УДК 616.728.2-089.844-089.193.4 DOI: 10.21823/2311-2905-2019-25-1-9-18

Mid-Term Outcomes of Revision Hip Arthroplasty with Acetabular Augments

A.A. Korytkin, Ya.S. Novikova, K.A. Kovaldov, S.B. Korolev, A.A. Zykin, S.A. Gerasimov, E.A. Gerasimov

Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation

Abstract

Acetabular defects are a major obstacle to achieving good outcomes after revision hip arthroplasty. One way to deal with this problem is to use acetabular augments. We aimed to describe mid-term outcomes of revision hip arthroplasty using acetabular augments. ***Materials and Methods.*** We analyzed 85 cases (83 patients) of revision hip arthroplasty using acetabular augments performed during 2012–2018 period: 53 women and 30 men with average age of 57±13 years (25–79). Distribution of acetabular defects was: 51 cases — Paprosky IIIA, 17 cases — Paprosky IIIB, 12 cases — Paprosky IIB, 5 cases — Paprosky IIC. 14 patients had chronic pelvic discontinuity. Aseptic loosening was indication for the operation in 83 cases, periprosthetic hip fracture — 1, dislocation — 1. The amount of previously undregone ipsilateral hipsurgeries was 1 in 35 cases, 2 in 25 cases, 3 and more in 25 cases. Average follow-up period was 38±19 months (1–79). ***Results.*** The average HHS score improved from 37±7 preoperatively to 73±9 after 3 months and to 80±11 after 12 months postoperatively (p = 0.001). Average VAS score improved from 7±2 preoperatively to 4±1 after 3 months and to 3±1 after 12 months postoperatively (p = 0.001). Stable acetabular fixation was achieved in each case according to X-ray findings at final follow-up. However, radiolucent lines were present around the cup in 10 cases (11.8 %) followed by no clinical evidence of aseptic loosening. Hip center of rotation was restored from 26.40±18.38 mm (4–75) preoperatively to 4.78±5.02 mm (0–20) postoperatively relatively to 0 point. Complications manifested in 9 out of 85 cases (10,6%). Distribution of complications was: periprosthetic joint infection in 6 cases, recurrent dislocation — 2, periprosthetic hip fracture — 1.7 patients required implant removal and exchange. ***Conclusions.*** Good mid-term outcomes can be achieved using acetabular augments during hip revision surgery in setting of acetabular defects. Acetabular augments are a reliable option in case of Paprosky IIIB, IIIA defects and chronic pelvic discontinuity, providing good mechanical stability.

Keywords: revision hip arthroplasty, acetabular defects, augments, pelvic discontinuity.

Background

Repair of acetabular bone defects in revision hip arthroplasty (RHA) is a complex task, and the successful outcome of the operation and the patient's satisfaction depend on the method for solving this task [1]. The aims of the reconstruction of the acetabulum are long-term survivorship and proper functioning of the implant. This is not possible without ensuring stable fixation of the acetabular component of the endoprosthesis, restoration of the rotation center of the hip and adequate compensation of a bone deficit [2]. Methods for repairing acetabular defects in RHA may be different. Along with bone alloplasty and the installation of a hemispherical porous-coated cup fixed with screws, various specialized devices are successfully

Cite as: Korytkin A.A., Novikova Ya.S., Kovaldov K.A., Korolev S.B., Zykin A.A., Gerasimov S.A., Gerasimov E.A. [Mid-Term Outcomes of Revision Hip Arthroplasty with Acetabular Augments]. *Travmatologiya i ortopediya Rossii* [Traumatology and Orthopedics of Russia]. 2019;25(1):9-18. (In Russ.). DOI: 10.21823/2311-2905-2019-25-1-9-18.

Yana S. Novikova; e-mail: novikova_jana@mail.ru

Received: 18.11.2018. Accepted for publication: 15.02.2019.

used to achieve the goals: extra-large hemispherical components (jumbo cup), oblong/bilobed cup, modular components from trabecular metal, rings, anti-protrusion cages and individual three-flange acetabular components [3–5]. Each of the above devices has its advantages and disadvantages. Thus, the choice of a specific hardware and technique of operation for RHA in acetabular defects is a matter for debate.

One of the solutions to this problem in patients with acetabular defects is the use of tantalum acetabular augments [6]. Tantalum is increasingly used in RHA, especially in major bone defects of the acetabulum: recent studies by foreign colleagues have reported good short-term outcomes of operations with tantalum augments [7–10].

We have been using tantalum acetabular augments for RHA in patients with acetabular defects since 2012. Of interest is an analysis of the survivorship of the device, clinical and radiographic findings in RHA using acetabular augments and comparing the data with the findings of other researchers.

