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Features of removal of stable femoral stems of hip endoprostheses

V. A. Filipenko, S. Ye. Bondarenko, O. P. Maruschack, Ye. V. Olinkevych

Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine, Kharkiv

The increase in the number of primary arthroplasty procedures has led to an increase in revision arthroplasty for periprosthetic infection and fractures of hip stems. The problem of removing stable stems remains relevant, as the lack of a unified approach leads to an increase in the duration of operations, an increased risk of complications and worsening of treatment outcomes. Objective. To review the existing methods and find out the most optimal approaches to the removal of stable stems of hip arthroplasties of different types of fixation. Methods. A systematic literature review was conducted using the electronic databases PubMed, Scopus, Web of Science for the period 1986–2023. 28 publications were analyzed. The authors' own clinical experience was used (171 revision interventions from 2013 to 2024). Results. The method of removal depends on the type of fixation and design of the endoprosthesis stem. The main methods are: use of special instruments, window osteotomy, extended proximal osteotomy, transfemoral osteotomy. The choice of method depends on the specific situation, starting with the least traumatic approach. Conclusions. Removal of stable stems requires an individual approach and careful planning. Cemented polished stems are usually easier to remove, but there may be difficulties with the removal of the cement mantle. Cementless stems with distal fixation often require more aggressive methods. The choice of method should be based on the principle of minimal trauma, taking into account the possibility of further revision arthroplasty. It is recommended to have several alternative surgical plans. The proposed methodology of intraoperative actions allows optimizing the decision-making process, which contributes to improving the results of revision hip arthroplasty.

Зростання кількості первинного ендопротезування призвело до збільшення частоти ревізійних втручань. Проблема видалення стабільних ніжок залишається актуальною, оскільки відсутність єдиного підходу призводить до збільшення тривалості операцій, підвищення ризику ускладнень та погіршення результатів лікування. Мета. Розглянути існуючі методики та з'ясувати найбільш оптимальні підходи до видалення стабільних ніжок ендопротезів кульшового суглоба різного типу фіксації. Методи. Проведено систематичний огляд літератури з електронних баз PubMed, Scopus, Web of Science за період 1986–2023 р., з яких відібрано 28 публікацій. Використано власний клінічний досвід авторів (171 ревізійне втручання з 2013 по 2024 рік). Результати. Методика видалення залежить від типу фіксації та дизайну ніжки ендопротеза. Основні методики: використання спеціальних інструментів, «вікончата», розширена проксимальна та трансфеморальна остеотомії. Вибір способу залежить від конкретної ситуації, починаючи з найменш травматичного підходу. Висновки. Видалення стабільних ніжок вимагає індивідуального підходу та ретельного планування. Цементні поліровані ніжки зазвичай легше видалити, але можуть виникнути складнощі з вилученням цементної мантії. Безцементні ніжки з дистальною фіксацією здебільшого вимагають агресивніших дій. Вибір методики повинен ґрунтуватися на принципі мінімальної травматичності з урахуванням можливості подальшого ревізійного ендопротезування. Рекомендується мати кілька альтернативних планів операції. Запропонована методика інтраопераційних дій дозволяє оптимізувати процес прийняття рішень, який сприяє покращенню результатів ревізійного ендопротезування кульшового суглоба. Ключові слова. Ендопротезування кульшового суглоба, ревізія кульшового суглоба, видалення стегнового компонента ендопротеза кульшового суглоба.

Key words. Hip arthroplasty, hip revision arthroplasty, femoral stem removal

Introduction

Total hip replacement is one of the most effective and common orthopedic procedures performed today. According to the Agency for Healthcare Research and Quality (AHRQ), more than 1 million hip and knee replacements are performed annually in the United States [1]. The increase in the number of primary total hip replacements over the past three decades, as well as the expansion of indications for this surgery in younger and more active patients, has led to a corresponding increase in the number of revision procedures. Analysis of trends shows that the proportion of such procedures remains significant. Between 1990 and 2002, 17.5 % of all hip replacements in the United States were revision procedures. This percentage was projected to remain stable at 16.3 % in 2005 and is projected to remain at 14.5 % in 2030 [2]. However, the increase in infectious complications is of particular concern. The percentage of revision hip arthroplasty due to periprosthetic infection increased from 9.7 % to 23.7 % during 2012–2022 [3]. Removal of stable endoprosthesis components, especially femoral components, poses significant technical challenges, as the endoprosthesis stem is usually stably fixed in the bone, which poses a risk of additional bone damage (significant bone defects and fractures). Despite the importance of this problem, there is no systematic approach in the current literature to the choice of a method for removing the stable femoral component of a hip endoprosthesis. The lack of a unified vision of solving this issue leads to an increase in the duration of operations, an increase in the risk of intraoperative complications, and a deterioration in long-term treatment results. In addition, a suboptimal choice of endoprosthesis removal technique can cause significant bone defects that complicate subsequent reconstruction and negatively affect the functional outcome.

