

Efficiency of two-stage revision arthroplasty in management of periprosthetic knee and hip joint infectionA.M. Ermakov¹, N.M. Kliushin^{1,2}, Iu.V. Ababkov¹, A.S. Triapichnikov¹, A.N. Koiushkov¹¹Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation;²Tyumen State Medical University, Tyumen, Russian Federation

Introduction Two-stage revision arthroplasty is the "gold standard" of surgical treatment of periprosthetic infection in most domestic and foreign hospitals. This technique involves removal of implant components, debridement of the purulent focus and installation of a cement spacer which is subsequently replaced with a permanent implant after 3–9 months. **Purpose** To evaluate mid-term results of two-stage surgical treatment of patients with chronic periprosthetic infection of the knee and hip joints. **Materials and methods** Treatment outcomes of 172 patients with periprosthetic infection who underwent two-stage revision arthroplasty in the period from 2011 to 2015 were assessed. Among them, 113 patients developed infection after hip replacement and 59 patients had infected knee joint. The average follow-up period was 4 ± 1.58 years (range: 2 to 6 years). **Results** Out of 113 two-stage procedures of hip joint revision, 102 (90.2 %) cases showed an arrest of infection. Four (3.6 %) patients with recurrence of the purulent process underwent resection arthroplasty, another four (3.6 %) rejected to replace the spacer with an implant, and three (2.6 %) had a two-stage re-revision. Out of 60 (59 patients) procedures of a two-stage knee joint revision, infection was arrested in 50 (83.3 %) cases; eight (13.4 %) had recurrence and underwent knee arthrodesis. One (1.6 %) refused to replace a spacer for an implant, and one more (1.6 %) had a two-stage repeated revision. **Conclusions** Two-stage knee and hip revision arthroplasty using a cement spacer is an effective option for treatment of chronic periprosthetic infection. It provides infection control in 86.7 % (83.3 % for knee and 90.2 % for hip joints) of cases in the mid-term follow-up period up to 5 years. However, the rate of re-infection remains significant and reaches 13.3 % (9.8 % for hip and 16.7 % for knee joints).

Keywords: arthroplasty, hip, knee, periprosthetic infection, treatment, two stage revision

INTRODUCTION

Rapid recovery of painless joint movements and limb weight-bearing as well as a short rehabilitation period are undoubted merits of joint replacement surgery [1, 2, 3]. Unfortunately, serious complications may develop after this surgical intervention such as instability and dislocation of components, limb length discrepancy, periprosthetic fractures, implant failure, heterotopic ossification, liner wear, arthrofibrosis [4, 5, 6, 7]. Foreign authors consider infection to be the most destructive complication [8, 9].

Periprosthetic infection is a heavy burden for patients and hospitals due to high rates of its recurrence and mortality. The cost of treating one patient with periprosthetic infection in foreign hospitals varies from \$ 30,000 to \$ 78,000, excluding outpatient costs, disability costs, and lost wages [10, 11, 12].

The system of periprosthetic infection management that has been established includes several approaches

with their inherent methodical techniques and technical means used. The main one is surgical revision in combination with etiotropic therapy. The use of this or that surgical approach largely depends on the time of infection manifestation, implant stability, sensitivity of microorganisms to antibacterial drugs, concomitant diseases, etc. [13, 14, 15, 16].

Two-stage surgical treatment of periprosthetic infection is the "gold standard" in most domestic and foreign clinics [17, 18, 19]. This technique involves implant removal, surgical debridement of a purulent and inflammatory focus and installation of a cement spacer with its subsequent replacement by a permanent implant after 3-9 months [20, 21, 22, 23].

Purpose of the study: to evaluate the mid-term results of two-stage surgical treatment in patients with periprosthetic infection of the knee and hip joints.