The objective of the study is to evaluate the mid-term outcomes of RHA using acetabular augments in patients with acetabular defects.

Materials and Methods

The outcomes of RHA with the insertion of acetabular augments in 98 patients wiacetabular defects performed from February 2012 to July 2018 were analyzed retrospectively. 15 patients did not attend the follow-up examination and were excluded from the study. In summary, the outcomes of 85 operations in 83 patients were studied. All patients consented to the processing and publication of personal data. There were 30 males, 53 females. The average age of patients was 57±13 years (from 25 to 79 years), the average BMI was 28.2±4.8 kg/m^2. In 50 cases, the right joint was operated, in 35 — the left joint. Postoperative follow-up averaged 38±19 months (from 1 to 79 months).

The type of acetabular defect was determined by the commonly used Paprosky classification [11]. In 12 cases the defects were classified as II B, in 5 — II C, in 51 — III A, in 17 – III B. 14 patients had a pelvic discontinuity at the level of the acetabulum. In most cases, the defects were segmental (57 of 85 cases). Fractures of the pelvic or hip bones as a result of trauma were the primary diagnosis in 29 patients, deforming osteoarthrosis in 23, dysplastic coxarthrosis in 16, avascular necrosis of the femoral head in 4, and no diagnosis given for 7 people. Indications for RHA were aseptic loosening of the endoprosthesis components in 83 cases, periprosthetic hip fracture in 1 case and recurrent dislocations in 1 case. According to laboratory results, periprosthetic infection (PPI) is excluded in 56 cases.

In 29 patients, a two-stage revision hip replacement was performed wipre-installation of an articulating spacer and subsequent insertion of the endoprosthesis components and additional supporting elements. The number of past surgical interventions performed on the operated joint prior to RHA using acetabular augments was: one in 35 patients, two in 25, three in 14, four in 7, five in 3, thirteen in 1 patient. In 17 patients, bohips were replaced.

All analyzed operations were performed under the guidance of a single surgeon. In 71 cases, posterior approach to the hip was performed, in 14 cases — anterolateral. Acetabular tantalum augments were inserted in all patients. In some cases, in order to achieve a stable fixation of the endoprosthesis components, in addition to acetabular augments, various meshes were used: acetabular ones in 4 and femoral ones in 2 patients. In 5 people, due to a significant deficit in bone mass of the acetabulum, several augments were used: 2 in 3 patients and 3 in 2 patients. Previous acetabular components were removed from all patients. The acetabulum was milled. Then, depending on the depand expanse of the bone de-

fect in the acetabulum, 1 to 3 augments were placed. Augments were fixed to the native bone wiscrews, and to the cup – wicement. If osteolysis around the femoral component was detected in preoperative radiography or the loosening of the endoprosthesis stem was diagnosed intraoperatively, then the stem was replaced. The total replacement of the endoprosthesis components was performed in 65 cases, the replacement of the acetabular component withe stem retained — in 20 revisions. The diameter of the endoprosthesis head in 26 cases was 28 mm, in 52–32 mm, in 7–36 mm. Ceramic heads of the endoprosthesis were installed in three patients; in other cases, a metal-polyethylene friction pair was used. On average, the operation lasted 147±47 minutes, the volume of intraoperative blood loss was 566±400 ml.

Clinical and X-ray studies were performed before surgery; 3, 6, and 12 months after surgery; then yearly. Clinical evaluation of the RHA outcomes was performed on the Harris scale for the hip joint. A score more than 90 was interpreted as excellent joint function, from 80 to 89 — good, from 70 to 79 — satisfactory, less than 70 — unsatisfactory [12]. Patient's pain intensity was assessed using a 10-point visual analogue scale (VAS) [13]. X-ray studies were performed using a panoramic radiograph of the pelvis in Lauenstein's projection; Judet view and CT scan of the pelvis were performed as needed. Preoperative planning was performed using the mediCAD Classic 5.1.0.7 software (mediCAD Hectec GmbH, Germany). Stability or loosening of the hip endoprosthesis acetabular component was assessed in three zones of the acetabulum according to the DeLee — Charnley system: along the radiolucent lines at the implant-bone, implant-cement and bone-cement interfaces [14]. The diagnosis „loosening of the hip endoprosthesis acetabular component" was made in the following cases:

– progression of radiolucent lines;

– breakage of screws fixing the acetabular component;

– migration of the cup by more than 2 mm and a change in the angle of inclination of the cup by more than 4° [10].

To assess the restoration of the rotation center of the hip after RHA, vertical offsets of the center of the endoprosthesis head relative to the contralateral hip were measured [15].