Purpose: to review existing methods and identify the most optimal approaches to removing stable stems of hip joint endoprostheses of various types of fixation.

Material and methods

The study was approved by the local Bioethics Committee of the State Establishment "Professor M. I. Sytenko Institute of Spine and Joint Pathology of the NAMS of Ukraine" (Protocol No. 246 dated 23.09.2024).

A systematic review of the literature was conducted using the scientometric electronic databases PubMed, Scopus, Web of Science and other relevant sources of scientific and medical information. The search was carried out using the keywords: hip arthroplasty, hip revision arthroplasty, removal of the femoral component of the hip joint endoprosthesis (hip arthroplasty, hip revision arthroplasty, femoral stem removal).

The search depth covered the period from 1986 to 2023, which allowed us to take into account both classical methods and modern approaches to the removal of stable stems of endoprostheses. The analysis included 28 publications that met the criteria of relevance and completeness of coverage of the problem under study. The scientific literature of the last 5 years consists of 10 sources.

In addition, the study used the authors' own clinical experience in performing revision surgeries to remove stable stems of hip joint endoprostheses. In the period from 2013 to 2024, 171 revision surgeries were performed in the clinic on this occasion. This allowed us to supplement theoretical information with practical observations and recommendations.

The selection of articles was carried out according to the following criteria: compliance with the research topic; the presence of a detailed description of the methods for removing stable stems of endoprostheses; presentation of the results of the clinical application of the described methods; publication in peer-reviewed scientific journals.

Articles that did not contain sufficient information about the technique of endoprosthesis removal or did not have clinical confirmation of the effectiveness of the described techniques were excluded.

Results

Unlike early periprosthetic infection, where the method of choice is revision surgery consisting of debridement and replacement of the friction pair [4], in the case of late infectious complications, all orthopedic surgeons recognize that the only possibility to cure them is intervention with complete removal of the endoprosthesis. In some cases, a new endoprosthesis is immediately installed after this (one-stage revision endoprosthesis) [5]. However, in most cases, a two-stage endoprosthetic repair is performed with the use of a temporary implant after the first stage — a spacer [6, 7], or without it (Girdlestone).

In both of these techniques, complete removal of the structure is initially provided. Minimization of complications in the form of significant bone defects and fractures of the femur requires very careful and meticulous preparation for this operation.

With the advent of special tools for removing the cementless endoprosthesis cup, this problem has been practically solved (Fig. 1).

There are no special difficulties with the cement cup (the polyethylene cup can be removed using a milling cutter, and the cement mantle with a chisel and a sharp spoon) [8].

It should be noted that removing a stable endoprosthesis stem is a very difficult task.

First, it is worth mentioning that the stems are divided by the type of fixation - cement or cementless. Cement polished stems can be removed using extractors (Fig. 2) (quite easily), but the cement mantle in the bone canal of the femur most often remains intact (Fig. 3).

Removing the proximal part of this mantle (approximately 1/3 of the length) using a chisel is carried out without any special problems, but complete removal of the cement is a much more complicated process.

Undoubtedly, there are special tools — long chisels (straight and fluted), special spoons with reverse stroke, drills, conical cutters with high thread, etc. [11] (Fig. 4).

