Case Report
https://doi.org/10.17816/2311-2905-8008

Reconstruction of Acetabular and Femoral Bone Defects with Impaction Bone Grafting in Revision Hip Arthroplasty: A Case Report

Vadim N. Golnik [1], Vladimir A. Peleganchuk [1], Yuriy M. Batrak [1], Vitaliy V. Pavlov [2], Irina A. Kirilova [2]

[1] *Federal Center for Traumatology, Orthopedics and Endoprosthetics, Barnaul, Russia*

[2] *Novosibirsk Research Institute of Traumatology and Orthopedics n.a. Ya.L. Tsivyan, Novosibirsk, Russia*

Abstract

Background. For many years, the main reasons for revision surgeries after hip arthroplasty remain aseptic loosening and osteolysis, which lead to formation of bone defects of various size and localization. Given the relatively young age of patients undergoing revision, the methods of biological restoration of the bone tissue, such as impaction bone grafting (IBG), are of particular interest.

Aim of the report — to demonstrate the delayed outcome of impaction bone grafting using compacted morselized bone allograft.

Case presentation. Complicated clinical case of a 62-year-old patient with Paprosky type IIA bone deficiency in the acetabulum and Paprosky type II bone defect in the proximal femur with aseptic loosening of the acetabular and femoral components of the hip prosthesis is presented. During revision arthroplasty with cemented components, IBG of the acetabulum and femur was performed with a reconstructive mesh augmentation of the acetabulum using Stryker X-Change technology. Bone allograft prepared with the heat disinfection method served as an osteoplastic material. Follow-up period was 4 years. Control X-rays demonstrate restoration of the center of rotation of the hip, presence of bone masses in the areas of pelvic and femoral bone defects, absence of osteoplastic material resorption and migration of implants during the follow-up period. Clinical assessment shows an improvement of the Harris Hip Score from 34 to 85 points.

Conclusion. Obtained results showed the efficacy of impaction bone grafting with the bone allograft prepared with the use of heat disinfection method in the mid-term period.

Keywords: impaction bone grafting, revision hip arthroplasty, bone defect, bone allograft, osteoplastic material.

Cite as: Golnik V.N., Peleganchuk V.A., Batrak Yu. M., Pavlov V.V., Kirilova I.A. Reconstruction of Acetabular and Femoral Bone Defects with Impaction Bone Grafting in Revision Hip Arthroplasty: A Case Report. *Traumatology and Orthopedics of Russia*. 2023;29(3):102-109. (In Russian). https://doi.org/10.17816/2311-2905-8008.

✉ *Irina A. Kirilova*; e-mail: irinakirilova71@mail.ru

Submitted:08.04.2023. Accepted: 16.05.2023. Published Online: 04.08.2023.

Клинический случай
УДК 616.728.2-089.844-089.193.4:616.71-089.844
https://doi.org/10.17816/2311-2905-8008

Замещение дефектов вертлужной впадины и бедренной кости с использованием импакционной костной пластики при ревизионном эндопротезировании тазобедренного сустава: клинический случай

В.Н. Гольник [1], В.А. Пелеганчук [1], Ю.М. Батрак [1], В.В. Павлов [2], И.А. Кирилова [2]

[1] *ФГБУ «Федеральный центр травматологии, ортопедии и эндопротезирования» Минздрава России, г. Барнаул, Россия*

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

Реферат

Актуальность. Основными причинами ревизионных вмешательств после эндопротезирования тазобедренных суставов в течение многих лет остаются асептическое расшатывание и остеолиз, которые приводят к образованию дефектов костной ткани различной протяженности и локализации. С учетом относительно молодого возраста пациентов, подвергающихся ревизии, особый интерес представляют методы биологической реставрации костной ткани, например импакционная костная пластика.

Целью сообщения является демонстрация отсроченного результата импакционной костной пластики при замещении дефектов вертлужной впадины и бедренной кости в ходе ревизионного эндопротезирования тазобедренного сустава.