Statistical analysis

Statistical analysis was conducted using Microsoft Office Excel and Statistica 6.1. For descriptive statistics, the data are presented as M±SD, where M is the mean value, SD is the standard deviation. To assess the differences in the compared groups, we used the Mann-Whitney U-test and Wilcoxon's rank sum test: we compared the results obtained at the last follow-up examination withe previous results. Differences were considered statistically significant at $p<0.05$.

Results

Over time, an improving tendency in the clinical and functional results on the Harris scale and a decrease in pain intensity on the VAS scale were observed and confirmed statistically ($p<0.001$). A significant improvement in the patient's well-being was observed as early as 3 months after RHA using acetabular augments. The average score on the Harris scale increased from 37±7 before the operation to 73±9 ($p = 0.001$) after 3 months and to 80±11 after 12 months ($p = 0.001$). Prior to the operation, the level of pain on the VAS scale corresponded to 7±2, it decreased to 4±1 ($p = 0.001$) after 3 months and to 3±1 after 12 months (p = 0.001).

The average sizes of acetabular augments were 51.54±3.34 mm (from 50 to 64 mm)/17.77±6.34 mm (from 10 to 30 mm). The amount of augments used is 1.08±0.35 (from 1 to 3). Based on the X-ray findings at the last follow-up examination, stable fixation of the acetabular component of the en-

doprosthesis was observed in all patients. In 10 cases (11.8%), radiolucent lines around the acetabular component of the endoprosthesis were observed on radiographs wino clinical signs of loosening. Two of 10 patients periodically experienced mild nagging pains in the hip region, which did not limit their normal lifestyle. The remaining patients were asymptomatic. In 17 patients, it was impossible to assess using radiographic measurements the accuracy of the restoration of the hip rotation center after arthroplasty due to the fact that these patients underwent replacement of the contralateral joint. In the remaining 68 cases, the rotation center of the hip, which required revision withe use of acetabular augments, was located above the contralateral side before the operation. On average, the rotation center of the hip was restored from 26.40±18.38 mm (from 4 to 75 mm) before surgery to 4.78±5.02 mm (from 0 to 20 mm) after RHA using acetabular augments.

Various postoperative complications developed in 9 cases out of 85 and led to repeated surgical interventions on the operated hip. The number of subsequent revision surgical interventions needed to achieve satisfactory results of endoprosthesis replacement differed in different patients and ranged from 1 to 3. Three patients were diagnosed wiPPI in the period from 1 to 17 months after RHA withe insertion of an augment. To eliminate PPI, conducting a single regular revision surgery was enough. One patient wia Coventry [16] type I surgical site infection (SSI) underwent a surgical treatment of a purulent wound wiretention of the endoprosthesis (DAIR). Two others wia type II infection underwent a Girdlestone operation. Two more patients, due to a type II peri-implant infection, underwent a two-stage surgical revision: after 7 months in one, and after 14 months in the second, the endoprosthesis was removed and an articulating spacer was placed. After another 8 and 5 months, respectively, patients also received an endoprosthesis of the hip using an acetabular augment. In the 6th patient, 4.6 months after endoprosthesis replacement using an augment, a Coventry type II peri-implant infection developed. A spacer impregnated with antibiotics was inserted to eradicate the infection. Subsequently, a relapse of infection occurred, leading to the development of osteomyelitis. After 3 months, a radical wound debridement was performed with the reinsertion of a sanitizing spacer. After another 3 weeks, the infection recurred. The SSI was sanitized and a decision was made to induce neo-arthrosis. Probably one of the main causes of recurrent PPI was the man's chemical dependence. In the 7th patient, recurrent dislocations of the endoprosthesis head occurred, and after 17.8 months, she had an unsuccessful replacement of the femoral component of the implant, which resulted in another recurrence of dislocation 5 days later. The dislocation was reduced by a closed method. However, in view of the repeated instability, after 3 weeks, the patient underwent a revision replacement of the acetabular component of the endoprosthesis using a dual mobility system. A segmental, type III B defect of the acetabulum and pelvic discontinuity in combination with a deficit of abductors caused another recurrence of dislocation, despite the use of a system with increased connectivity. The complication was resolved by a closed reduction, and from then on, the patient was recommended to wear an orthopedic fixator to prevent recurrence of dislocation. In the 8th patient, a week after hip arthroplasty using an augment, there was a dislocation, reduced by a closed method. Then a week later, the dislocation recurred. It was decided to perform an open reduction of the head of the endoprosthesis into the acetabulum with an additional reorientation of the liner. Despite the satisfactory X-ray imaging, the patient was concerned by chronic pain. Therefore, 18.5 months later she underwent therapeu-

tic joint aspiration. Infection was excluded. Pain was significantly reduced, and no further surgical intervention was required. The ninth patient suffered an injury as a result of falling 7 months after RHA — an open reposition and metallo-osteosynthesis of the periprosthetic fracture by a plate (ORIF) was required with retention of endoprosthesis of the hip.