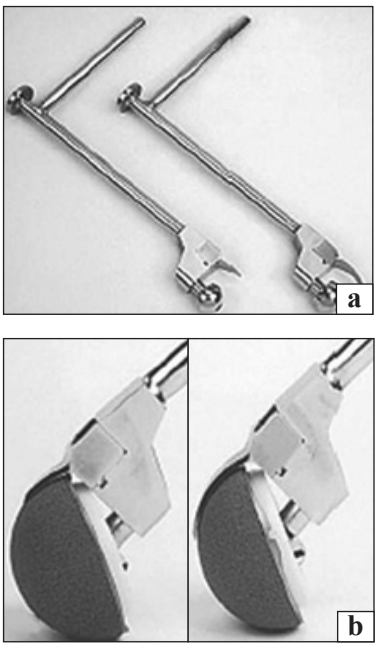

Fig. 1. System used to remove well-fixed, cementless acetabular components: two blades — short on the left (a) and full radius on the right (b) [9]

Fig. 2. Femoral component extractor [2]

However, all these devices do not always allow for complete removal of the distal part of the cement. Some experts believe that complete removal of the cement mantle is not necessary in single-stage arthroplasty, and it is possible to install a new cement stem if the cement remnants do not interfere (the "cement-in-cement" technique), but not everyone agrees with this [10, 12]. We are also convinced that during the treatment of periprosthetic infection, the cement should be completely removed.

Clinical example No. 1

A 62-year-old patient G. was diagnosed with late periprosthetic infection of the right hip joint (Fig. 5, a). Condition after two-stage revision hip replacement: removal of the components of the hip replacement (femoral — using an extractor, cement mantle — using a long bit), installation of a metal-cement spacer (Fig. 5, b), revision of the right hip joint, removal of the metal-cement spacer, installation of an augment, cement cup, revision modular stem with a ceramic head, plastic surgery of the cavity defect of the medial wall of the acetabular fossa with granules of biphasic ceramics based on hydroxylapatite (Fig. 5, c).

For complete removal of the cement mantle, two types of femoral osteotomy can be performed: extended proximal (ETO) and transfemoral (Wagner) [13–16] (Fig. 6, c).

They differ in the size of the circumference and orientation. Extended proximal osteotomy usually covers one third of the femoral circumference,

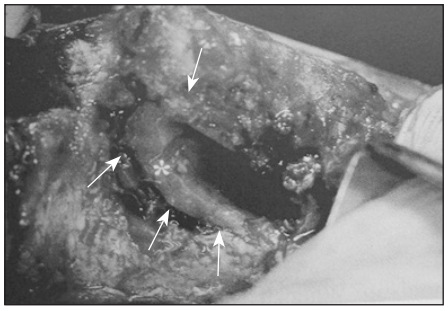

Fig. 3. Remains of cement mantle after removal of the femoral component [10]

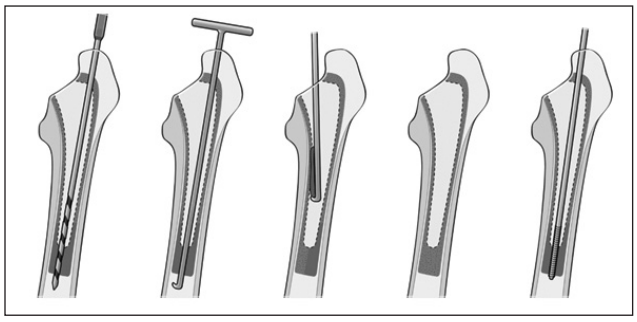

Fig. 4. Variants of distal cement mantle removal [11]

accessed in the sagittal plane (Fig. 6a), while transfemoral osteotomy covers half of the femoral circumference, accessed in the frontal plane (Fig. 6b).

After the osteotomy, part of the bone wall remains connected to the periosteum and opens like a lid, allowing for expanded access to the cement mantle and its complete removal. This is followed by osteosynthesis with wire, staples, or cables, and insertion of a spacer or revision stem [15, 17].

The advantage of this technique is very good visual control, which allows for easy cement removal [18].

Its disadvantages are trauma, weakening of the mechanical strength of the proximal femur and the risk of further fracture, development of instability of the spacer or endoprosthesis stem (with one-stage revision endoprosthesis).

Another technique is used in cases where most of the cement mantle can be removed, but its distal part remains in the femoral canal, the so-called "window" osteotomy of the femur. To perform this, it is necessary to find out the boundaries of the cement residues in the distal part of the femoral mantle. From another, relatively small, access, first, using a thin drill, the boundaries of the cement location are specified, then a "window" is made with a pendulum saw, 1 cm wide at its location. The formed bone flap is removed (Fig. 7).

After that, the cement is removed, the bone flap is placed in its place and fixed with a metal wire, ties or cable. Then a revision stem or spacer is installed [15, 19].