Описание случая. Представлен сложный клинический случай лечения пациента 62 лет с дефицитом костной ткани в области вертлужной впадины IIA типа по Paprosky и проксимального отдела бедренного кости типа II по Paprosky с асептическим расшатыванием ацетабулярного и бедренного компонентов эндопротеза. В ходе ревизионного эндопротезирования с использованием компонентов эндопротеза цементной фиксации выполнена импакционная костная пластика вертлужной впадины и бедренной кости с аугментацией реконструктивной сеткой надацетабулярного массива по технологии Stryker X-Change. В качестве костнопластического материала использована аллокость, заготовленная с помощью метода термодезинфекции. Срок наблюдения составил 4 года. Контрольные рентгенограммы демонстрируют восстановление центра ротации тазобедренного сустава и костного массива в области дефектов тазовой и бедренной костей, отсутствие резорбции костнопластического материала и миграции эндопротеза. При кинической оценке состояния по шкале Harris отмечено улучшение с 34 до 85 баллов.

Заключение. Среднесрочные результаты показали эффективность импакционной костной пластики с использованием аллокости, заготовленной методом термодезинфекции.

Ключевые слова: импакционная костная пластика, ревизионное эндопротезирование тазобедренного сустава, костный дефект, аллокость, костнопластический материал.

Для цитирования: Гольник В.Н., Пелеганчук В.А., Батрак Ю.М., Павлов В.В., Кирилова И.А. Замещение дефектов вертлужной впадины и бедренной кости с использованием импакционной костной пластики при ревизионном эндопротезировании тазобедренного сустава: клинический случай. *Травматология и ортопедия России*. 2023;29(3):102-109. https://doi.org/10.17816/2311-2905-8008.

Кирилова Ирина Анатольевна; e-mail: irinakirilova71@mail.ru

Рукопись получена: 08.04.2023. Рукопись одобрена: 16.05.2023. Статья опубликована онлайн: 04.08.2023.

BACKGROUND

The number of revision hip arthroplasties is increasing annually. This type of intervention is characterized by a higher cost compared to primary hip replacement as it requires a large stock of various implants, an appropriate instrumental support, the use of additive technologies, bone grafting, and the need for specialists experienced in revision arthroplasty, which ultimately affects expenses [1, 2]. This trend is typical both for countries with intensive development of primary arthroplasty and those without significant growth. In the former case, despite the low growth rate of revision arthroplasties, the total number of these surgeries is increasing annually [3]. In the latter case, the increase of number of revision interventions is significantly higher than that of primary surgeries [1]. Long-term results of revision surgeries are characterized by a higher complication rate than primary surgeries. Five-year survival rates after various revision surgeries range from 67.0 to 84.8% [4]. Aseptic loosening and osteolysis have been the main causes of revision interventions after hip arthroplasty for many years, leading to bone defect formation of various size and localization [1, 3, 5, 6, 7, 8]. Given the relatively young age of patients undergoing revision, the methods of biological restoration of the bone tissue, such as impaction bone grafting (IBG), are of particular interest [9].

The aim of the report is to demonstrate the delayed outcome of impaction bone grafting using compacted morselized bone allograft.

CASE PRESENTATION

A 62-year-old patient was admitted with complaints of pain in the left hip, significant restriction of movements, shortening of the left leg and lameness.

Status localis. The patient walks on his own using crutches. The distance he is able to walk does not exceed 300 m. Examination revealed a relative shortening of the left lower limb by 2 cm. The Harris hip score is 34 points.

Anamnesis. Left hip replacement with W. Link cemented prosthesis was performed 13 years ago. In the postoperative period there were dislocations of the femoral component, for which a revision surgery with replacement of the pelvic component was performed. Pain in the left hip joint has been disturbing the patient periodically for 11 years and has been gradually progressing. Restriction of movement and shortening developed. Two years ago, due to severe pain syndrome and prevalent dysfunction, the right hip replacement with SL-Plus/R3 (Smith&Nephew) prosthesis was performed for aseptic necrosis of the femoral head.

Secondary diagnosis. Stage 3 essential hypertension, drug-controlled 1st grade arterial hypertension, cardiovascular risk 4, functional class 2 of the stage 1 CHF. CHD: artificial pacemaker (2017). Transitory atrioventricular block g rade 1. Lower extremity varicose vein disease, CVD grade 1, postthrombophlebitic syndrome of the left iliofemoral segment, the right popliteotibial segment, complicated by PATE. Condition after implantation of permanent inferior vena cava filter (2011).