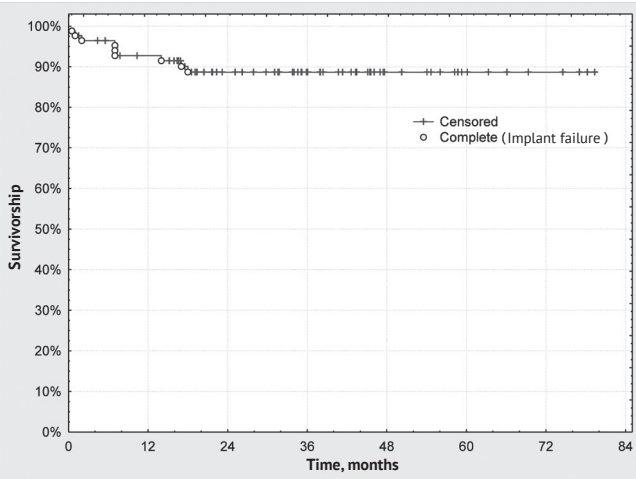

Fig. 1. Kaplan-Meyer mid-term cup and acetabular augment survivorship with revision for any reason as the endpoint

It was established that the survivorship of implants with acetabular augments in a maximum follow-up period of 6 years was 88.7% (Fig. 1).

Interestingly, a relationship was discovered between the deviation of the rotation center of the hip from the contralateral joint after surgery and the survivorship of the endoprosthesis acetabular component as evidenced by the direct correlation of these parameters of average strength ($\gamma = 0.4$; $p = 0.027$).

Clinical case

Female patient G., 49 years old. Suffering from rheumatoid arthritis with a lesion of the joints mainly in the lower extremities from the age of 27 years. Total arthroplasty of the right hip was performed in a regional hospital of the Russian Federation in 2012. The postoperative period was complicated by sciatic nerve neuropathy. Signs of the SSI appeared in November 2015. A fistula in the postoperative scar opened (Fig. 2 a).

Due to the failure of conservative treatment, in August 2016, the components of the endoprosthesis were removed and the right hip spacer was installed (Fig. 2 b). In the postoperative period, aspiration of synovial fluid from the joint cavity was performed three times. The infection was excluded. In January 2017, the woman was hospitalized for a planned replacement of the right hip spacer and revision arthroplasty (Fig. 2 c).

Before the operation, the patient could walk with a cane for a distance of up to 300 meters. The cranial offset of the rotation center of the hip and the migration of the acetabular component of the spacer beyond the Kohler line were noted on a panoramic radiograph of the pelvis, which, according to Paprosky, corresponded to the III B type acetabular defect. A pelvic discontinuity was also observed, which corresponded to a type IV AAOS classification. The Harris scale score before the operation was 28, the level of pain on the VAS scale was 7 (Fig. 3 a).

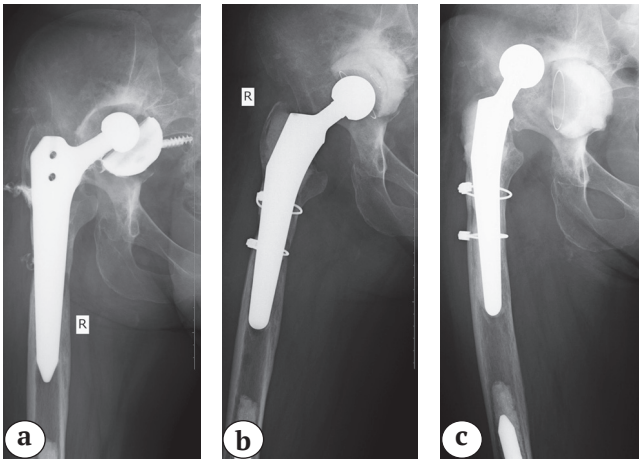

Fig. 2. Right hip X-rays of female patient G. before revision arthroplasty of the right hip with the installation of acetabular augments: infection of the surgical site with fistula (a); a spacer of the right hip joint (b); instability of a spacer of the right hip joint (c)