MATERIAL AND METHODS

Treatment outcomes of 172 patients with revision using a cement spacer in the period from periprosthetic infection who underwent a two-stage 2011 to 2015 were analyzed. Infection developed

■ Ermakov A.M., Kliushin N.M., Ababkov Iu.V., Triapichnikov A.S., Koiushkov A.N. Efficiency of two-stage revision arthroplasty in management of periprosthetic knee and hip joint infection. *Genij Ortopedii*. 2018. T. 24. No 3. pp. 321-326. DOI 10.18019/1028-4427-2018-24-3-321-326. (In Russian)

in 113 patients after hip and in 59 patients after knee joint replacement. Mean age of patients was 51.93 ± 10.9 years (range: 22 to 80 years). The study was approved by the ethics committee of the institution in accordance with the standards of the 1975 Helsinki Declaration, revised in 2008.

All patients were diagnosed with periprosthetic infection according to the recommendations of the Proceedings of the International Consensus Meeting on Periprosthetic Joint Infection [24, 25]. After careful preoperative planning, surgical access to the infected joint was performed using standard methods (**Fig. 1, a**), all implant components were carefully removed with the help of revision instruments. Next, the infection focus was radically debrided followed by the installation of a cement spacer (preformed or block-like) of an appropriate size with antibacterial drugs (vancomycin and/or gentamicin and/or cefazolin) (**Fig. 1, c**).

The material for microbiological and histological studies was harvested intra-operatively. Taking into account the findings of agent detection in the material, a course of etiotropic therapy was indicated for 6 weeks (two weeks parenteral and four weeks oral).

In an outpatient phase, clinical and radiological condition of patients, blood parameters (leukocytes,

ESR and CRP) and microbiological findings of the joint contents were monitored. In the absence of clinical and laboratory signs of a purulent process, the second stage of treatment was performed, during which the elements of the cement spacer were removed (**Fig. 2, a**) and new components were implanted (**Fig. 2, b, c**). The average period between the treatment stages was 8.84 ± 5.8 (from 4 to 32) months.

Results of infection arrest were evaluated basing on the international multidisciplinary agreement Delphi, according to which the following criteria were used [26]:

- a) Eradication of infection (absence of wounds, fistulas, drainage, pain, and recurrence of infection caused by the same strain of microorganism);
- b) None of surgical intervention to stop infection after the last operation (reimplantation);
- c) None of lethal outcome due to sepsis.

Treatment outcomes of 172 patients were followed up in the terms from two to 6 years. The average follow-up period was 4 ± 1.58 years. Statistical processing was carried out using the Microsoft Excel software with the calculation of the mean value and statistical deviation.