This procedure is less traumatic, the risk of fracture is lower, but still the postoperative loading of the limb should be very careful. To prevent fracture, the spacer or revision stem should be immersed 5–6 cm distal to the level of the formed "window" in the femur [20].

Removal of unpolished cement stems is technically a more difficult intervention due to the stronger connection of such stems with the cement mantle. It is mostly possible to remove them only together with the cement, which is very difficult given their stability. Therefore, first we also try to remove the proximal part of the cement mantle with a chisel, then form

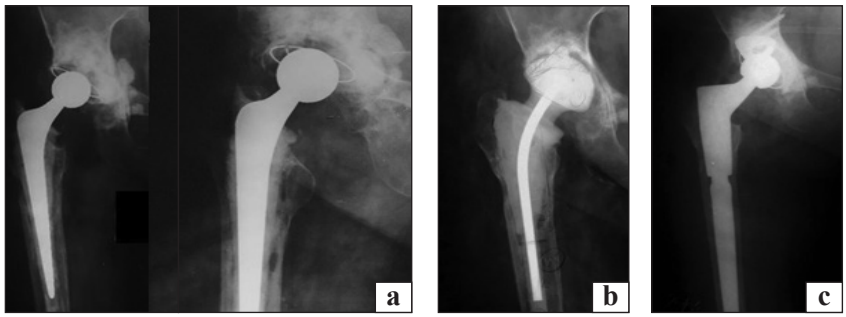

Fig. 5. Patient G. Radiographs "before" and "after" surgical interventions: periprosthetic infection of the right hip joint (a); condition after revision intervention and installation of a metal-cement spacer (b) and after revision arthroplasty (c)

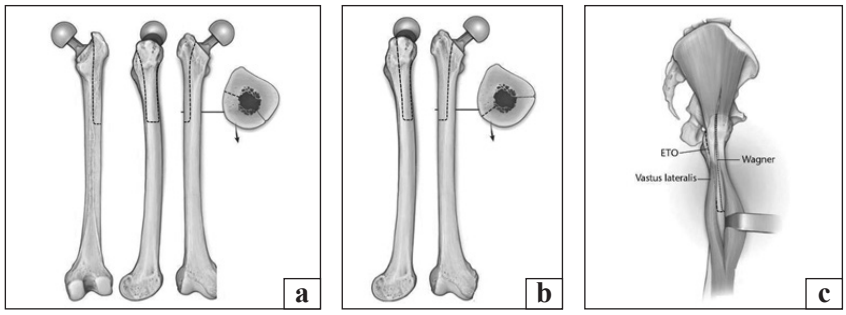

Fig. 6. Schematic representation of the lines of cuts that need to be made for the extension of the proximal osteotomy (a) and for the transfemoral osteotomy (b). Visual comparison of two methods (c) [15]

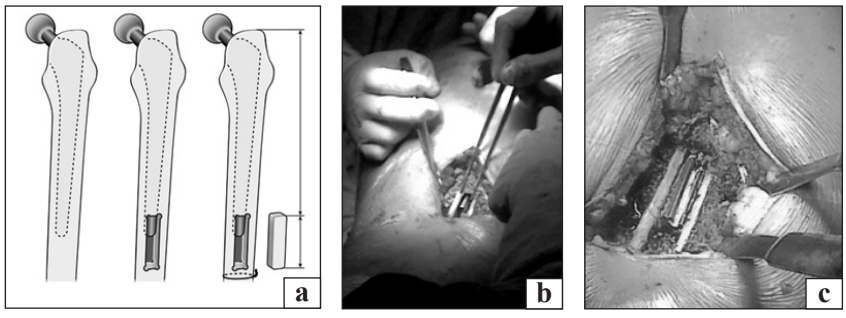

Fig. 7. Schematic representation of the technique of performing a "window" osteotomy (a). [11]. Intraoperative clinical example of the technique of "window" osteotomy (b, c)

a "window" in the femur along the remaining cement, remove it and knock out the stem from the side of this "window" in the proximal direction. Unlike the removal of cement residues, in the case of polished stems, the width of the "window" can reach one third of the circumference of the femur due to the size of the cement mantle.

Clinical example No. 2

A 73-year-old patient G. was diagnosed with late periprosthetic infection after unipolar cement endoprosthetic repair of the left hip joint due to a fracture of the femoral neck (Fig. 8, a). The operation was a two-stage revision of the left hip joint. A "window" osteotomy of the femur was performed and the unipolar endoprosthesis and bone cement were removed without the use of a spacer (Fig. 8, b). Revision endoprosthesis of the left hip joint was performed after 12 weeks (Fig. 8, c).

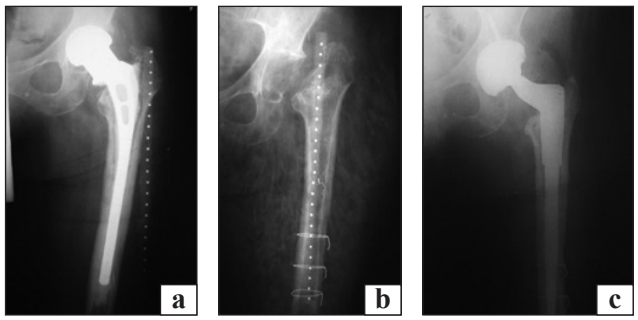

Fig. 8. Patient G. Condition "before" and "after" surgical interventions: periprosthetic infection of the left hip joint (a); condition after revision, removal of endoprosthesis components (b); condition after revision endoprosthetic repair of the left hip joint (c)

In our own observations, in the presence of a massive cement mantle of irregular shape (with uneven contours), the method of choice is immediately an extended proximal osteotomy of the femur.

Removal of cementless stems depends on the type of fixation: proximal, intermediate (metaphyseal) or distal.

The stem of the proximal fixation is easiest to remove, because osseointegration is observed only in its proximal part. This allows the stem to be mobilized with a chisel and removed without violating the integrity of the femur and without creating additional complications in the future during the installation of a revision stem [11] (Fig. 9).

Clinical example No. 3

A 61-year-old patient S. was diagnosed with late periprosthetic infection of the right hip joint after total cementless arthroplasty (Fig. 10, a).

Condition after two-stage revision arthroplasty of the right hip joint, removal of the stem using a flexible bit with the installation of a cement spacer (Fig. 10, b), removal of the spacer and installation of the revision stem, replacement of the cup and head (Fig. 10, c).

The stem of the intermediate (metaphyseal) fixation (Muller type) is more difficult to remove, but in most cases, it is still possible to mobilize it using flexible bits, loosen it and knock it out. Some designs have a high-quality ceramic coating of the entire surface, which causes fusion with the bone tissue of the femur of almost the entire surface of the stem. Excessive efforts can lead to a fracture of the femur and

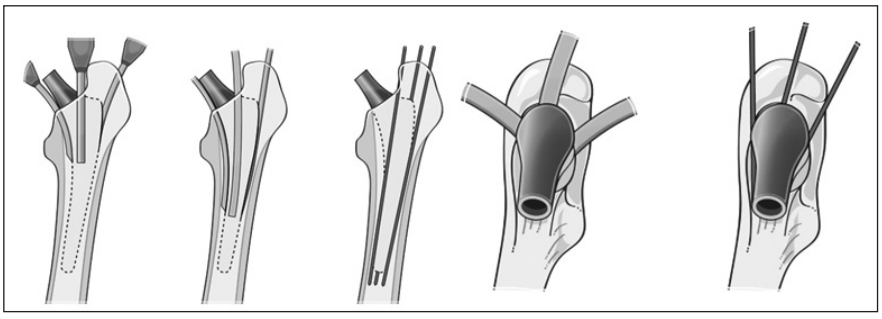

Fig. 9. Schematic representation of extraction of the femoral component with cementless proximal type of fixation using a flexible bit and its mobilization using Steinmann pins [21]

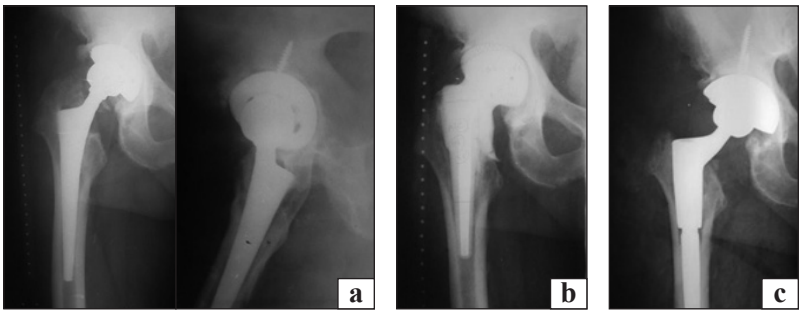

Fig. 10. Patient S. Radiographs "before" and "after" surgical interventions: periprosthetic infection of the right hip joint (a); after revision of the joint, installation of a cement spacer (b); after revision arthroplasty (c)

significantly increase the trauma of the operation [11, 13]. Therefore, if it is not possible to mobilize the femoral component using flexible bits, there is a need to perform an extended proximal femoral osteotomy.

Clinical example No. 4

A 54-year-old patient L. was diagnosed with late periprosthetic infection of the right hip joint (Fig. 11, a). Condition after two-stage revision endoprosthetic repair: removal of endoprosthesis components (femoral metaphyseal fixation using a flexible bit), installation of a cement spacer (Fig. 11, b); its removal and installation of a Wagner-type revision stem (Fig. 11, c).

The greatest difficulties are caused by the removal of the distal fixation stem of Zweymuller type, or another design.

It is mostly impossible to mobilize such stems even with the help of flexible bits. However, we always try to use them first and loosen the stem. Sometimes this works, which significantly reduces the trauma of the intervention and facilitates the installation of a spacer or revision stem.

Clinical example No. 5

A 72-year-old patient Y. was diagnosed with late periprosthetic infection of the left hip joint (Fig. 12, a). A two-stage revision arthroplasty was performed —removal of the prosthesis components, replacement of defects with a metal-cement spacer (Fig. 12, b) with its subsequent removal (Fig. 12, c) and installation of a Kerboull ring, cement cup and cementless Wagner stem. Due to the destruction of the proximal femur, it became possible to effectively remove the femoral component of the distal fixation using a flexible bit.

Most often, an extended proximal femoral osteotomy must be performed. Preliminary work with the use of a flexible bit facilitates and accelerates the mobilization of the stem after femoral osteotomy.

Clinical case No. 6

A 62-year-old patient G. was diagnosed with late periprosthetic infection of the right hip joint (Fig. 13, a). Condition after two-stage revision arthroplasty: revision of the right hip joint, extended proximal osteotomy of the right femur, removal of endoprosthesis components, metal osteosynthesis of the proximal femur with a cable system (Fig. 13, b). At the second stage, the defects of the acetabular fossa were repaired with biphasic ceramic granules and allografts, an augment, a cement cup and a revision pedicle were installed, and the upper third of the femur was fixed with tape (Fig. 13, c).

Removal of broken stems

Fracture of the femoral component accounts for approximately 1% of revisions after primary total hip arthroplasty [22, 23].

It is quite easy to remove the proximal part of the stem, but the distal part is usually well fixed in the femoral canal and it is very difficult to reach it. Such cases are more common with long stems and revision modular ones [24, 25].

There are special devices for this, for example, a technique in which, after osteotomy of the femur at the level of the stem fracture, a hole is first made in the distal part of the stem to a depth of 1–1.5 cm

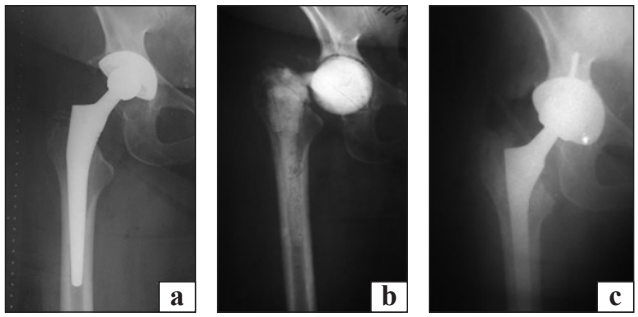

Fig. 11. Patient L. Radiographs "before" and "after" surgical interventions: periprosthetic infection of the right hip joint (a); condition after revision, installation of a cement spacer (b); after revision arthroplasty (c)

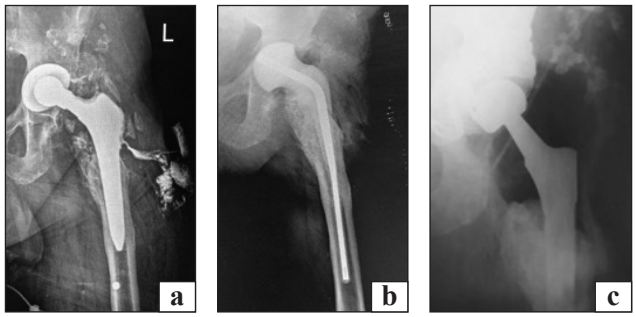

Fig. 12. Patient Y. Radiographs “before” and “after” surgical interventions: periprosthetic infection of the left hip joint (a); after revision, installation of a metal-cement spacer (b); after revision arthroplasty (c)

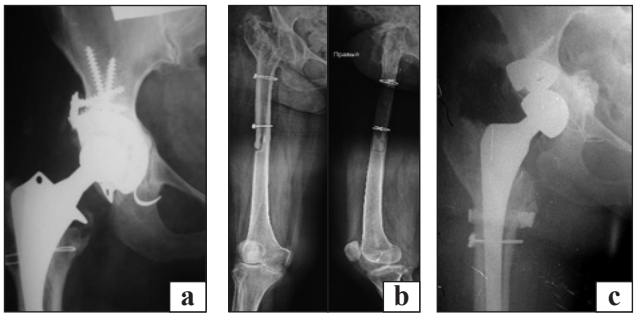

Fig. 13. Patient G. Radiographs “before” and “after” surgical interventions: periprosthetic infection of the right hip joint (a); after revision with extended proximal osteotomy (b); after revision arthroplasty (c)

with a drill, then a thread is cut with a tap, a removal tool is screwed into this hole, after which the stem is removed with a hammer (Fig. 14).

Clinical example No. 7

A 77-year-old patient K. was diagnosed with late periprosthetic infection of the left hip joint. Condition after two-stage revision arthroplasty: removal of prosthesis components, replacement of the defect with a metal-cement spacer (Fig. 15, a), removal of the spacer, installation of a revision stem (Fig. 15, b). Fracture of the modular stem of the left hip joint endoprosthesis (Fig. 15, c). Condition after revision arthroplasty, femoral osteotomy, removal of a stem fragment, replacement of the modular stem (Fig. 15, d).

As a rule, an extended proximal femoral osteotomy [26] or a "window" [27, 28] is used.

It is better to form a "window" immediately distal to the end of the stem and apply force by direct blows to the stem in the distal-proximal direction. In order to reach the distal part of the stem after its displacement in the proximal direction, metal cylinders 2–3 cm long and 8–10 mm in diameter are immersed in the femoral canal. This gives a possibility to apply force directly to the end of the stem without additional trauma to the femur.

Clinical example No. 8

A 50-year-old patient S. was diagnosed with late periprosthetic infection of the right hip joint, fracture of the endoprosthesis stem (Fig. 16, a). Condition after one-stage revision endoprosthesis of the right hip joint, "window" osteotomy of the femoral diaphysis, removal of the broken stem, installation of the revision construct stem (Fig. 16, b).

Fig. 14. Removal of the distal part of the broken stem using a tap in a clinical example

Discussion

Our study emphasizes the importance of an individual approach and careful preoperative planning during the removal of stable endoprosthesis stems.

Literature review and our own clinical experience show that the choice of endoprosthesis removal technique depends largely on the type of fixation and stem design. This is consistent with the data of J. M. Laffosse, who also emphasizes the need for a differentiated approach to the removal of different types of endoprostheses [11].

During the removal of cement stems, we encountered the problem of removing the cement mantle, especially in the case of polished stems. This issue was also described in the work of F. Pipino, who proposed the "cement-in-cement" technique for cases where complete cement removal is not possible [10]. However, unlike Pipino, we believe that for the treatment of periprosthetic infection, the cement should be removed completely. This is consistent with the recommendations of the Second International Consensus Conference on Periprosthetic Infection [4].

For the removal of unpolished cement stems, we often used a "window" osteotomy. This method is also described by K. A. Zweymuller et al., who emphasize the effectiveness of this technique for removing cemented stems [20].

Regarding cementless stems, our experience shows that proximally fixed stems are usually easier to remove than distally fixed stems. This is in line with the findings of R. P. Shah et al., who described a technique using Steinmann pins to remove well-fixed cementless stems [21].

For distally fixed stems, we often used an extended proximal femoral osteotomy. This technique is described in detail by T. I. Younger et al. and remains an effective method for difficult cases [13].

We paid special attention to the problem of removing broken stems. We used both special instruments

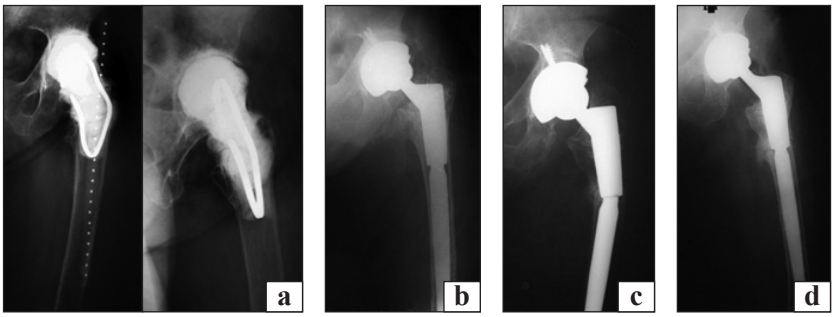

Fig. 15. Patient K. Radiographs "before" and "after" surgical interventions: after revision of the left hip joint, removal of components and replacement of the defect with a metal-cement spacer (a); after revision arthroplasty (b); fracture of the modular stem of the endoprosthesis (c); after revision arthroplasty, osteotomy of the femur, removal of a stem fragment, replacement of the modular stem (d)

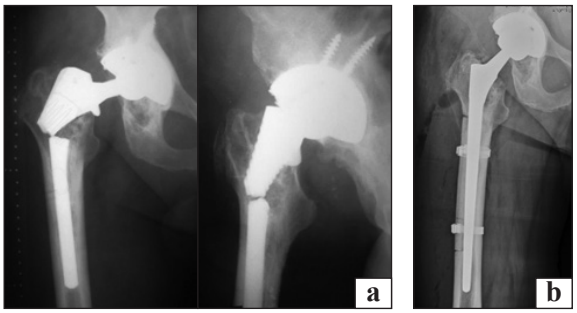

Fig. 16. Patient S. Radiographs "before" and "after" surgical interventions: fracture of the endoprosthesis stem (a); after revision arthroplasty, removal of the broken stem and its replacement (b)

(e. g., the tap technique) and osteotomy. This is consistent with the approach described by P. Wahl et al., who also emphasize the effectiveness of osteotomy for removing broken stems [26].

Our study has certain limitations. First, a comparative analysis of the effectiveness of different endoprosthesis removal techniques was not conducted. Second, long-term results after revision endoprosthesis using different stem removal techniques were not presented. These aspects may be the subject of further development.

Despite the listed limitations, this study has important practical significance. The proposed intraoperative procedure allows for optimizing the decision-making process depending on the type of prosthesis fixation. This may contribute to improving the results of revision hip arthroplasty and reducing the risk of intraoperative complications.

Conclusions

Removal of stable hip joint endoprostheses is a complex surgical task that requires an individual approach and careful preoperative planning.

The choice of technique depends on the type of fixation (cemented or cementless) and the design of the endoprosthesis stem. Cemented polished stems are usually easier to remove, but difficulties may arise with removing the cement mantle. Cementless stems with distal fixation often require more aggressive removal techniques.

The main methods of removal are using special instruments (extractor, chisel), "window" osteotomy, extended proximal osteotomy and transfemoral osteotomy. The choice should be based on the principle of minimal trauma, considering the possibility of subsequent revision endoprosthesis.

Special techniques or instruments may be required when removing broken stems. In such cases, a "windowed" or extended proximal femoral osteotomy is often effective.

It is recommended to have several alternative surgical plans with appropriate material support to allow intraoperative changes in tactics. It is better to start with the least traumatic techniques, moving to more aggressive ones only if necessary.

The proposed sequence of intraoperative actions allows for optimizing the decision-making process depending on the type of prosthesis fixation, which contributes to improving the results of revision hip arthroplasty.

Conflict of interest. The authors declare the absence of a conflict of interest.

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FEATURES OF REMOVAL OF STABLE FEMORAL STEMS OF HIP ENDOPROSTHESES

V. A. Filipenko, S. Ye. Bondarenko, O. P. Maruschack, Ye. V. Olinkevych

Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine, Kharkiv

✉ Volodymyr Filipenko, MD, Prof. in Orthopaedics and Traumatology: filippenko1957@gmail.com

✉ Stanislav Bondarenko, MD, DSci in Orthopaedics and Traumatology: bondarenke@gmail.com

✉ Olexii Marushchak, MD, PhD: dr.marushchak@yahoo.com

✉ Yevgen Olinkevych, MD: princ1206@gmail.com