Preoperative X-rays dated 30/07/2018 showed (Fig. 1):

- pelvic prosthetic component loosening, Paprosky type IIA defect [10];
- femoral component loosening and subsidence, Paprosky type II defect of the femur [11];
- varus remodeling of the left femoral intramedullary canal;
- Brooker stage 3 heterotopic ossification of the left hip joint;
- right hip arthroplasty.

In the preoperative period, the left hip arthrocentesis was performed, followed by cytologic and microbiologic studies of synovial fluid aspirate. No data indicating the presence of infectious process in the joint were obtained.

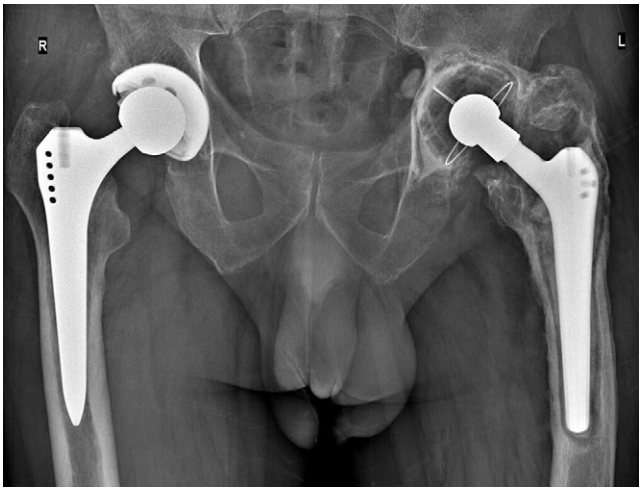

Fig. 1. Plain pelvis X-ray before revision of the left hip (explanation in the text)

On 02.08.2018, the left hip revision arthroplasty using Stryker Exeter prosthesis and IBG of the acetabulum and proximal femur with bone allograft and augmentation of the supraaceta-bular bone mass with reconstructive mesh were performed.

The approach was performed along the old postoperative scar on the anteroexternal surface of the thigh. The anterior portion of the gluteus medius muscle was isolated, cut off and retracted using instruments. The bone bed and the components of the prosthesis were separated from the scar tissues and bony overgrowths. On revision of the components, the stem and the acetabular component of the prosthesis were completely unstable. The femoral component was exteriorized and removed. The acetabular component was removed without technical difficulties. Tissue examination did not reveal any significant inflammatory changes. The acetabulum and the femoral intramedullary canal were cleared of scar tissue, granulations, and fibrous membrane. On examination, a segmental defect of the posterior edge of the acetabulum was detected, but in general, the limitation was preserved. The defect was classified as type III according to the AAOS classification [13]. It was repaired using a reconstructive mesh fixed with two screws.

In order to replace the bone defect, bone grafting material from the hospital bone bank was prepared in the form of allogeneic bone chips of 8-10 mm in diameter for the acetabular plasty and 5-6 mm for the femoral IBG (Fig. 2). The size and the quality of bone chips are important for the early mechanical stability of the impacted bone allograft. The particles should be of the largest size that can be impacted between the acetabular bone walls and the impactor.

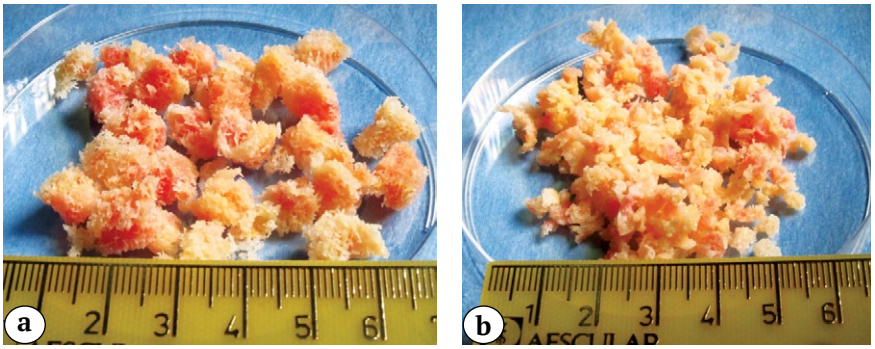

Fig. 2. Production of bone chips:
a — for acetabular IBG;
b — for femoral IBG prepared with a bone mill

IBG of the acetabulum was performed using Stryker X-Change* revision instruments. After cement-based volume restoration, a 58 mm Stryker Contemporary acetabular component was implanted. Using Stryker X-Change revision instruments, impaction grafting of the femur was performed with impactor No. 4 with offset 44. Reduction test with head -4 (32 mm) was performed. Joint stability test showed no dislocation. Stryker Exeter stem was implanted into the prepared cement-based bed. The head -4 (32 mm) was permanently fixed to the neck of the femoral component after cement hardening. Prosthesis was assembled in the wound. Surgical wound was sutured layer by layer, aseptic dressing was applied.

