lead to Subsidence of a Non-Modular Tapered Stem after Revision Hip Arthroplasty? *Traumatology and Orthopedics of Russia.* 2024;30(1): 42-51. (In Russian). doi: 10.17816/2311-2905-17417.
61. Boettcher J.M., Sellenschloh K., Huber G., Ondruschka B., Morlock M.M. A Modified Wagner Stem Design Increases the Primary Stability in Cementless Revision Hip Arthroplasty. *Arthroplast Today.* 2025;32:101622. doi: 10.1016/j.artd.2025.101622.
62. Kovaldov K.A., Morozova E.A., Gerasimov E.A., Gerasimov S.A. Revision total hip arthroplasty with custom-made hip implant for Paprosky type IV femoral bone loss. *Genij Ortopedii.* 2023;29(5):546-551. (In Russian). doi: 10.18019/1028-4427-2023-29-5-546-551.

Authors' information

✉ Igor I. Shubnyakov — Dr. Sci. (Med.)

Address: 8, Akademika Baykova st., St. Petersburg, 195427, Russia

<https://orcid.org/0000-0003-0218-3106>

e-mail: shubnyakov@mail.ru

Andrey A. Korytkin — Cand. Sci. (Med.), Associate Professor

<https://orcid.org/0000-0001-9231-5891>

e-mail: andrey.korytkin@gmail.com

Alexey O. Denisov — Dr. Sci. (Med.)

<https://orcid.org/0000-0003-0828-7678>

e-mail: med-03@ya.ru

Alisagib A. Dzhavadov — Cand. Sci. (Med.)

<https://orcid.org/0000-0002-6745-4707>

e-mail: alisagib.dzhavadov@mail.ru

Aymen Riahi — Cand. Sci. (Med.)

<https://orcid.org/0000-0001-8407-5453>

e-mail: riahi_aymen@outlook.com

Maksim S. Guatsaev

<https://orcid.org/0000-0003-1948-0895>

e-mail: mguatsaev@inbox.ru

Abdula M. Chililov — Cand. Sci. (Econ.), Associate Professor

<https://orcid.org/0000-0001-9638-7833>

e-mail: chililov@mail.ru

Rashid M. Tikhilov — Dr. Sci. (Med.), Professor,

Corresponding Member of the RAS

<https://orcid.org/0000-0003-0733-2414>

e-mail: rtikhilov@gmail.com