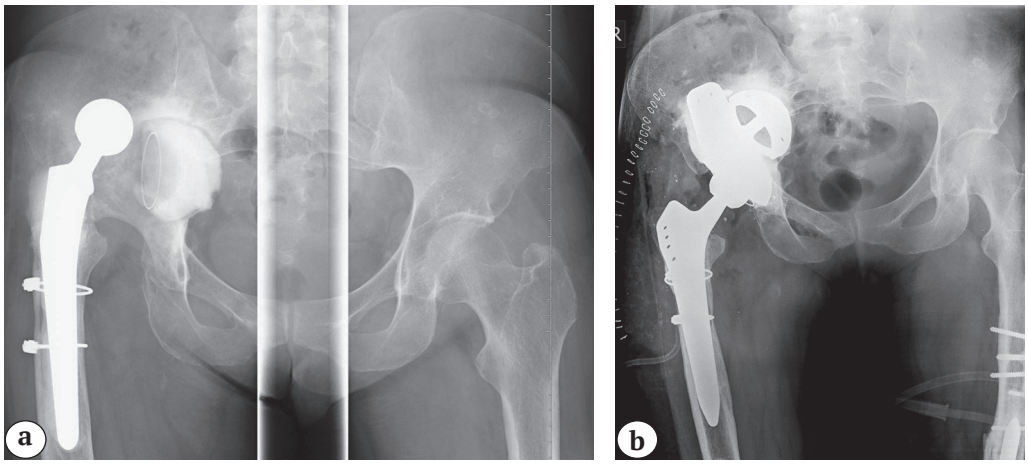

Fig. 3. Pelvis X-rays of female patient G.: before revision arthroplasty of the right hip with the installation of acetabular augments (a); after revision arthroplasty (b)

In January 2017, the patient underwent a revision arthroplasty of the right hip through the posterior approach. An unstable spacer, remnants of the cement mantle in the femoral canal, and para-articular scars were removed. Using two pins and a Paprosky distractor, the distraction of the disconnected parts of the pelvis was performed. After performing impaction bone grafting of acetabular defects with spongy allografts, 3 augments were placed: acetabular augment 58 mm by 20 mm, acetabular augment 58 mm by 15 mm and column support augment (Fig. 3 b). The patient was discharged one week after surgery. At discharge, she moved on crutches at the distance up to 200 m, with partial load on the operated limb. After activation, the patient noted a decrease in the intensity of pain and the alignment of the length of the limbs. The range of motion in the operated joint has increased. At the one year follow-up examination, the patient was satisfied with the result. The score on the Harris scale was 88, the level of pain on the VAS scale dropped to 1. X-ray findings showed that the components of the endoprosthesis were stable.

Discussion

The annual growing need for revision arthroplasty of the hip is an important clinical and economic concern [17]. Over time, issues relating to the features of the surgical technique and the choice of specific types of endoprostheses and devices for revision surgical interventions will attract more and more attention. Preoperative planning based on accurate radiographic assessment is an important component of the revision surgical intervention. It allows the surgeon to assess the severity of bone deficit before the operation and to decide on the type of implant and the technique of restoring the anatomy of the hip necessary for its normal functioning after arthroplasty [18].

According to the literature, aseptic loosening of the endoprosthesis components is one of the most common causes of revision surgical interventions now [19]. Our results correspond to these data: aseptic loosening caused revision arthroplasty in 97.6% of the cases considered. Aseptic loosening, which is often associated with the effect of polyethylene product degradation or metal debris, leads to resorption of the bone tissue surrounding the acetabular component of the endoprosthesis and formation of bone defects. The issue of replenishing the bone deficit is particularly acute in cases of large segmental defects of the acetabulum. In 80% of the cases that we studied, acetabular defects were classified as Paprosky type

III. 16.5% of patients were diagnosed with pelvic discontinuity. There is no conclusive solution to the problem of acetabulum reconstruction with repairing the segmental defects of the acetabulum. The development and search for special techniques and devices are ongoing.

Treatment of patients with acetabular defects should include the restoration of the rotation center of the hip and replenishing the bone deficit. Although impaction bone alloplasty can be successfully used to achieve these goals, some authors have noted a high level of implant failure, particularly, in Paprosky III B defects, ranging from 22% to 45% [20]. The high level of implant failure in bone grafting with large defects of the acetabulum is explained by the fact that in the process of revascularization and remodeling, the allograft weakens and loses the ability to withstand the load imposed by the implant. As a result, the allograft collapses and endoprosthesis is loosened [21]. When anti-protrusive cages and bone alloplasty are used together, despite good primary stability, a high level of implant failure in Paprosky type III acetabular defects is also reported (from 9 to 64%) [22]. A possible cause of unsatisfactory results is the surface of anti-protrusion cages devoid of pores. Despite the gradual restructuring of the allograft into a normally functioning living bone tissue, the absence of pores on the surface of the cage makes it impossible to achieve adequate secondary biological fixation at the implant-allograft interface [22]. In addition, cementing the liner in the cage can lead to the penetration of a certain amount of cement through the screw holes to the pelvic bone. As a result, over time, fatigue failure of the cage screws or flanges may occur [23]. Oval cups (oblong/bilobed cup) often do not correspond to the bone defect in shape, which, according to some data, leads to a high level of failure of the endoprosthesis (more than 20%) with follow-up periods of more than 40 months. [21, 24]. Three-flange individual devices precisely fit the defects of a particular patient and allow to achieve good treatment results. However, the disadvantages of their use include a rather high cost and a longer construction time [5].