In the control X-ray dated 03.08.2018 after revision arthroplasty, acetabular reconstruction with mesh and IBG and proximal femoral reconstruction with IBG using Stryker Exeter cement stem, the bone grafting material filled the acetabulum evenly (Fig. 3 a). The posterior edge of the acetabulum is augmented with a reconstructive mesh, the femoral component is positioned correctly, parallel to the femoral axis, the osteoplastic material fills the femoral intramedullary canal evenly, with the same intensity in all zones. Radiolucent lines at the osteoplastic material-cement interface are not observed.

In the postoperative period, the patient was ambulated; the 1st stage of rehabilitation was performed. No complications were observed.

* https://www.bizwan.com/_mydoc/stryker/Hip/049%20X-change%20Revision%20Instruments%20Surgical%20Technique%20-%20Femur%20and%20Acetabulum.pdf

The patient was discharged on the 14th day after the surgery with the recommendation of limited weight bearing on the operated limb for 12 weeks.

The results of revision surgery after 4 months and 4 years are shown in Figures 3 b and 3 c, respectively.

On physical examination, the patient has no complaints of pain. There is a slight lameness. The patient moves on his own without any means of support, uses a cane occasionally during long walks, does not experience serious social and everyday restrictions. The HHS is 85 points.

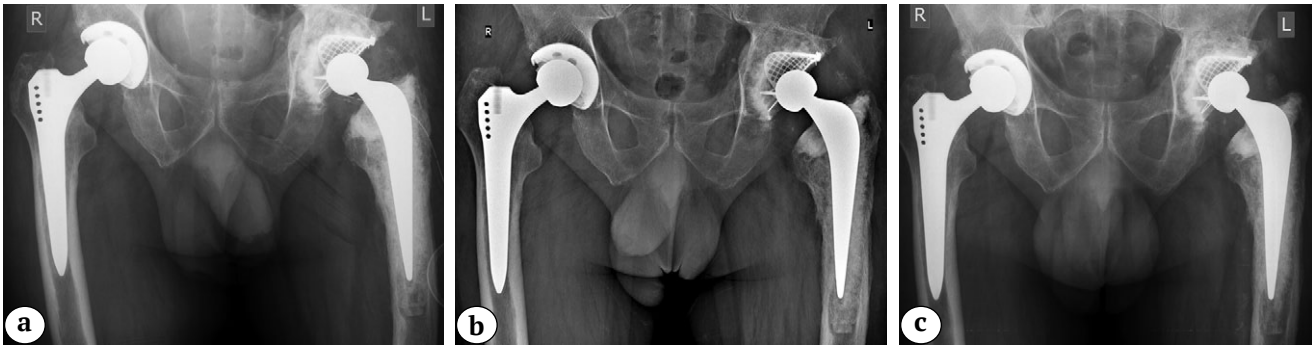

Fig. 3. Plain pelvis X-rays after the left hip revision:
a — control X-ray immediately after the surgery (02.08.2018): even distribution of osteoplastic material, restoration of the center of rotation of the joint;
b — 4 months after the surgery (24.12.2018): position of components remains unchanged, no migration of the acetabular and femoral components is observed, the state of osteoplastic material is satisfactory with no signs of resorption; radiolucent lines at the osteoplastic material-cement interface are absent;
c — 4 years after the surgery (24.10.2022): X-ray signs of restructuring of osteoplastic material in the pelvic and femoral bones, radiolucent lines at the osteoplastic material-cement interface are absent, position of components remains unchanged with no signs of migration or subsidence

DISCUSSION

Various methods are currently available to restore the bone deficit, ranging from filling bone defects with bone cement and application of various modular systems with metal augments to the use of patient-specific 3D constructs [14, 15]. It is very important to minimize bone deficiency, especially in young patients, and to try to restore the bone mass. In fact, only one out of many techniques can partially solve this problem, which is IBG using allogeneic bone [16].

The aim of IBG is to achieve stable fixation of the implant using compaction of the morselized allogeneic bone graft and subsequently to provide conditions for reparative regeneration by gradual replacement of allogeneic bone with the patient's own bone. This is a rather attractive technique that allows one to anticipate bone regeneration both structurally and functionally. On the other hand, it is difficult to balance between achieving primary stable fixation of the implant and a long biological process of allogeneic bone remodeling [17, 18, 19, 20].

The outcome of revision arthroplasty was always worse than that after primary arthroplasty. The smooth endosteal surface remaining after removal of the primary implant does not allow to achieve reliable fixation of the bone cement on the surface, which leads to early loosening of the cemented prosthesis. IBG solves this problem, which is confirmed by long-term results [21, 22, 23, 24].

The use of IBG is possible under certain conditions in a bone wound. First, bone allograft must be retained inside the bone defect; second, it must be structural and able to withstand mechanical load; third, it must create conditions for reliable fixation of the cemented pelvic component of the prosthesis. Creation of such conditions is possible in case of a specific form of the acetabular bone defect — the most important criterion is its limitation. In primary pathology, an example of such defects is the acetabular roof protrusion in cases of systemic connective tissue diseases or posttraumatic defects [22, 25, 26].

A prerequisite for IBG is the integrity of the pelvic support structures: anterior and posterior columns (Paprosky types IIA, IIIB defects). At the same time, cavitary bone defects with minor segmental deficit (AAOS type III) can be transformed into completely limited ones with the help of reconstructive meshes. In this case, the use of IBG is also possible [21, 22].

One of the key points of successful bone defect grafting is the high-quality preparation of osteoplastic material [27, 28, 29]. Studies have shown that bone fragments of 8-10 mm in diameter provide the best initial stability [21, 30]. Another advantage of large particles is that they form a more porous and more permeable compacted bone layer. This is important since reduced porosity can impede the neoosteogenesis in compacted bone masses. In addition, comparison of bone ingrowth in compacted material with non-ideal particle size distribution (non-ideal distribution ensures at each level that voids between larger particles are open and not filled by smaller particles) with ideal particle distribution showed increased bone tissue formation [31, 32].

CONCLUSION

The clinical example of impaction bone grafting using osteoplastic material from the allogeneic femoral head prepared by heat disinfection method shows the possibility of bone restoration in case of defects. Bone grafting efficiency has been shown in the mid-term in a rather uncommon case where it was performed both in the acetabular area and in the proximal femur. Further studies are required to confirm the efficacy of impaction bone grafting in revision hip arthroplasty in case of bone deficiency.

DISCLAIMERS

Author contribution

Golnik V.N. — treatment of patient, study concept and design, data collection and processing, the analysis of data, the drafting of the article.

Peleganchuk V.A. — data analysis and interpretation, drafting the article.

Batrak Yu.M. — data collection and processing, literature search and analysis, writing the article.

Pavlov V.V. — data analysis and interpretation, drafting the article.

Kirilova I.A. — the literature search and analysis, the analysis and interpretation of data, the drafting of the article.

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.

REFERENCES

1. Gwam C.U., Mistry J.B., Mohamed N.S., Thomas M., Bigart K.C., Mont M.A. et al. Current epidemiology of revision total hip arthroplasty in the United States: National Inpatient Sample 2009 to 2013. *J Arthroplasty.* 2017;32(7):2088-2092. doi: 10.1016/j.arth.2017.02.046.
2. Kurtz S.M., Lau E.C., Ong K.L., Adler E.M., Kolisek F.R., Manley M.T. Which clinical and patient factors influence the national economic burden of hospital readmissions after total joint arthroplasty? *Clin Orthop Relat Res.* 2017;475(12):2926-2937. doi: 10.1007/s11999-017-5244-6.
3. Patel A., Pavlou G., Mújica-Mota R.E., Toms A.D. The epidemiology of revision total knee and hip arthroplasty in England and Wales: a comparative analysis with projections for the United States. A study using the National Joint Registry dataset. *Bone Joint J.* 2015;97-B(8):1076-1081. doi: 10.1302/0301-620X.97B8.35170.
4. 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.
5. Kummerant J., Wirries N., Derksen A., Budde S., Windhagen H., Floerkemeier T. The etiology of revision total hip arthroplasty: current trends in a retrospective survey of 3450 cases. *Arch Orthop Trauma Surg.* 2020;140(9):1265-1273. doi: 10.1007/s00402-020-03514-3.
6. Kerzner B., Kunze K.N., O'Sullivan M.B., Pandher K., Levine B.R. An epidemiological analysis of revision aetiologies in total hip arthroplasty at a single high-volume centre. *Bone Jt Open.* 2021;2(1):16-21. doi: 10.1302/2633-1462.21.BJO-2020-0171.R1.
7. Hip Surgery Guide. Ed. by R.M. Tikhilov, I.I. Shubnyakov. St. Petersburg: RNIITO im. R.R. Vredena; 2014. Vol. I. p. 221-256. (In Russian).

8. Tikhilov R.M., Shubnyakov I.I., Denisov A.O. Classifications of Acetabular Defects: Do They Provide an Objective Evidence for Complexity of Revision Hip Joint Arthroplasty? (Critical Literature Review and Own Cases). *Traumatology and Orthopedics of Russia.* 2019;25(1): 122-141. doi: 10.21823/2311-2905-2019-25-1-122-141.
9. Colo E., Rijnen W.H., Schreurs B.W. The biological approach in acetabular revision surgery: impaction bone grafting and a cemented cup. *Hip Int.* 2015;25(4): 361-367. doi: 10.5301/hipint.5000267.
10. 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.
11. Valle C.J., Paprosky W.G. Classification and an algorithmic approach to the reconstruction of femoral deficiency in revision total hip arthroplasty. *J Bone Joint Surg Am.* 2003;85-A Suppl 4:1-6. doi: 10.2106/00004623-200300004-00001.
12. Brooker A.F., Bowennan J.W., Robinson R.A., Riley L.H. Ectopic ossification following total hip replacement. Incidence and a method of classification. *J Bone Joint Surg Am*. 1973;55(8):1629-132.
13. D'Antonio J.A., Capello W.N., Borden L.S., Bargar W.L., Bierbaum B.F., Boettcher W.G. et al. Classification and management of acetabular abnormalities in total hip arthroplasty. *Clin Orthop Relat Res*. 1989;(243):126-137.
14. García-Cimbrelo E., García-Rey E. Bone defect determines acetabular revision surgery. *Hip Int.* 2014; 24 Suppl 10:S33-S36. doi: 10.5301/hipint.5000162.
15. Tikhilov R.M., Dzhavadov A.A., Kovalenko A.N., Bilyk S.S., Denisov A.O., Shubnyakov I.I. Standard Versus Custom-Made Acetabular Implants in Revision Total Hip Arthroplasty. *J Arthroplasty.* 2022;37(1):119-125. doi: 10.1016/j.arth.2021.09.003.
16. van Egmond N., De Kam D.C., Gardeniers J.W., Schreurs B.W. Revisions of extensive acetabular defects with impaction grafting and a cement cup. *Clin Orthop Relat Res.* 2011;469(2):562-573. doi: 10.1007/s11999-010-1618-8.
17. Ling R.S., Timperley A.J., Linder L. Histology of cancellous impaction grafting in the femur. A case report. *J Bone Joint Surg Br.* 1993;75(5):693-696. doi: 10.1302/0301-620X.75B5.8376422.
18. Linder L. Cancellous impaction grafting in the human femur: histological and radiographic observations in 6 autopsy femurs and 8 biopsies. *Acta Orthop Scand.* 2000;71(6):543-552. doi: 10.1080/000164700317362154.
19. van der Donk S., Buma P., Verdonschot N., Schreurs B.W. Effect of load on the early incorporation of impacted morsellized allografts. *Biomaterials*. 2002;23(1):297-303. doi: 10.1016/s0142-9612(01)00108-9.
20. Wang J.S., Tägil M., Aspenberg P. Load-bearing increases new bone formation in impacted and morselized allografts. *Clin Orthop Relat Res.* 2000;(378):274-281. doi: 10.1097/00003086-200009000-00038.
21. Waddell B.S., Della Valle A.G. Reconstruction of noncontained acetabular defects with impaction grafting, a reinforcement mesh and a cemented polyethylene acetabular component. *Bone Joint J.* 2017;99-B(1 Supple A): 25-30. doi: 10.1302/0301-620X.99B1.BJJ-2016-0322.R1.
22. Garcia-Cimbrelo E., Cruz-Pardos A., Garcia-Rey E., Ortega-Chamarro J. The survival and fate of acetabular reconstruction with impaction grafting for large defects. *Clin Orthop Relat Res.* 2010;468(12):3304-3313. doi: 10.1007/s11999-010-1395-4.
23. Comba F., Buttaro M., Pusso R., Piccaluga F. Acetabular revision surgery with impacted bone allografts and cemented cups in patients younger than 55 years. *Int Orthop.* 2009;33(3):611-616. doi: 10.1007/s00264-007-0503-x.
24. Busch V.J., Gardeniers J.W., Verdonschot N., Slooff T.J., Schreurs B.W. Acetabular reconstruction with impaction bone-grafting and a cemented cup in patients younger than fifty years old: a concise follow-up, at twenty to twenty-eight years, of a previous report. *J Bone Joint Surg Am.* 2011;93(4):367-371. doi: 10.2106/JBJS.I.01532.
25. Schreurs B.W., Luttjeboer J., Thien T.M., de Waal Malefijt M.C., Buma P., Veth R.P. et al. Acetabular revision with impacted morselized cancellous bone graft and a cemented cup in patients with rheumatoid arthritis. A concise follow-up, at eight to nineteen years, of a previous report. *J Bone Joint Surg Am*. 2009;91(3):646-651. doi: 10.2106/JBJS.G.01701.
26. Iwase T., Ito T., Morita D. Massive bone defect compromises postoperative cup survivorship of acetabular revision hip arthroplasty with impaction bone grafting. *J Arthroplasty.* 2014;29(12):2424-2429. doi: 10.1016/j.arth.2014.04.001.
27. Pierannunzii L., Zagra L. Bone grafts, bone graft extenders, substitutes and enhancers for acetabular reconstruction in revision total hip arthroplasty. *EFORT Open Rev.* 2016;1(12):431-439. doi: 10.1302/2058-5241.160025.
28. Fölsch C., Dharma J., Fonseca Ulloa C.A., Lips K.S., Rickert M., Pruss A. et al. Influence of thermodisinfection on microstructure of human femoral heads: duration of heat exposition and compressive strength. *Cell Tissue Bank.* 2020;21(3):457-468. doi: 10.1007/s10561-020-09832-5.
29. Anastasieva E.A., Cherdantseva L.A., Tolstikova T.G., Kirilova I.A. Deproteinized Bone Tissue as a Matrix for Tissue-Engineered Construction: Experimental Study. *Traumatology and Orthopedics of Russia.* 2023;29(1): 46-59. (In Russian). doi: 10.17816/2311-2905-2016.
30. Voor M.J., Nawab A., Malkani A.L., Ullrich C.R. Mechanical properties of compacted morselized cancellous bone graft using one-dimensional consolidation testing. *J Biomech.* 2000;33(12):1683-1688. doi: 10.1016/s0021-9290(00)00156-1.
31. Pratt J.N., Griffon D.J., Dunlop D.G., Smith N., Howie C.R. Impaction grafting with morsellised allograft and tricalcium phosphate-hydroxyapatite: incorporation within ovine metaphyseal bone defects. *Biomaterials*. 2002;23(16):3309-3317. doi: 10.1016/s0142-9612(02)00018-2.
32. Verdonschot N., Schreurs B., van Unen J., Slooff T., Huiskes R. Cup stability after acetabulum reconstruction with morsellized grafts is less surgical dependent when larger grafts are used. *Trans Orthop Res Soc.* 1999;24:867.

Authors' information

✉ *Irina A. Kirilova* — Dr. Sci. (Med.)
Address: 17, Frunze st., Novosibirsk, 630091, Russia
https://orcid.org/0000-0003-1911-9741
e-mail: irinakirilova71@mail.ru

Vadim N. Golnik
https://orcid.org/0000-0002-5047-2060
e-mail: vgolnik@mail.ru

Vladimir A. Peleganchuk — Dr. Sci. (Med.)
https://orcid.org/0000-0002-2386-4421
e-mail: 297501@mail.ru

Yuriy M. Batrak — Cand. Sci. (Med.)
https://orcid.org/0000-0003-0489-1480
e-mail: 297501@mail.ru

Vitaliy V. Pavlov — Dr. Sci. (Med.)
https://orcid.org/0000-0002-8997-7330
e-mail: pavlovdoc@mail.ru