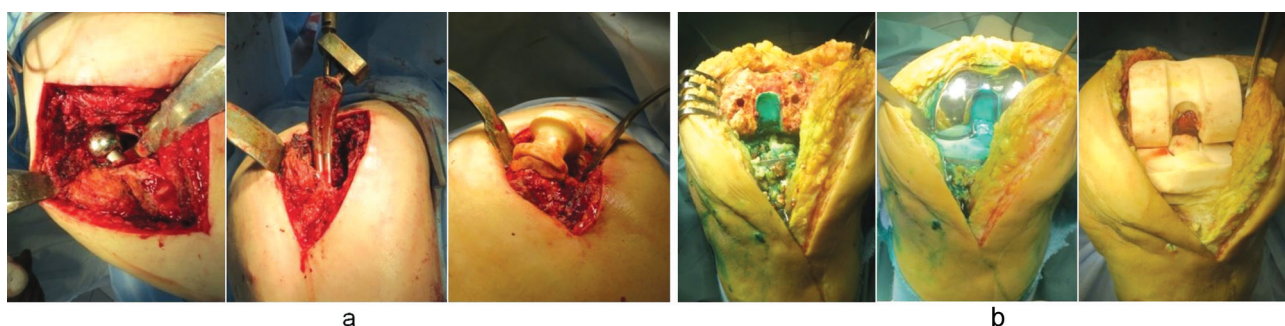


Fig. 1 First stage of revision intervention on the hip (a) and knee (b) joints

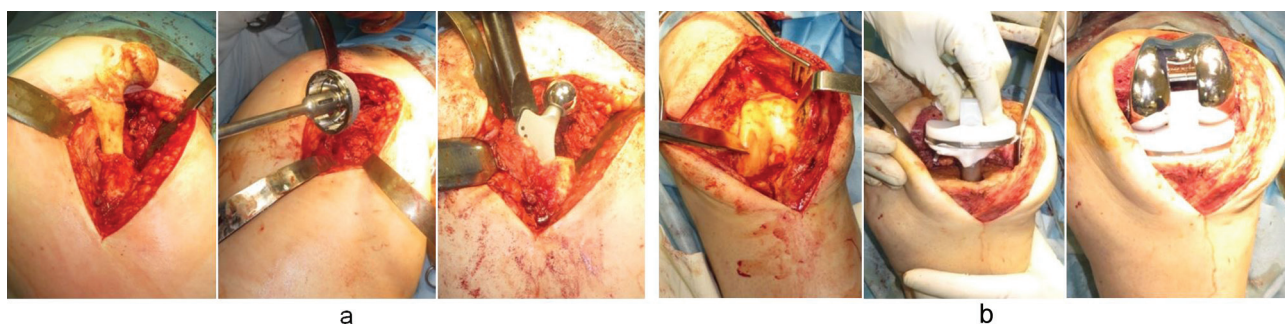


Fig. 2 The second stage of revision intervention on the hip (a) and knee (b) joints

RESULTS

According to D.T. Tsukayama's classification, 90 (52 %) patients had acute postoperative infection, 36 (21 %) patients late chronic and 34 (20 %) acute hematogenous. ones Positive intra-operative culture

was detected in 12 (7 %) patients. However, at the time of admission to our clinic, infection manifestation period was more than 4 weeks in all patients, which was an absolute indication for removal of infected implants.

Clinical and radiologic examination revealed that 144 (84 %) patients had fistulas and seven (4 %) had wounds; edema and hyperemia of the postoperative suture was present in 21 (12 %) patients.

Patients with periprosthetic infection in the hip joint had the following types of defects according to the classification of Paprosky W.G. [27]. Defects of the acetabulum of type I were observed in 36 % of patients, 55 % of patients had type II and only 9 % had type III. At the same time, among the defects of the femur, types I and II prevailed (38 % and 33 %, respectively); type III and type IV defects were detected in 25 % and 4 % of cases, respectfully.

In patients with knee joint infection, bone defects were classified according to AORI [28]. Among the knee joint defects, type I was most common (37 %); type IIA and type IIB were observed in 21 % and 18 %, respectively, and type III was detected in 24 % of patients.

According to clinical indications, a microbiology of biomaterials was studied in 172 patients, the results of which are shown in **Fig. 3**.

Analysis of treatment results was carried out in accordance with the international multidisciplinary agreement Delphi, which are presented in Table 1.

It can be seen from the table that recurrence of the infection after the removal of the infected hip implant and installation of a cement spacer occurred in 37 (32.7 %) cases, of which 15 patients with early relapse of infection had debridement without removal of the

spacer. Spacers were re-installed in 14 patients and four had resection arthroplasty. The remaining four refused to replace the spacer with an implant. After the second stage of treatment, infection recurred in only 3 (2.6 %) patients who underwent a two-stage revision again. In total, two-stage treatment was successfully completed in 102 (90.2 %) of 113 patients with periprosthetic hip joint infection.

There were sixty procedures of two-stage revision in 59 patients with periprosthetic infection of the knee joint as one patient had bilateral involvement. After the first stage of treatment (installation of the spacer), a relapse of the purulent inflammatory process was detected in 17 (28.3 %) cases, of which four patients with early recurrence had joint debridement without removal of the spacer; the spacer was reinstalled in six patients and seven patients had arthrodesis of the knee joint. After the second stage of treatment, re-infection happened only in two (3.3 %) patients. One of them repeated the procedure of two-stage treatment and the other underwent arthrodesis. In total, out of 60 cases of two-stage revision performed in 59 patients, 50 (83.3 %) were successful.

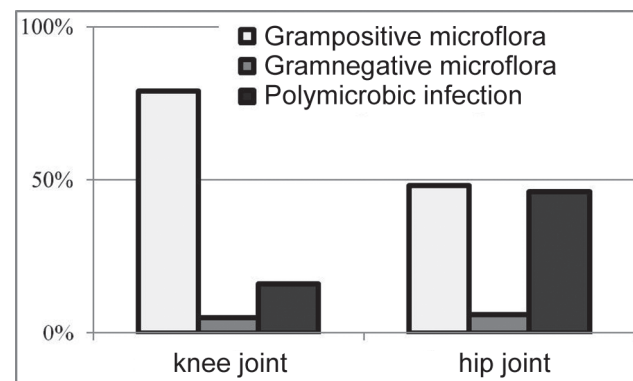


Fig. 3 Intraoperative data of microbiological study in patients with periprosthetic infection

Table 1

Treatment results in patients with periprosthetic infection treated with the technique of two-stage revision arthroplasty

Результат лечения	Periprosthetic infection location			
	Hip joint (113 patients)		Knee joint (59 patients)*	
	I stage	II stage	I stage	II stage
Infection recurrence	37 (32.7 %)	3 (2,6 %)	17 (28,3 %)	2 (3,3 %)
Infection arrest	76 (67.3 %)	110 (97,4 %)	43 (71,7 %)	58 (96,7 %)*
	102 (90.2 %) – successful; 4 (3.6 %) – resection arthroplasty; 4 (3.6 %) – rejected to change the spacer for implant; 3 (2.6 %) – two-stage re-revision		50 (83.3 %) – successful; 8 (13.4 %) – arthrodesis; 1 (1.6 %) – rejected to change the spacer for implant; 1 (1.6 %) – two-stage re-revision	

* – 59 patients with periprosthetic infection of the knee joint had 60 procedures of two-stage treatment as one patient had bilateral involvement

DISCUSSION

Two-stage revision joint arthroplasty with the use of a cement spacer is a complex medical procedure that allows surgeons to expect successful treatment outcomes in terms of arresting a purulent process. This is ensured by the possibility of carrying out a double surgical debridement in combination with courses of etiotropic therapy and subsequent arthroplasty of the joint [29, 30]. However, there have been publications recently that express doubt in high effectiveness of this treatment technique [31, 32].

We analyzed latest literature sources on the effectiveness of a two-stage revision arthroplasty. The data are reflected in table 2.

Dieckmann R. et al. demonstrate a 93 % infection control with good functional results after a two-stage

revision arthroplasty [18]. The most successful rates with the suppression of a purulent inflammatory process in 94 % of cases were achieved in American hospitals [33].

Pelt C.E. with colleagues showed the highest rate of infection recurrence after a two-stage treatment with a 22 % lethal outcome [34]. Claassen L. also ascertains a significant reinfection, which reaches 24 % [35].

Citak M. performed literature review and concluded that there are no differences between different types of spacers in terms of infection arrest [36].

Elimination of purulent process in our clinic was 86.7 % (83.3 % for the knee and 90.2 % for the hip joint) of cases with an average follow-up period of 4.1 years and 13.3 % relapse of infection (9.8 % for the hip and 16.7 % for the knee joints).

Table 2

Summary data on the effectiveness of using two-stage revision arthroplasty

Authors	Number of cases	Follow-up	Infection recurrence	Infection arrest
Dieckmann R., 2014	43	3.86 года	7 %	93 %
Pelt C.E., 2014	58	3.16 года	36 %	64 %
Citak M., 2015	1018	3 года	9 %	91 %
Claassen L., 2015	50	3 года	24 %	76 %
Drexler M., 2015	82	3 года	14.6 %	85.4 %
Lichstein P., 2015	107	3.7 года	6 %	94 %
Our results	172	4.1 года	13.3 %	86.7 %

CONCLUSIONS

Two-stage revision arthroplasty with the use of a cement spacer is rather an effective option in the management of periprosthetic infection. It suppresses the purulent process in 86.7 % (83.3 % for the knee

and in 90.2 % for the hip joint) at the mid-term follow-up period of 5 years. However, the recurrence rate remains high, reaching 13.3 % (9.8 % for the hip and 16.7 % for the knee joints).

Conflict of interest: there is no declared conflict of interests.

REFERENCES

1. Khan M., Della Valle C.J., Jacofsky D.J., Meneghini R.M., Haddad F.S. Early postoperative complications after total hip arthroplasty: current strategies for prevention and treatment. *Instr. Course Lect.*, 2015, vol. 64, pp. 337-346.
2. Koenig K., Huddleston J.I. 3rd, Huddleston H., Maloney W.J., Goodman S.B. Advanced age and comorbidity increase the risk for adverse events after revision total hip arthroplasty. *J. Arthroplasty*, 2012, vol. 27, no. 7, pp. 1402-1407. DOI: 10.1016/j.arth.2011.11.013.
3. Singh J.A., Lewallen D.G. Ninety-day mortality in patients undergoing elective total hip or total knee arthroplasty. *J. Arthroplasty*, 2012, vol. 27, no. 8, pp. 1417-1422. DOI: 10.1016/j.arth.2012.03.008.
4. Sharkey P.F., Lichstein P.M., Shen C., Tokarski A.T., Parvizi J. Why are total knee arthroplasties failing today – has anything changed after 10 years? *J. Arthroplasty*, 2014, vol. 29, no. 9, pp. 1774-1778. DOI: 10.1016/j.arth.2013.07.024.
5. Zhang T., Zheng C., Ma H., Sun C. Causes of early failure after total hip arthroplasty. *Zhonghua Yi Xue Za Zhi*, 2014, vol. 94, no. 48, pp. 3836-3838.
6. Iamthanaporn K., Chareancholvanich K., Pornrattanamaneewong C. Revision primary total hip replacement: causes and risk factors. *J. Med. Assoc. Thai*, 2015, vol. 98, no. 1, pp. 93-99.
7. Huang Z., Sun C. Causes of failure after total knee arthroplasty. *Zhonghua Yi Xue Za Zhi*, 2015, vol. 95, no. 20, pp. 1606-1608.

8. Kapadia B.H., Berg R.A., Daley J.A., Fritz J., Bhavé A., Mont M.A. Periprosthetic joint infection. *Lancet*, 2016, vol. 387, no. 10016, pp. 386-394. DOI: 10.1016/S0140-6736(14)61798-0.
9. Soares D., Leite P., Barreira P., Aido R., Sousa R. Antibiotic-loaded bone cement in total joint arthroplasty. *Acta Orthop. Belg.*, 2015, vol. 81, no. 2, pp. 184-190.
10. Vrgoc G., Japjec M., Gulán G., Ravlić-Gulan J., Marinović M., Bandalović A. Periprosthetic infections after total hip and knee arthroplasty – a review. *Coll. Antropol.*, 2014, vol. 38, no. 4, pp. 1259-1264.
11. Niska J.A., Meganck J.A., Pribaz J.R., Shahbazian J.H., Lim E., Zhang N., Rice B.W., Akin A., Ramos R.I., Bernthal N.M., Francis K.P., Miller L.S. Monitoring bacterial burden, inflammation and bone damage longitudinally using optical and μ CT imaging in an orthopaedic implant infection in mice. *PLoS One*, 2012, vol. 7, no. 10, pp. e47397. DOI: 10.1371/journal.pone.0047397.
12. Garrido-Gómez J., Arrabal-Polo M.A., Girón-Prieto M.S., Cabello-Salas J., Torres-Barroso J., Parra-Ruiz J. Descriptive analysis of the economic costs of periprosthetic joint infection of the knee for the public health system of Andalusia. *J. Arthroplasty*, 2013, vol. 28, no. 7, pp. 1057-1060. DOI: 10.1016/j.arth.2013.02.012.
13. Liu B., Tikhilov R.M., Shubniakov I.I., Bozhkova S.A., Artiukh V.A., Denisov A.O. Analiz effektivnosti saniruiushchikh operatsii pri paraendoproteznoi infektsii [Analysis of the effectiveness of debridement surgeries for paraendoprosthetic infection]. *Travmatologiya i Ortopediya Rossii*, 2014, no 2, pp. 22-29. (In Russian) DOI: <http://dx.doi.org/10.21823/2311-2905-2014-0-2-22-29>.
14. Hsieh P.H., Huang K.C., Lee P.C., Lee M.C. Two-stage revision of infected hip arthroplasty using an antibiotic-loaded spacer: retrospective comparison between short-term and prolonged antibiotic therapy. *J. Antimicrob. Chemother.*, 2009, vol. 64, no. 2, pp. 392-397. DOI: 10.1093/jac/dkp177.
15. Moran E., Byren I., Atkins B.L. The diagnosis and management of prosthetic joint infections. *J. Antimicrob. Chemother.*, 2010, vol. 65, no. Suppl. 3, pp. iii45-iii54. DOI: 10.1093/jac/dkq305.
16. De Man F.H., Sendi P., Zimmerli W., Maurer T.B., Ochsner P.E., Ilchmann T. Infectiological, functional, and radiographic outcome after revision for prosthetic hip infection according to a strict algorithm. *Acta Orthop.*, 2011, vol. 82, no. 1, pp. 27-34. DOI: 10.3109/17453674.2010.548025.
17. Parvizi J., Zmistowski B., Adeli B. Periprosthetic joint infection: treatment options. *Orthopedics*, 2010, vol. 33, no. 9, pp. 659. DOI: 10.3928/01477447-20100722-42.
18. Dieckmann R., Schulz D., Gosheger G., Becker K., Daniilidis K., Streitzbürger A., Hardes J., Hoell S. Two-stage hip revision arthroplasty with a hexagonal modular cementless stem in cases of periprosthetic infection. *BMC Musculoskelet. Disord.*, 2014, vol. 15, pp. 398. DOI: 10.1186/1471-2474-15-398.
19. Preobrazhenskii P.M., Kazemirskii A.V., Goncharov M.Iu. Sovremennye vzgliady na diagnostiku i lechenie patsientov s periproteznoi infektsiei posle endoprotezirovaniia kolennogo sustava [Current views on diagnosing and treatment of patients with periprosthetic infection after the knee arthroplasty]. *Genij Ortopedii*, 2016, no. 3, pp. 94-104. (In Russian)
20. Tsung J.D., Rohrsheim J.A., Whitehouse S.L., Wilson M.J., Howell J.R. Management of periprosthetic joint infection after total hip arthroplasty using a custom made articulating spacer (CUMARS); the Exeter experience. *J. Arthroplasty*, 2014, vol. 29, no. 9, pp. 1813-1818. DOI: 10.1016/j.arth.2014.04.013.
21. Jakobs O., Schoof B., Klatte T.O., Schmidl S., Fensky F., Guenther D., Frommelt L., Gehrke T., Gebauer M. Fungal periprosthetic joint infection in total knee arthroplasty: a systematic review. *Orthop. Rev. (Pavia)*, 2015, vol. 7, no. 1, pp. 5623. DOI: 10.4081/or.2015.5623.
22. Babis G.C., Sakellariou V.I., Pantos P.G., Sasalos G.G., Stavropoulos N.A. Two-stage revision protocol in multidrug resistant periprosthetic infection following total hip arthroplasty using a long interval between stages. *J. Arthroplasty*, 2015, vol. 30, no. 9, pp. 1602-1606. DOI: 10.1016/j.arth.2015.04.004.
23. Komarov R.N., Mitrofanov V.N., Novikov A.V., Korolev S.B. Taktika lecheniia infektsionnykh oslozhnenii posle endoprotezirovaniia tazobedrennogo sustava [Tactics of treating infection complications after the hip arthroplasty]. *Travmatologiya i Ortopediya Rossii*, 2016, vol. 22, no. 4, pp. 25-34. (In Russian)
24. Enayatollahi M.A., Parvizi J. Diagnosis of infected total hip arthroplasty. *Hip Int.*, 2015, vol. 25, no. 4, pp. 294-300. DOI: 10.5301/hipint.5000266.
25. Parvizi J., Jacovides C., Zmistowski B., Jung K.A. Definition of periprosthetic joint infection: is there a consensus? *Clin. Orthop. Relat. Res.*, 2011, vol. 469, no. 11, pp. 3022-3030. DOI: 10.1007/s11999-011-1971-2.
26. Diaz-Ledezma C., Higuera C.A., Parvizi J. Success after treatment of periprosthetic joint infection: A Delphi-based international multidisciplinary consensus. *Clin. Orthop. Relat. Res.*, 2013, vol. 471, no. 7, pp. 2374-2382. DOI: 10.1007/s11999-013-2866-1.
27. Della Valle C.J., Paprosky W.G. The femur in revision total hip arthroplasty evaluation and classification. *Clin. Orthop. Relat. Res.*, 2004, no. 420, pp. 55-62.
28. Qiu Y.Y., Yan C.H., Chiu K.Y., Ng F.Y. Review article: bone defect classifications in revision total knee arthroplasty. *J. Orthop. Surg. (Hong Kong)*, 2011, vol. 19, no. 2, pp. 238-243. DOI: 10.1177/230949901101900223.
29. Berend K.R., Lombardi A.V. Jr., Morris M.J., Bergeson A.G., Adams J.B., Sneller M.A. Two-stage treatment of hip periprosthetic joint infection is associated with a high rate of infection control but high mortality. *Clin. Orthop. Relat. Res.*, 2013, vol. 471, no. 2, pp. 510-518. DOI: 10.1007/s11999-012-2595-x.
30. Ilchmann T., Zimmerli W., Ochsner P.E., Kessler B., Zwicky L., Graber P., Clauss M. One-stage revision of infected hip arthroplasty: outcome of 39 consecutive hips. *Int. Orthop.*, 2016, vol. 40, no. 5, pp. 913-918. DOI: 10.1007/s00264-015-2833-4.
31. Zhang A.L., Feeley B.T., Schwartz B.S., Chung T.T., Ma C.B. Management of deep postoperative shoulder infections: is there a role for open biopsy during staged treatment? *J. Shoulder Elbow Surg.*, 2015, vol. 24, no. 1, pp. 15-20. DOI: 10.1016/j.jse.2014.04.007.

32. Mortazavi S.M., Vegari D., Ho A., Zmistowski B., Parvizi J. Two-stage exchange arthroplasty for infected total knee arthroplasty: predictors of failure. *Clin. Orthop. Relat. Res.*, 2011, vol. 469, no. 11, pp. 3049-3054. DOI: 10.1007/s11999-011-2030-8.
33. Lichstein P., Su S., Hedlund H., Suh G., Maloney W.J., Goodman S.B., Huddleston J.I. 3rd. Treatment of periprosthetic knee infection with a two-stage protocol using static spacers. *Clin. Orthop. Relat. Res.*, 2016, vol. 474, no. 1, pp. 120-125. DOI: 10.1007/s11999-015-4443-2.
34. Pelt C.E., Grijalva R., Anderson L., Anderson M.B., Erickson J., Peters C.L. Two-stage revision TKA is associated with high complication and failure rates. *Adv. Orthop.*, 2014, vol. 2014, pp. 659047. DOI: 10.1155/2014/659047.
35. Claassen L., Plaass C., Daniilidis K., Calliess T., Von Lewinski G. Two-stage revision total knee arthroplasty in cases of periprosthetic joint infection: an analysis of 50 cases. *Open Orthop. J.*, 2015, vol. 9, pp. 49-56. DOI: 10.2174/1874325001509010049.
36. Citak M., Citak M., Kendoff D. Dynamic versus static cement spacer in periprosthetic knee infection: A meta-analysis. *Orthopade*, 2015, vol. 44, no. 8, pp. 599-606. DOI: 10.1007/s00132-015-3091-2.

Received: 30.03.2018

Information about the authors:

1. Artem M. Ermakov, M.D., Ph.D.,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation;
Email: ema_cab@mail.ru
2. Nikolai M. Kliushin, M.D., Ph.D.,
¹Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation;
²Tyumen State Medical University, Tyumen, Russian Federation
3. Iurii V. Ababkov, M.D., Ph.D.,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation
4. Aleksandr S. Triapichnikov, M.D., Ph.D.,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation
5. Andrei N. Koiushkov, M.D.,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation