Genij Ortopedii. 2021. Vol. 27, no. 5. P. 502-507.

Original article

https://doi.org/10.18019/1028-4427-2021-27-5-502-507

Treatment of pertrochanteric fractures in elderly patients: is dynamic fixation so important?

I.M. Shcherbakov[1], V.E. Dubrov[1]✉, A.S. Shkoda[2], Yu.S. Zlobina[3], A.A. Shelupaev[3], K.A. Saprykina[1], D.A. Zyuzin[1]

[1]Lomonosov Moscow State University, Moscow, Russian Federation
[2]Clinical hospital No. 67 named after L.A. Vorokhobov of Moscow Healthcare Department, Moscow, Russian Federation
[3]Research Institute of Healthcare Organization and Medical Management of Moscow Healthcare Department, Moscow, Russian Federation
Corresponding author: Vadim E. Dubrov, vduort@gmail.com

Abstract

Introduction The problem of complications after surgical treatment of pertrochanteric fractures in elderly patients is relevant and far from a solution. **Materials and methods** The retrospective study was based on the analysis of the results of treatment of 129 patients with pertrochanteric femoral fractures (average age 76 years). All fractures in the early time from trauma were fixed with two types of cephalomedullary nails, either dynamic or static. All patients could not limit the load on the operated limb after surgery because of different reasons. **Results** The results of treatment were evaluated in 109 patients after one year. In dynamic cephalomedullary fixator group (59 patients), there were 7 orthopedic complications with a functional Harris scale result of 68 points (range, 26 to 94 points). In static cephalomedullary fixator group (50 patients), there were 14 orthopedic complications with a functional Harris score of 56.5 points (range, 15 to 92 points). **Discussion** Higher results of treatment in the group of dynamic fixator in the condition of full-weight bearing on the operated limb may be associated with the possibility of dynamization of the part of fixator in response to bone resorption in the contact area of bone fragments. The use of dynamic cephalomedullary fixators instead of static ones for treatment of pertrochanteric femoral fractures in elderly patients exercising full weight-bearing leads to a decrease in orthopedic complications (from 28 to 11.9 %) and improves the functional results of treatment.
Keywords: cephallomedullary osteosynthesis, hip fracture, osteoporosis

For citation: Shcherbakov I.M., Dubrov V.E., Shkoda A.S., Zlobina Yu.S., Shelupaev A.A., Saprykina K.A., Zyuzin D.A. Treatment of pertrochanteric fractures in elderly patients: is dynamic fixation so important? *Genij Ortopedii*, 2021, vol. 27, no 5, pp. 502-507. https://doi.org/10.18019/1028-4427-2021-27-5-502-507

INTRODUCTION

Management of low-energy fractures of the proximal femur in the elderly population with osteoporosis has become relevant in the recent decades in all countries of the world, regardless of the type of climate, race, age and other demographic characteristics [1–7] The tactics of treatment of pertrochanteric fractures, aimed at their earliest surgical stabilization, minimization of anesthetic and surgical trauma and rapid activation of patients in the postoperative period, has been recognized by most authors as the only chance to save the patient's life [1, 2, 5]. However, in addition to life-threatening problems, these patients face postoperative complications that significantly worsen the results of treatment and sometimes require repeated surgeries that inevitably worsen the quality of life and prevent a return to the pre-traumatic level of physical and social activity [7, 8]. And if the treatment of general surgical (infectious, thromboembolic, etc.) complications, the theoretical bases of the etiology and prevention have already been formulated, orthopedic complications (fracture nonunion, aseptic instability of the implant, peri-implant fractures, etc.) require further study [4, 9].

Such complications may be caused by violations of the fixator implantation technology. However, even in the case of full adherence to surgical technologies, complications cannot be avoided [10]. It is assumed that one of the main factors influencing the incidence of orthopedic complications is the cyclic mechanical load applied to the "femur-implant" system during patient's motion and walking. The ratio of the maximum permissible load and its real magnitude at various stages of bone repair in the process of postoperative rehabilitation can determine the potential risk of complications for each specific system [11].

By the nature of the change in the interposition of the elements of the "bone-implant" system, all metal fixators are divided into dynamic and static ones. In the first group, the predicted displacement of the fixator components relative to each other occurs in the structure due resorption of bone tissue and changes in the topographic and anatomical relationships during the healing of the fracture, while in the second it does not. Theoretically, these structural features should determine the rehabilitation strategy in the postoperative period, walking with a full dosed load on the operated limb or without any loading at all.

Thus, the purpose of this study was to improve the results of treatment of elderly patients with pertrochanteric fractures by reducing the number of complications and improving the quality of restoration of the function of the injured limb through a rational choice of the types of metal fixators and postoperative rehabilitation.

MATERIAL AND METHODS

The study analyzes treatment results of 129 patients in an average age of 76 years (range, 53 to 97 years) with pertrochanteric fractures of the femur who were treated from 2009 to 2017 at the clinical departments of general and specialized Surgery at the Faculty of Fundamental Medicine of Moscow State Lomonosov University. The inclusion criteria for the study were low-energy pertrochanteric femoral fractures (according to the OTA/

AO 31A1-3 classification [12]), age over 50 years, and patients' not capable to limit the load on the operated limb by walking due to various medical reasons. Exclusion criteria were multiple and high-energy trauma, metastatic lesion or primary tumor of the proximal femur, as well as technical errors in performing osteosynthesis that could affect treatment outcomes. Informed consent was obtained from all patients. The study was carried out in accordance with the ethical principles presented by the World Medical Association Declaration of Helsinki, 1964, as amended in 2011, and the "Rules of Clinical Practice in the Russian Federation" approved by the Order N 266 of the Ministry of Health of the Russian Federation dated 19.06. 2003.

The average time to hospital admission from the moment of injury was 1.2 days (median 2.5 days, from 1 hour to 11 days). Radiological diagnostics included plain X-rays of the pelvis with the capture of the hip joints in frontal and lateral projections. Computed tomography was used in 53 patients according to indications (ambiguity in the assessment of the nature of the fracture by continuation of the fracture line to the femoral neck or subtrochanteric region). The AO/ASIF classification was used for the distribution of the patients into groups depending on the type of fracture, [12]. Preoperative examination was carried out according to the standard techniques [6].

All patients underwent surgical treatment with the use of cephalomedullary nails in the early stages of admission (from 6 hours to 3 days). The group of dynamized fixators randomly included 66 patients, who were treated with Targon PF nail manufactured by Aesculap B. Braun (Germany). The remaining 63 patients are included in the static fixation group; these patients used static fixators: a trochanteric rod (Gamma) manufactured by Deost (Russia) or PFN nail manufactured by Synthes Depuy (USA).

The operation was performed on an orthopedic table with the patient being supine. Closed reduction was performed on an orthopedic table with limb extension along the axis, rotation control and flexion / extension in the hip joint. Overcorrection in the form of excessive internal rotation was deliberately avoided by performing reduction to prevent limitation of external rotation and pain by movements in the hip joint in the postoperative period.

Reduction was monitored using an X-ray image intensifier. The criteria for achieving reduction were restoration of the mutual position of the fragments of the greater trochanter and the diaphysis, achievement of the target values of the neck-shaft angle in the frontal projection (130 ± 2°), and restoration of the anteversion of the femoral neck in the lateral projection. Special means were not sought to achieve anatomical reduction of the lesser trochanter and small fragments of the greater trochanter. In all cases, the implantation of the fixator was started only after all these criteria were met.

The implantation of metal fixators was carried out according to the standard methods recommended by the manufacturers. The criteria for the correct placement of the implant were the location of the intramedullary component in the medullary canal, the position of the upper edge of the nail at the level of the apex of the greater trochanter, the alignment of the femoral neck, cervical and derotation screws, the correct choice of screw length and exclusion of penetration into the cavity of the hip joint. In the frontal projection, the placement of screws in the region of the upper pole of the head was avoided, in the axial projection - the placement of screws in the posterior or anterior third of the neck and head of the femur, while striving to achieve a TAD value less than 25 mm [13].

To control the reduction and position of metal fixators after surgery, X-rays of the hip joint were taken in two projections.

Regardless of the clinic in which the patients were treated, they were activated one day after the operation. Respiratory gymnastics, simple exercises for the upper limb girdle, isometric muscle tension of the lower limbs were performed only with the participation of a physical therapy instructor, excluding independent attempts to activate for prevention of repeated falls. On the first day of training, all patients sat in bed with their legs lowered, and 54 patients (41.9 %) began to walk using a walker, while the instructor focused the trainee's attention on the need to start walking making a step with the operated leg to the distance of the foot.

It should be noted that all patients walked with full load on the operated limb, despite the explanation of the need to unload the operated leg with additional external support. The inability to limit the load was associated with weakness of the muscles of the upper limbs due to sarcopenia, consequences of fractures of the bones of the upper limb (distal metaepiphysis of the radius, proximal humerus), consequences of acute cerebrovascular accidents, various forms of mental impairment (cognitive disorders, up to dementia), obesity (Table 1).

Table 1

Reasons resulting in inability to limit the load on the operated limb

Reason	Number of patients (%)
Fractures of the distal metaepiphysis of the radius in anamnesis with limited function of the wrist joint and hand	12 (9.3)
Cognitive impairment	47 (36.4)
Consequences of acute celebrovascular attack	11 (8.5)
Consequences of proximal humerus fractures with limited function of the upper limb	9 (7.0)
Muscle weakness associated with senile sarcopenia	31 (24)
Obesity	19 (14.8)
Total	129 (100)

At follow-ups, the patients underwent X-ray control (on average, 6 and 12 weeks after the operation, and after 1 year). Walking without external support was allowed after 3 months if there were signs of fracture consolidation and no complications. Evaluation of treatment results in each group was carried out in terms of mortality, frequency and nature of complications, according to the Harris hip score at one year after surgery, and consolidation. Orthopedic complications included peri-implant fractures of the femoral shaft, migration of cut-out components, breach of fixator elements, and the development of avascular necrosis of the femoral head. The "cut-out" effect was defined as collapse of the femoral neck with a decrease in offset and migration of the screw (screws) [14]. Comparison of the results between the groups was conducted by the method of nonparametric statistics using the Mann-Whitney tests and the χ-square due to the discrete nature of the distribution of values and sample sizes not exceeding 60 (Statistica 10.0, StatSoft) [15]. The null hypothesis implied that the differences between the compared groups are insignificant and both samples are parts of the same general population. By calculating both criteria, $p < 0.05$ was taken as the level of significance at which the null hypothesis was rejected.

RESULTS

Mortality rate in the first year after surgery was 13.5 % (17 people) (Table 2). The groups were comparable in terms of mortality (χ-square value 0.989, $p = 0.320$, the differences are insignificant).

Among the patients whose results were followed up for 10-14 months (average, one year), 3 had infectious complications, one of which was superficial and was arrested by local treatment of the postoperative wound and antibiotic therapy. Two patients had deep suppuration, non-union of fractures, which required the removal of metal fixators and long-term treatment, followed by an unfavorable functional outcome. These patients were excluded from the study.

Table 2

Mortality in the groups

Gender	Dynamic fixator	Static fixator	Total
Females	4	5	9
Males	3	5	8
Total	7	10	17

Among the remaining 109 patients, women were 71.6 % (78 people), and men were 31 people (28.4 %). The average age of patients was 78.5 years in women (range, 53 to 97 years), and 72.8 years in men (range, 60 to 87 years). The selected groups of patients were comparable in terms of age, gender, and types of fractures (Tables 3–5).

Fracture consolidation was achieved in all cases. The incidence of orthopedic complications was 19.3 % (21 cases); the incidence of complications in the dynamizable fixator group was 11.9 %, and in the static fixator group it was 28 %. The structure of complications is presented in Table 6.

Among orthopedic complications, there were three diaphyseal peri-implant femoral fractures, which occurred due to low-energy impact in the period from 3 to 7 months after the operation. These complications required in all cases the removal of metal fixators and the installation of a longer intramedullary nail. All these fractures consolidated with a good functional outcome according to the Harris scale.

Table 3

Comparison between groups in number and gender (χ^2 0.009, $p = 0.926$, insignificant differences)

Gender	Dynamic fixator	Static fixator	Total
Females	42	36	78
Males	17	14	31
Total	59	50	109

Table 4

Comparison of patient groups by age, median (minimum; maximum), years

Gender	Dynamic fixator	Static fixator	Total
Females	78 (53; 90)	76,5 (59; 97)	77 (53; 97)
Males	73 (60; 82)	72,5 (65; 87)	73 (60; 87)
Total	76 (53; 90)	76 (59; 97)	76 (53; 97)

Table 5

Comparison of patient groups by types of fractures (χ^2 0.335, $p = 0.846$, insignificant differences)

Types of fracture	Dynamic fixator	Static fixator	Total
A1	18	13	31
A2	30	28	58
A3	11	9	20
Total	59	50	109

A fracture of the distal locking screws was recorded in two patients from the static fixator group, and the fractures healed with good functional results according to the Harris scale (Table 6).

Table 6

Comparison of patient groups by the incidence of complications

Complications	Dynamic fixator, n (%)	Static fixator, n (%)	Total, n (%)
Avascular necrosis of the femoral head	1 (4.8)	2 (9.6)	3 (14.3)
Peri-implant fractures	1 (4.8)	2 (9.6)	3 (14.3)
Uncontrolled migration of fixator components, secondary displacement of fragments, post-traumatic varus deformity	5 (23.8)	8 (38.1)	13 (61.9)
Fixator or screw break	0 (0)	2 (9.6)	2 (9.6)
Total	7 (33.3)	14 (66.7)	21 (100)

The development of avascular necrosis was noted in 3 patients after consolidation of the fracture was achieved. Subsequently, this complication required the removal of the metal fixator and total hip arthroplasty due to severe pain and limited function.

"Cut-outs" in the area of the neck and head of the femur were found in 13 patients with their distribution into groups presented in Table 6. In 7 cases, screw protrusion through the upper pole of the head with varus deformity of the proximal femur was noted, and protrusion through the posterior wall of the head and neck in six.

The frequency of orthopedic complications in the group of dynamic fixators was significantly lower than in the group of static fixators (χ-square test 4.53, $p = 0.034$).

The functional results of treatment are presented in Table 7. It should be noted that in the group of the dynamic fixator, significantly better functional results of treatment were revealed compared to the group of static fixators (Mann-Whitney U-test 1122, $p < 0.05$). At the same time, statistically significant differences were revealed both between the groups of women (Mann-Whitney U-test 563, $p < 0.05$) and men (Mann-Whitney U-test 51, $p < 0.01$).

Table 7

Comparison of the functional results of treatment after 1 year between the groups according to the Harris scale, median (minimum; maximum), points

HHS	Dynamic fixator	Static fixator
Females	58.5 (34; 89)	59 (15; 92)
Males	81 (26; 94)	56.5 (31; 82)
Total	68 (26; 94)	56.5 (15; 92)

DISCUSSION

Thus, the purpose of this study was to establish whether the ability to dynamize inherent in the design of the cephalomedullary nail has an impact on the incidence of complications and functional results of treatment in elderly patients who cannot consciously limit the load on the leg after surgery.

The available literature shows different rates of orthopedic complications after cephalomedullary osteosynthesis of femoral fragments in transtrochanteric fractures. In one of the works [16], the incidence of complications of an orthopedic nature for the PFN nail was reported in 13 % (7 out of 53 patients), of which 2 were cut-out, 3 were screw migration as a Z-effect, and 2 were nonunion of the fracture. It is comparable with the results of our study, and the authors of that publication also point to the possibility of movement of the screws of the PFN fixator relative to the intramedullary component in shortening of the axis of the femoral neck (on average, up to 6 mm for this fixator). However, such dynamization occurs spontaneously and is not inherent in the implant structure. The functional results of treatment for the PFN nail on the Harris scale averaged 70.8 points (from 24.7 to 97.0 points), that is slightly higher than in our study.

The authors of another article [17] indicated the incidence of "cut-out" complications as 14 % for the static fixator PFN and 5.7 % for PFNA, but these data are given for the period 3 months after implantation. The authors declare that walking with full load on the operated leg is persuaded in the rehabilitation of patients after surgery; however, the article does not provide exact data on the nature of postoperative rehabilitation.

Other authors [18] reported the overall incidence of mechanical complications ("cut-out" and lateralization of screws and blades) up to 12 %, but all patients after surgery were allowed to walk with full load on the operated limb. One study [10] reported 2.7 % cut-out complications for the PFN-A implant.

Kawatani Y et al [19] studied the results of using the Targon PF nail with the possibility of dynamizing the cervical screw in the treatment of pertrochanteric fractures in elderly patients. The authors reported walking with full load on the operated leg immediately after surgery. The study of 310 patients after 12 months revealed only 4 mechanical complications: nonunion, peri-implant femoral fracture, Z-effect and lateral migration of the neck screw sleeve that totaled only 1.25 %. The authors explain such a low incidence of complications precisely by the ability of the nail elements to dynamize. The authors of another article [20] write about the same low incidence of complications (1.1 %). One later publication [21] reported higher incidence of complications with "cut-out" found in 6.8 %.

In all of the above studies, only the authorization of patients to walk with full load on the operated leg is reported. There is no analysis of the extent to which patients complied with this recommendation. After all, in everyday clinical practice, only a part of patients, especially elderly and senile patients, can limit the load after surgery due to pain in the hip joint or fear of fragments displacement. In contrast to this approach, a topical issue of our study was the targeted selection of a group of patients who were unable to limit the load on the operated limb for one reason or another.

The differences in the incidence of complications between the groups of static and dynamic fixators identified in our study may lie in the phenomenon of bone resorption in the contact area of bone fragments, which occurs at the first stage of fracture consolidation under load conditions and is accompanied by inevitable bone collapse. The implantation of metal implants stabilizes the fragments and allows the "bone-implant" system to partially compensate for the functional loss of the limb before the onset of fracture consolidation. However, it cannot be considered completely mechanically identical to the intact bone.

As shown by mathematical modeling with the finite element method, in a cyclic load on the "bone-implant" system by body weight and simultaneous development of resorption, especially against the background of due to senile osteoporosis, an inevitable varus displacement of the proximal femur fragment occurs with shortening of the femoral neck axis [11]. The components of static structures cannot adequately displace following the

fragments, what results to the formation of load loci (so-called stress overload zones) with a subsequent increase in pressure in the contact area of the fixator and bone. All this leads not only to overload and possible breakage of the metal fixator, but also to increased reactive resorption of bone tissue with subsequent instability of the implant or "cutting" of the bone with a rigid metal fixator ("cut-out" effect).

In regard to these considerations, early loading on the limb after osteosynthesis of a fracture cannot be recommended and should be excluded in all possible cases to prevent orthopedic complications. However, elderly patients, due to a number of reasons (cognitive impairment, consequences of fractures of the upper limb bones, stroke, sarcopenia, obesity, etc.) are often unable to limit this load. It is impossible to completely abandon verticalization, since such a refusal leads to the appearance of hypostatic complications and an increase in mortality. Because of this, the primary task in elderly and senile patients in the treatment of fractures of the bones of the lower extremity, especially the femur, is not so a return to the pre-traumatic level of activity but prevention of life-threatening hypodynamic complications.

Dynamic fixators due to the possible displacement of the fixator elements (sliding of the dynamic screw in the sleeve with redistribution of axial forces, etc.) enable to level the discrepancy between the cyclic load of the body weight and the biomechanical properties of the "non-consolidated bone-implant" system. This allows not only to reduce the risk of fixator migration and the development of the "cut-out" effect, to achieve fracture consolidation with a decrease in the complication rate but also to provide a recovery of early and regular functional activity.

Undoubtedly, the incidence of orthopedic complications is influenced by other factors besides the choice of the type of fixator and the type of load on the operated leg, for example by the severity of osteoporosis, the position of the fixator at the time of implantation, and fracture type [18]. The limitations of our study are the small sample size of patients sample and insufficient consideration of other factors. The severity of osteoporosis was not taken into account, the position of the fixator elements after implantation was not assessed by special mathematical methods, the groups were identical by the types of fractures. Clarifying the impact of each of these along with some others may be a topic for further study.

CONCLUSIONS

1. Dynamic fixation in pertrochanteric fractures of the femur in elderly patients provides, under conditions of body weight-loading, reduction of orthopedic complications (in our study from 28 to 11.9 %) and improvement of functional outcomes (HHS 68 and 56.5 points in the dynamic and static fixator groups, respectively).

2. The use of dynamic structures for treatment of pertrochanteric fractures of the femur is preferable in patients with poor control of load on the operated leg.

REFERENCES

1. Casati A., Aldegheri G., Vinciguerra E., Marsan A., Fraschini G., Torri G. Randomized comparison between sevoflurane anaesthesia and unilateral spinal anaesthesia in elderly patients undergoing orthopaedic surgery. *Eur. J. Anaesthesiol*., 2003, vol. 20, no. 8, pp. 640-646. DOI: 10.1017/s0265021503001030.
2. Chechik O., Amar E., Khashan M., Kadar A., Rosenblatt Y., Maman E. In support of early surgery for hip fractures sustained by elderly patients taking clopidogrel: a retrospective study. *Drugs Aging*, 2012, vol. 29, no. 1, pp. 63-68. DOI: 10.2165/11598490-000000000-00000.
3. Iwata T., Nozawa S., Dohjima T., Yamamoto T., Ishimaru D., Tsugita M., Maeda M., Shimizu K. The value of T1-weighted coronal MRI scans in diagnosing occult fracture of the hip. *J. Bone Joint Surg. Br*., 2012, vol. 94, no. 7, pp. 969-973. DOI: 10.1302/0301-620X.94B7.28693.
4. Knobe M., Drescher W., Heussen N., Sellei R.M., Pape H.C. Is helical blade nailing superior to locked minimally invasive plating in unstable pertrochanteric fractures? *Clin. Orthop. Relat. Res*., 2012, vol. 470, no. 8, pp. 2302-2312. DOI: 10.1007/s11999-012-2268-9.
5. Radcliff T.A., Henderson W.G., Stoner T.J., Khuri S.F., Dohm M., Hutt E. Patient risk factors, operative care, and outcomes among older community-dwelling male veterans with hip fracture. *J. Bone Joint Surg. Am*., 2008, vol. 90, no. 1, pp. 34-42. DOI: 10.2106/JBJS.G.00065.
6. Saygi B., Ozkan K., Eceviz E., Tetik C., Sen C. Skin traction and placebo effect in the preoperative pain control of patients with collum and intertrochanteric femur fractures. *Bull. NYU Hosp. Jt. Dis*., 2010, vol. 68, no. 1, pp. 15-17.
7. Varela-Egocheaga J.R., Iglesias-Colao R., Suárez-Suárez M.A., Fernández-Villán M., González-Sastre V., Murcia-Mazón A. Minimally invasive osteosynthesis in stable trochanteric fractures: a comparative study between Gotfried percutaneous compression plate and Gamma 3 intramedullary nail. *Arch. Orthop. Trauma Surg*., 2009, vol. 129, no. 10, pp. 1401-1407. DOI: 10.1007/s00402-009-0955-0.
8. Sylliaas H., Brovold T., Wyller T.B., Bergland A. Progressive strength training in older patients after hip fracture: a randomised controlled trial. *Age Ageing*, 2011, vol. 40, no. 2, pp. 221-227. DOI: 10.1093/ageing/afq167.
9. Zhang S., Zhang K., Jia Y., Yu B., Feng W. InterTan nail versus Proximal Femoral Nail Antirotation-Asia in the treatment of unstable trochanteric fractures. *Orthopedics*, 2013, vol. 36, no. 3, pp. e288-e294. DOI: 10.3928/01477447-20130222-16.
10. Malko A.V., Savintsev A.M. «Cutout» effekt kak prichina oslozhnenii maloinvazivnogo osteosinteza perelomov proksimalnogo otdela bedrennoi kosti konstruktsiei PFN-A ["Cut-out" effect as a cause of complications of little-invasive osteosynthesis for fractures of proximal femur with PFN-A design]. *Vestnik SPbGU*, Ser. 2, 2014, no. 1, pp. 214-220. (in Russian)
11. Dubrov V.E., Kuzkin I.A., Shcherbakov I.M., Matveev A.L., Iudin A.V. Virtualno-eksperimentalnoe obosnovanie dinamicheskogo osteosinteza pri lechenii perelomov proksimalnogo otdela bedrennoi kosti [Virtual-experimental substantiation of dynamic osteosynthesis in the treatment of fractures of the proximal femur]. *Biulleten Eksperimentalnoi Biologii i Meditsiny*, 2017, vol. 163, no. 2, pp. 261-267. (in Russian)

12. *AO/OTA Fracture and Dislocation Classification Compendium* – 2018. Available at: https://classification.aoeducation.org/
13. Baumgaertner M.R., Curtin S.L., Lindskog D.M., Keggi J.M. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. *J. Bone Joint Surg. Am*., 1995, vol. 77, no. 7, pp. 1058-1064. DOI: 10.2106/00004623-199507000-00012.
14. Murena L., Moretti A., Meo F., Saggioro E., Barbati G., Ratti C., Canton G. Predictors of cut-out after cephalomedullary nail fixation of pertrochanteric fractures: a retrospective study of 813 patients. *Arch. Orthop. Trauma Surg*., 2018, vol. 138, no. 3, pp. 351-359. DOI: 10.1007/s00402-017-2863-z.
15. Glants S. *Mediko-biologicheskaia Statistika* [Medical and Biological Statistics]. Transl. from Engl. M., Praktika, 1999, 459 p. (in Russian)
16. Knobe M., Münker R., Sellei R.M., Schmidt-Rohlfing B., Erli H.J., Strobl C.S., Niethard F.U. Die instabile pertrochantäre Femurfraktur. Komplikationen, Fraktursinterung und Funktion nach extra- und intramedullärer Versorgung (PCCP™, DHS und PFN) [Unstable pertrochanteric femur fractures. Failure rate, lag screw sliding and outcome with extra- and intramedullary devices (PCCP, DHS and PFN)]. *Z. Orthop. Unfall*., 2009, Vol. 147, no. 3, pp. 306-313. (in German) DOI: 10.1055/s-0029-1185349.
17. Lenich A., Vester H., Nerlich M., Mayr E., Stöckle U., Füchtmeier B. Clinical comparison of the second and third generation of intramedullary devices for trochanteric fractures of the hip – Blade vs screw. *Injury*. 2010. vol. 41, no. 12, pp. 1292-1296. DOI: 10.1016/j.injury.2010.07.499.
18. Lang N.W., Breuer R., Beiglboeck H., Munteanu A., Hajdu S., Windhager R., Widhalm H.K. Migration of the Lag Screw after Intramedullary Treatment of AO/OTA 31.A2.1-3 Pertrochanteric Fractures does not result in higher incidence of cut-outs, regardless of which implant was used: A comparison of Gamma Nail with and without U-Blade (RC) Lag Screw and Proximal Femur Nail Antirotation (PFNA). *J. Clin. Med*., 2019, vol. 8, no. 5, pp. 615. DOI: 10.3390/jcm8050615.
19. Kawatani Y., Nishida K., Anraku Y., Kunitake K., Tsutsumi Y. Clinical results of trochanteric fractures treated with the TARGON® proximal femur intramedullary nailing fixation system. *Injury*, 2011, vol. 42, no. Suppl. 4, pp. S22-S27. DOI: 10.1016/S0020-1383(11)70008-0.
20. Takigawa N., Moriuchi H., Abe M., Yasui K., Eshiro H., Kinoshita M. Complications and fixation techniques of trochanteric fractures with the TARGON(®) PF. *Injury*, 2014, vol. 45, no. Suppl. 1, pp. S44-S48. DOI: 10.1016/j.injury.2013.10.036.
21. Kim K.H., Han K.Y., Kim K.W., Lee J.H., Chung M.K. Local Postoperative Complications after Surgery for Intertrochanteric Fractures using Cephalomedullary Nails. *Hip Pelvis*, 2018, vol. 30, no. 3, pp. 168-174. DOI: 10.5371/hp.2018.30.3.168.

The article was submitted 26.10.2019; approved after reviewing 25.09.2020; accepted for publication 23.08.2021.

Information about the authors:

1. Ivan M. Shcherbakov – M.D., imscherbackov@yandex.ru;
2. Vadim E. Dubrov – Doctor of Science (Medical), Professor, vduort@gmail.com;
3. Andrey S. Shkoda – Doctor of Science (Medical), Professor;
4. Alexey A. Shelupaev;
5. Yuliya S. Zlobina;
6. Dmitrii A. Zyuzin – M.D., zuz-pas59@yandex.ru;
7. Kseniya A. Saprykina – M.D.

Conflict of interests *The authors declare no conflicts of interest.*

The authors declare no financial support from third parties.