Abroad, tantalum augments were introduced into clinical practice in 1997. It is known that a high degree of porosity and a rough microtexture of the surface of tantalum augments contribute to better osteointegration and primary stability during implantation [25]. A number of studies have shown good and excellent outcomes using acetabular augments in revision arthroplasty of the hip [1, 6–10, 23]. Elganzoury and Bassiony observed 18 patients who underwent revision arthroplasty of the hip using trabecular metal cups and tantalum augments [8]. The median of the follow-up was 18 months. Good and excellent early clinical and radiological results of treatment were demonstrated in 83.3% of patients. The authors concluded that the use of tantalum augments can improve the fixation of the acetabular component of the hip implant and is a promising solution to the problem of bone deficiency, particularly, in Paprosky type II and III defects.

Grappiolo et al. investigated 55 cases of acetabular reconstruction using trabecular augments in patients with Paprosky type III defects and having no pelvic discontinuity with an average follow-up of 53.7 months. The authors found that the use of tantalum augments has a statistically significant effect on the increase in range of motion of the hip, the restoration of the length of the lower limb and the increase in patient satisfaction with surgery [23]. Postoperative complications that needed one more revision developed in 7.3% of cases and included loosening of the acetabular component (5.4%) and recurrent dislocations (1.8%). In our study, at the time of writing, the overall complication rate was 10.6% (9 of 85 cases): in six cases — periprosthetic infection (in one, Coventry type 1 and in five, Coventry type 2), in two cases — recurrent dislocation and in

one — periprosthetic fracture. In seven cases out of nine, a revision surgery was required with the replacement of the endoprosthesis or its components; the implant was retained for two patients.

Tokarski et al. compared the results of revision arthroplasty of the hip using tantalum and titanium acetabular components [26]. The authors reported 95% survivorship of tantalum endoprostheses (in 434 patients out of 454 over 40 months) and noted a decrease in the risk of infectious complications when using tantalum compared to titanium. In our study, all augments were tantalic, so we cannot make a similar comparison. However, analyzing the distribution of postoperative complications, we can conclude that the peri-implant infection occurred most often.

According to Whitehouse et al., the midterm survivorship of implants containing a cup and acetabular augments is 92% at 10 years [27]. Grappiolo et al. found that the survivorship of the endoprosthesis at 2 and 5 years in patients with major acetabular defects was 96.4% and 92.8%, respectively [23]. We obtained similar data on the midterm survivorship of the implant, which was 88.7% at 6 years. When analyzing the comparative figure determined by other researchers when using impaction bone grafting, anti-protrusion cages or oval cups, the survival rate of a device containing the cup and augment was higher in our study. The obtained data on the direct correlation between the deviation of the rotation center of the hip after the operation and the subsequent revision of the acetabular component confirm the importance of restoring the anatomy of the hip.

Adaptive bone remodeling in response to contact with a metal implant, or stress shielding syndrome, often leads to bone resorption and the development of peri-implant osteoporosis, which reduces bone quality [28]. We found that in 10 patients, more than 11% of the total sample, radiolucent lines around the acetabular component of the endoprosthesis were detected on radiographs at the last follow-up examination. In all cases, radiolucent lines were revealed in zone III of the acetabulum according to the DeLeeBassiony–BassionyCharnley system. The presence of radiolucent lines indicated insufficient contact between the endoprosthesis of the hip and the acetabulum surface or the cement mantle. We believe that to achieve stable fixation of the acetabular component of the endoprosthesis and reduce the likelihood of osteolysis in the future, the acetabular component must be additionally fixed with screws in the third DeLee and Charnley zone.

Versatility is one of the advantages of acetabular augments. The modular system of augments allows the surgeon to perform an individual reconstruction of the acetabulum. The combination of cups of various sizes and acetabular augments makes it possible to repair an acetabular defect, to ensure maximum contact of the implant with the patient's bone, and to achieve restoration of the rotation center of the hip regardless of the size and shape of the bone defect. The use of acetabular augments allowed us to obtain good results in the treatment of patients with large defects of the acetabulum and the presence of a pelvic discontinuity.

Thus, many studies have shown good clinical and radiological results in treating patients with significant bone deficit of the acetabulum, particularly, in Paprosky type III defects, using tantalum augments for revision arthroplasty of the hip. We believe that, over time, there will be an increased percentage of use of various implants in combination with tantalum acetabular augments for arthroplasty of the hip. The study was limited by its retrospective nature and relatively short follow-up period. However, given the need to improve the outcomes of hip revisions in Paprosky type III defects and the presence of pelvic discontinuity, it has theoretical and practical value.

The use of acetabular augments in revision arthroplasty of the hip for the reconstruction of the acetabulum shows encouraging early and mid-term clinical and radiographic outcomes. The use of acetabular augments makes it possible to get closer to restoring the rotation center of the hip, adequately compensate for the deficit of bone tissue in the acetabulum, and firmly fix the acetabular component of the endoprosthesis. Thus, revision arthroplasty using acetabular augments is an acceptable alternative method for reconstruction of the acetabulum with unlimited bone defects, even Paprosky III A and III B defects and pelvic discontinuity, providing a good mechanical stability.

Competing interests: the authors declare that they have no competing interests.

Funding: the authors have no support or funding to report.

Consent for publication: the patient provided voluntary consent for publication of case data.

Литература [References]

1. Hosny H.A.H., El-Bakoury A., Fekry H., Keenan J. Mid-term results of graft augmentation prosthesis II cage and impacted allograft bone in revision hip arthroplasty. *J Arthroplasty.* 2018;33(5):1487-1493. DOI: 10.1016/j.arth.2017.11.060.
2. Deirmengian G.K., Zmistowski B., O'Neil J.T., Hozack W.J. Management of acetabular bone loss in revision total hip arthroplasty. *J Bone Joint Surg Am.* 2011;93(19): 1842-1852. DOI: 10.2106/jbjs.j.01197.
3. Von Roth P., Abdel M.P., Harmsen W.S., Berry D.J. Uncemented jumbo cups for revision total hip arthroplasty: a concise follow-up, at a mean of twenty years, of a previous report. *J Bone Joint Surg Am.* 2015; 97-A(4):284-287. DOI: 10.2106/jbjs.n.00798.
4. Amenabar T., Rahman W.A., Hetaimish B.M., Kuzyk P.R., Safir O.A., Gross A.E. Promising mid-term results with a cup-cage construct for large acetabular defects and pelvic discontinuity. *Clin Orthop Relat Res.* 2016;474(2): 408-414. DOI: 10.1007/s11999-015-4210-4.
5. Korytkin A.A., Zakharova D.V., Novikova Ya.S., Gorbatov R.O., Kovaldov K.A., El Moudni Y.M. [Custom triflange acetabular components in revision hip replacement (Experience Review)]. *Travmatologiya i ortopediya Rossii* [Traumatology and Orthopedics of Russia]. 2017;23(4):101-111. (In Russ.). DOI: 10.21823/2311-2905-2017-23-4-101-111.
6. Alfaro J.J.B., Fernandez J.S. Trabecular Metal buttress augment and the Trabecular Metal cup-cage construct in revision hip arthroplasty for severe acetabular bone loss and pelvic discontinuity. *Hip Int.* 2010;20(suppl 7): 119-127. DOI: 10.1177/11207000100200s720.
7. Long W.J., Noiseux N.O., Mabry T.M., Hanssen A.D., Lewallen D.G. Uncemented porous tantalum acetabular components: early follow-up and failures in 599 revision total hip arthroplasties. *Iowa Orthop J.* 2015;35:108-113.
8. Elganzoury I., Bassiony A.A. Early results of trabecular metal augment for acetabular reconstruction in revision hip arthroplasty. *Acta Orthop Belg.* 2013;79:530-535.
9. Gehrke T., Bangert Y., Schwantes B., Gebauer M., Kendoff D. Acetabular revision in THA using tantalum augments combined with impaction bone grafting. *Hip Int.* 2013;23(4):359-365. DOI: 10.5301/hipint.5000044.
10. Jeong M., Kim H.J., Lim S.J., Moon Y.W., Park Y.S. Revision total hip arthroplasty using tantalum augment in patients with Paprosky III or IV acetabular bone defects: a minimum 2-year follow up study. *Hip Pelvis.* 2016;28(2):98-103. DOI: 10.5371/hp.2016.28.2.98.
11. Paprosky W.G., Perona P.G., Lawrence J.M. Acetabular defect classification and surgical reconstruction in revision arthroplasty: a 6-year follow-up evaluation. *J Arthroplasty.* 1994;9(1):33-44. DOI: 10.1016/0883-5403(94)90135-x.
12. Harris W.H. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am.* 1969;51(4):737-755. DOI: 10.2106/00004623-196951040-00012.
13. Huskisson E.C. Measurement of pain. *Lancet.* 1974; 304:1127-1131.
14. DeLee J.G. Charnley J. Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop Relat Res.* 1976;(121):20-32. DOI: 10.1097/00003086-197611000-00003.
15. Shi H.F., Xiong J., Chen Y.X., Wang J.F., Wang Y.H. Radiographic analysis of the restoration of hip joint center following open reduction and internal fixation of acetabular fractures: a retrospective cohort study. *BMC Musculoskelet Disord.* 2014;15 (1):277. DOI: 10.1186/1471-2474-15-277.
16. Coventry M.B. Treatment of infections occurring in total hip surgery. *Orthop Clin North Am.* 1975;6:991-1003. DOI: 10.1016/s0140-6736(74)90884-8.
17. Bozic K.J., Kamath A.F., Ong K., Lau E., Kurtz S., Chan V., Vail T.P., Rubash H., Berry D.J. Comparative epidemiology of revision arthroplasty: failed THA poses greater clinical and economic burdens than failed TKA. *Clin Orthop Relat Res.* 2015;473(6):2131-2138. DOI: 10.1007/s11999-014-4078-8.
18. Tikhilov R.M., Shubnyakov I.I. [Guide to hip surgery]. SPb.: RNIITO im. R.R. Vredena, 2015. Vol. II. 356 p. (In Russ.).
19. Tikhilov R.M., Shubnyakov I.I., Kovalenko A.N., Totoyev Z.A., Lyu B., Bilyk S.S. [The structure of early revisions after hip replacement]. *Travmatologiya i ortopediya Rossii* [Traumatology and Orthopedics of Russia]. 2014;(2): 5-13.(InRuss.).DOI:10.21823/2311-2905-2014-0-2-5-13.
20. Lee P.T., Raz G., Safir O.A., Backstein D.J., Gross A.E. Long-term results for minor column allografts in revision hip arthroplasty. *Clin Orthop Relat Res.* 2010;468(12):3295-3303. DOI: 10.1007/s11999-010-1591-2.
21. Pulido L., Rachala S.R., Cabanela M.E. Cementless acetabular revision: past, present, and future. Revision

total hip arthroplasty: the acetabular side using cementless implants. *Int Orthop*. 2011;35(2):289-298. DOI: 10.1007/s00264-010-1198-y.
22. Hansen E., Shearer D., Ries M.D. Does a cemented cage improve revision THA for severe acetabular defects? *Clin Orthop Relat Res*. 2011;469(2):494-502. DOI: 10.1007/s11999-010-1546-7.
23. Grappiolo G., Loppini M., Longo U.G., Traverso F., Mazziotta G., Denaro V. Trabecular metal augments for the management of Paprosky type III defects without pelvic discontinuity. *J Arthroplasty*. 2015;30(6):1024-1029. DOI: 10.1016/j.arth.2015.01.001.
24. Chen W.M., Engh C.A., Hopper R.H., McAuley J.P., Engh C.A. Acetabular revision with use of a bilobed component inserted without cement in patients who have acetabular bone-stock deficiency. *J Bone Joint Surg Am*. 2000;82(2):197-206. DOI: 10.2106/00004623-200002000-00005.
25. Noiseux N.O., Long W.J., Mabry T.M., Hanssen A.D., Lewallen D.G. Uncemented porous tantalum acetabular components: early follow-up and failures in 613 primary total hip arthroplasties. *J Arthroplasty*. 2014;29(3):617-620. DOI: 10.1016/j.arth.2013.07.037.
26. Tokarski A.T., Novack T.A., Parvizi J. Is tantalum protective against infection in revision total hip arthroplasty? *Bone Joint J*. 2015;97-B(1):45-49. DOI: 10.1302/0301-620x.97b1.34236.
27. Whitehouse M.R., Masri B.A., Duncan C.P., Garbuz D.S. Continued good results with modular trabecular metal augments for acetabular defects in hip arthroplasty at 7 to 11 years. *Clin Orthop Relat Res*. 2014;473(2):521-527. DOI: 10.1007/s11999-014-3861-x.
28. Agadzhanyan V.V., Pronskikh A.A., Demina V.A., Gomzyak V.I., Sedush N.G., Chvalun S.N. [Biodegradable implants in orthopedics and traumatology. Our first experience]. *Politravma* [Polytrauma]. 2016;4:85-93. (In Russ.).

INFORMATION ABOUT AUTHORS:

Andrey A. Korytkin — Cand. Sci. (Med.), Head of Adult Orthopedics Department, Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation

Yana S. Novikova — Cand. Sci. (Biol.), Junior Researcher, Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation

Kirill A. Kovaldov — PhD Student, Orthopedic Surgeon, Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation

Svyatoslav B. Korolev — Dr. Sci. (Med.), Professor, Head of Traumatology, Orthopedics and Military Field Surgery Department, orthopedic surgeon, Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation

Andrey A. Zykin — Cand. Sci. (Med.), Orthopedic Surgeon, Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation

Sergey A. Gerasimov — Orthopedic Surgeon, Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation

Evgeny A. Gerasimov — PhD Student, Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation