



Original Article

<https://doi.org/10.21823/2311-2905-1653>

Mid-Term Results of Total Hip Arthroplasty for Femoral Neck Nonunions in Long-Term Hemodialysis Patients

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Background: Performing primary arthroplasty in patient with renal osteodystrophy is associated with a number of difficulties due to low bone mineral density, which complicates the fixation of the endoprosthesis components, the presence of bone defects, and functional insufficiency of the gluteal muscles. **The aim of the study** — evaluation of the mid-term results of primary total hip arthroplasty using cemented femoral and acetabular implants in hemodialysis patients with nonunions of the femoral neck.

Methods: The authors conducted a study of 26 hemodialysis patients with pseudarthrosis of the femoral neck. The patients were divided into 3 groups: group I (12 patients) — classification type A of the femoral neck nonunion, group II (10 patients) — classification type B, group III (4 patients) — of type C who underwent total hip arthroplasty.

Results: The longest surgery duration was observed in patients of the III study group — 121.25±19.26 minutes. There were no statistically significant differences between the patients of the II and III study groups. The smallest rate of intraoperative blood loss was noted among patients of the 1st study group — 440.83±133.65 ml, the statistical significance of the differences was obtained both between the 1st and II, and between the I and III study groups, respectively. The smallest total number of complications after surgery was obtained in the 1st group — 4 (8.33%). Revisions were performed in 8 (30.7%) patients among all three groups. There was a significant improvement on the Oxford hip score after 12 months (mean 29.8) and 24 months (mean 33.1) in all groups compared with preoperative results (mean 12.5). Twelve months after surgery, the average value of the pain severity was reduced by 72.6% and amounted to 2.01. The risk of getting any orthopedic complication in cemented total hip arthroplasty of the classification type A of the pseudarthrosis is 2.5, with type B — 3.4, with type C — 5.7.

Conclusions: The classification of femoral neck nonunions in hemodialysis patients allows to determine the tactics of surgical treatment. Cemented dual mobility cups are effective in patients with any type of femoral neck nonunions.

Keywords: femoral neck nonunions, cemented total hip arthroplasty, chronic hemodialysis, renal osteodystrophy.

Funding: state budgetary funding.

Competing interests: the authors declare that there are no competing interests.

Cite as: Tsed A.N., Mushtin N.E., Dulaev A.K., Schmeljew A.V. [Mid-Term Results of Total Hip Arthroplasty for Femoral Neck Nonunions in Long-Term Hemodialysis Patients]. *Travmatologiya i ortopediya Rossii* [Traumatology and Orthopedics of Russia]. 2021;27(4):21-30. (In Russian). <https://doi.org/10.21823/2311-2905-1653>.

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Submitted: 16.07.2021. Accepted: 25.10.2021. Published Online: 12.11.2021.



Среднесрочные результаты тотального эндопротезирования у пациентов с псевдоартрозом шейки бедренной кости, находящихся на хроническом гемодиализе

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Реферат

Актуальность. Выполнение первичной артропластики на фоне ренальной остеодистрофии сопряжено с рядом трудностей, обусловленных низкой минеральной плотностью костной ткани, что усложняет фиксацию компонентов эндопротеза, наличием костных дефектов, а также функциональной недостаточностью ягодичных мышц. **Цель исследования** — оценка среднесрочных результатов первичного эндопротезирования тазобедренного сустава с применением цементных бедренных и ацетабулярных компонентов у пациентов с ложными суставами шейки бедренной кости (ШБК), находящихся на гемодиализе. **Материал и методы.** Проведено исследование 26 пациентов гемодиализного профиля с ложными суставами ШБК. Пациенты были распределены на 3 группы: группа I (12 человек) — тип А псевдоартроза ШБК по классификации авторов, группа II (10 человек) — тип В, группа III (4 больных) — тип С, которым было выполнено тотальное эндопротезирование тазобедренного сустава. **Результаты.** Наибольшая длительность операции отмечена у больных III группы исследования — $121,25 \pm 19,26$ мин. Между пациентами II и III групп статистически значимых отличий не обнаружено. Наименьший показатель интраоперационной кровопотери отмечен среди больных I группы исследования — $440,83 \pm 133,65$ мл, статистическая значимость отличий получена как между I и II, так и между I и III группами исследования. Наименьшее общее число осложнений после операции получено в I группе — 4 (8,33%). Ревизионные вмешательства были выполнены у 8 (30,7%) пациентов всех трех групп. Отмечено значимое улучшение функциональных показателей по шкале Oxford Hip Score через 12 мес. (среднее значение 29,8) и 24 мес. (среднее значение 33,1) во всех группах в сравнении с предоперационными результатами (среднее значение 12,5). Через 12 мес. после операции среднее значение выраженности боли было снижено на 72,6% и составляло 2,01. Риск развития любого ортопедического осложнения при тотальном цементном эндопротезировании у пациентов с ложным суставом ШБК типа А составляет 2,5; при типе В — 3,4; при типе С — 5,7. **Заключение.** Предложенная рабочая классификация псевдоартрозов ШБК у пациентов, находящихся на хроническом гемодиализе, позволяет определять тактику хирургического лечения. Цементные ацетабулярные компоненты двойной мобильности эффективны при первичном эндопротезировании тазобедренного сустава при всех типах псевдоартроза ШБК.

Ключевые слова: ложный сустав шейки бедренной кости, тотальное цементное эндопротезирование тазобедренного сустава, хронический гемодиализ, ренальная остеодистрофия.

Источник финансирования: государственное бюджетное финансирование.

Цед А.Н., Муштин Н.Е., Дулаев А.К., Шмелев А.В. Среднесрочные результаты тотального эндопротезирования у пациентов с псевдоартрозом шейки бедренной кости, находящихся на хроническом гемодиализе. *Травматология и ортопедия России*. 2021;27(4):21-30. <https://doi.org/10.21823/2311-2905-1653>.

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Рукопись получена: 16.07.2021. Рукопись одобрена: 25.10.2021. Статья опубликована онлайн: 12.11.2021.

Background

The annual increase in the frequency of intra-articular fractures of the proximal femur is a global problem of modern traumatology. The issues of high mortality remain relevant (14-40%) [1, 2, 3, 4], general somatic complications (bedsores, pneumonia, thrombosis, cardiovascular, etc.) (9-25%) [5, 6, 7] and orthopedic complications, among which the most common are non-unions of the femoral neck [8, 9]. In general population, the risks of various complications and an unsatisfactory outcome of treatment proximal femur fractures have a direct correlation with age. In the population of patients with end-stage chronic kidney disease (CKD) and in need of renal replacement therapy (RRT), the frequency of both general somatic and orthopedic complications is significantly higher and has no relation to age and gender [10, 11].

Against the background of violations of calcium-phosphorus metabolism and the processes of remodeling of bone tissue and its mineralization, the problem arises not only of restoring the integrity of the bone, but also the strength of fixation of various metal implants. In addition, when performing various types of osteosynthesis for a pathological fracture of the femoral neck in young patients undergoing chronic hemodialysis develop infectious complications, which significantly complicates further treatment [12]. The most common pathogens of infectious complications of surgical intervention site in patients receiving chronic hemodialysis are *Staphylococcus aureus* and *Streptococcus epidermidis*, spreading hematogenously through the arteriovenous fistula [13]. In case of detection of a deep infection of the area of the hip joint after surgical treatment, hip arthroplasty is performed in two stages [14].

Total hip replacement is the method of choice for patients with terminal CKD, not only in cases of the development of femur neck non-union, but also with fresh intracapsular fractures of the proximal femur, regardless of age. However, performing primary arthroplasty against the background of renal osteodystrophy is associated with a number of difficulties due to low bone mineral density, which complicates the fixation of the endoprosthesis components, the presence of bone defects of both the acetabulum and the femur [15], as well as functional insufficiency of the gluteal muscles, which is reflected in the high frequency of the endoprosthesis dislocations [16].

The aim of the study was to evaluate the medium-term results of primary hip replacement with the use of cement femoral and acetabular components in patients with femoral neck non-union undergoing hemodialysis.

Methods

Design

A retrospective single-center randomized study of 26 patients with hemodialysis profile with femoral neck non-union treated at the Clinic of Traumatology and Orthopedics of the First St. Petersburg State Medical University named after Academician I.P. Pavlov" from 2017 to 2020

Criteria for inclusion in the study:

- femoral neck non-union (fracture at least 12 months);
- presence of stage 5 CKD (chronic hemodialysis for at least 3 years);
- cement acetabular and femoral components of hip endoprosthesis intended for primary arthroplasty;
- the presence of bone defects of the acetabulum and proximal femur, including those requiring bone grafting.

Exclusion criteria:

- follow-up period less than 12 months after surgery;
- absence of laboratory indicators of any degree of renal osteodystrophy (an increase in parathyroid hormone more than 300 pg/mg, a decrease in serum level of 1.25 OH-D₃ less than 40 ng/ml, an increase in the bone fraction of alkaline phosphatase more than 100 IU/l);
- absence of histological confirmation of renal osteodystrophy (from a biopsy of the femoral head).

The study involved 15 (57.7%) women and 11 (42.3%) men, their average age was 59.2 years (min – 36, max – 80). The average follow-up period for patients was 27.3 months (95% CI: 23-31 months). The main characteristics of the clinical material are presented in Table 1.

Classification

To date, there is no generally accepted classification of femoral neck non-union, which would allow predicting the outcome of hip replacement depending on the radiological and functional changes of the hip joint. In this regard, we have proposed 3 classification types of femoral neck non-union for an objective assessment of the results of the performed operations (Fig. 1):

Type A – shortening of the lower limb (no more than 2 cm); absence of additional local signs of osteoporosis (the value of the Barnet – Nordin morphocortical index is more than 0.4 units); absence of functional insufficiency of the gluteal muscles (the patient's ability to perform active movements in the hip joint); absence of osteolysis of the femoral head.

Type B – shortening of the lower limb more than 2 cm; signs of local osteoporosis (Barnet-Nordin in-

dex < 0.4 units); functional insufficiency of the gluteal muscles (lack of active movements in the hip joint); osteolysis of the femoral head.

Type C is femoral neck non-union, complicated by the presence of a previously implanted hardware, which led to infection of the hip joint and/or the development of a defect of the acetabulum or proximal femur as a result of its migration.

To diagnose hip infection in a patient with previously implanted hardware, we recommend following the algorithm accepted at the Second Second International Consensus Meeting on Periprosthetic infection in 2018 [17]. In addition to laboratory parameters, it is necessary to perform a puncture of the replaced joint with a cytological examination of the fluid and seeding to determine the sensitivity spectrum of antibiotics. Surgical tactics in the diagnosis of deep PJI against the background of femoral neck non-

union in patients undergoing chronic hemodialysis involves two-stage treatment.

In accordance with our proposed classification of femoral neck non-union, patients were divided into 3 groups: group I – 12 (46.1%) patients – classification type A of femoral neck non-union, group II – 10 (38.4%) patients – type B, group III – 4 (15.5%) patients – type C. Hip replacement in all cases, it was performed by one surgical team using Harding's approach under spinal-epidural anesthesia.

Figure 2 shows the distribution of cement components of hip endoprosthesis in the studied groups of patients. Among the patients of groups I and III, the implanted components were distributed approximately equally. Group II patients were significantly more likely to have low-profile cement acetabular components and femoral components of the Müller type.

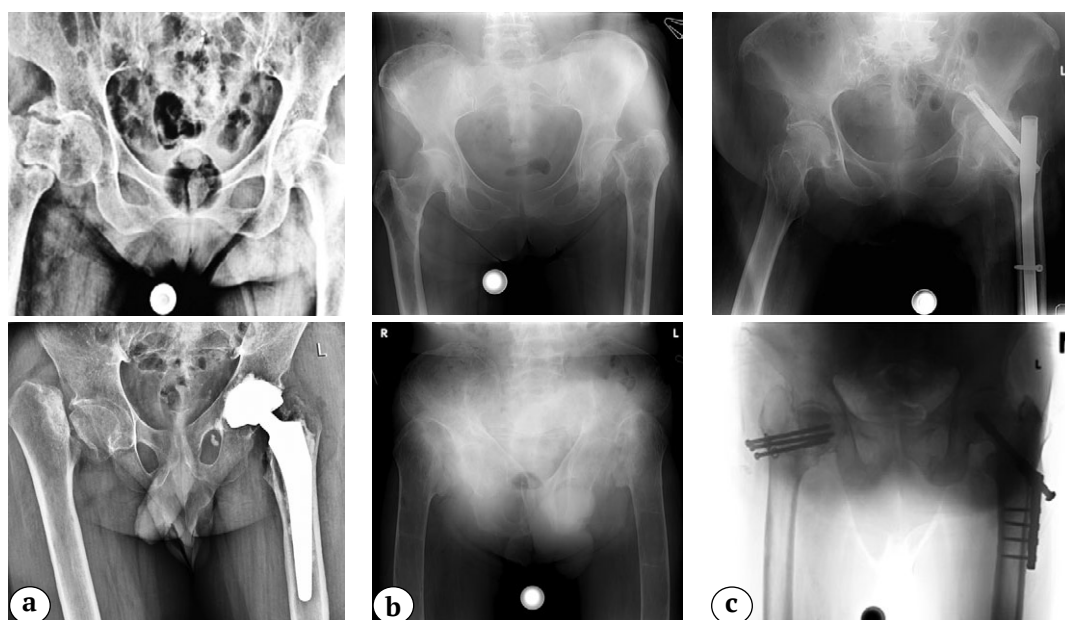


Fig. 1. Types of the femoral neck false joints according to the authors' classification: a – type A; b – type B; c – type C (explanation in the text)

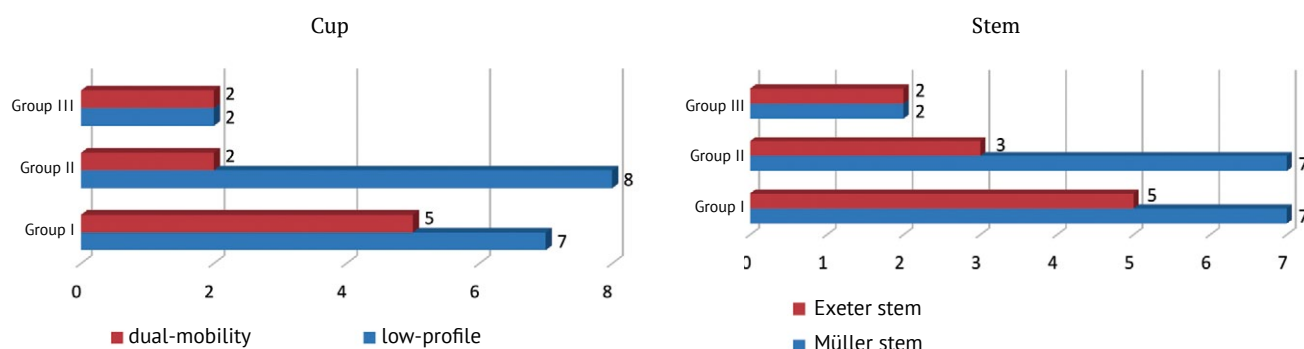


Fig. 2. Distribution of cemented components by groups

Outcome assessment

Functional results were evaluated on the 48-point Oxford Hip Score (OHS) scale 12 and 24 months after total cemented hip arthroplasty and compared with preoperative baseline data. The severity of pain was assessed on a 10-point visual analog scale (VAS) after 12 months.

Statistical analysis

The normality of the quantitative indicators distribution was carried out on the basis of the Shapiro-Wilk criterion. With an abnormal distribution, logarithm was performed. The significance of the differences in the quantitative indicators of the duration of surgery and the amount of blood loss was assessed using a single-factor analysis of variance using the ANOVA module. In identifying the statistical difference, an additional analysis was carried out by pairwise comparison of aggregates using the a posteriori Tukey criterion. During the statistical analysis of qualitative parameters in the structure of complications and the frequency of revision interventions, the exact Fisher criterion for small samples was used. Statistical processing of the obtained data was performed using the IBM SPSS v.20 program.

Results

The average age of the primary fracture was 13.5 (SD = 2.02) months. This value is identical to the timing of the primary complex hip replacement in these patients. The average follow-up period for patients of all study groups was 27.3 (SD = 3.64) months.

Table 2 shows the results of perioperative indicators and the overall frequency of complications and revision interventions in the study groups. The longest duration of total cemented arthroplasty was observed in group III patients (type C of femoral neck non-union) — 121.25 ± 19.26 min. Such results are associated with the need for one-stage removal of metal structures previously implanted due to the femoral neck fracture. However, when comparing the duration of surgery between patients of groups II and III, no statistically significant differences were found. When assessing intraoperative blood loss, the lowest indicator was found in patients of group I of the study — 440.83 ± 133.65 ml, and the statistical significance of the differences was obtained both between groups I and II, and between groups I and III of the study. The lowest total number of complications after total cemented arthroplasty was obtained in group I (type A non-union) — 4 (8.33%).

In the structure of orthopedic complications, postoperative hematomas were most common (30.7% in all study groups), which, on the one hand, is associated with a violation of the hemostasis system in hemodialysis patients, and on the other hand, explains the high frequency of infectious complications (23.07% among all patients). Statistically, deep PJI was significantly more common among patients after hip arthroplasty for femoral neck non-union classification types B and C (Table 3). The same results were obtained for other orthopedic complications, such as periprosthetic fractures, dislocations, osteolysis around the cement mantle of the implants. The frequency of intraoperative bleeding in patients of all groups did

Table 1

Main characteristics of the clinical material

Parameter	Quantity	
	total	%
Gender:		
male	11	42,3
female.	15	57,7
Affected side:		
right lower extremity	12	46,1
left lower extremity	14	53,9
Acetabular component:		
cement standard (low profile)	17	65,4
cement double mobility	9	34,6
Femoral component:		
cement standard (Müller type)	16	61,5
cement standard (Exeter type)	10	38,5

Table 2

The main perioperative indicators and the overall frequency of complications

Parameter	Type A (n = 12)	Type B (n = 10)	Type C (n = 4)	p
Surgery duration, min.	99,58±14,11	109,5±13,56	121,25±19,26	pI-II = 0,15085 pI-III = 0,02394* pII-III = 0,64492
Intraoperative blood loss, ml	440,83±133,65	654,03±141,59	750±158,11	pI-II = 0,01400* pI-III = 0,00038* pII-III = 0,32305
Number of revisions, n	1 (8,33%)	5 (50,00%)	2 (50,00%)	
Complications, n	4 (33,32%)	8 (80,00%)	3 (75,00%)	pI-II = 0,043* pI-III = 0,26 pII-III = 1,01

* The value is statically significant.

Table 3

The structure of orthopedic complications in the groups

Complication type	Type A n (%)	Type B n (%)	Type C n (%)	Total n (%)
Bleeding	0 (0)	2 (20)	0 (0)	2 (7,69)
Periprosthetic fracture	0 (0)	3 (30)	2 (50)	5 (19,2)
Endoprosthesis dislocation	0 (0)	4 (40)	0 (0)	4 (15,3)
Osteolysis	1 (8,3)	3 (30)	0 (0)	4 (15,3)
Stress-shielding syndrome	1 (8,3)	3 (30)	1 (25)	5 (19,2)
Postoperative hematoma	1 (8,3)	6 (60)	1 (25)	8 (30,7)
Deep PJI	1 (8,3)	3 (30)	2 (50)	6 (23,07)

not exceed 10%, which is due to the use of an original blood-saving algorithm for patients on chronic hemodialysis, involving the sequential administration of erythropoietin, conjugated estrogens and desmopressin, as well as mandatory transfusion of two doses of erythrocyte mass to increase the hematocrit above 30 mmol/l [18].

In a detailed analysis of orthopedic complications in the study groups, we established the relative risk of complications with a ratio of chances (RC) depending on the type of femoral neck non-union. The risk of developing any orthopedic complication with total cement hip replacement of the classification type A of the non-union is 2.5 (CI 95%: 0.6797-9.6078; p = 0.1649), OR – 3.33 (CI 95%: 0.605-18.371; p = 0.1232); with type B – 3.4 (CI 95%: 1.0524-11.0321; p = 0.0408), OR – 5.33 (95% CI: 1.156-24.559; p = 0.0125); with type C – 5.7 (95% CI: 1.7365-19.0401; p = 0.0042), OR – 6.6 (95% CI: 0.895-49.676; p = 0.0118).

During the study period, revision interventions were performed in 8 (30.7%) patients of all three groups. At the same time, in group I, i.e. among patients with the most favorable clinical picture of femoral neck non-union, revision arthroplasty was performed only in one patient, and the largest number of revisions were performed in patients of group II.

Single-stage revision hip replacement was performed in only two patients (7.69%) (osteolysis of the femoral component of the endoprosthesis), and both had classification type B of femoral neck non-union. In 8 (30.7%) patients, revisions were performed in 2 stages due to the development of infection in the surgical intervention site. Moreover, these patients had intraoperative periprosthetic fractures (3 patients – 11.5%), as well as one recurrent dislocation of the endoprosthesis head (3.8%). Of the 8 patients, three (11.5%) had the classification type B of femoral neck non-union, 2 (7.6%) – type C, and only one (3.8%) patient who un-

derwent revision hip arthroplasty had the classification type A of femoral neck non-union. Thus, our assumption about an increase in the risks of complications during primary hip arthroplasty due to femoral neck non-union associated with the classification type of non-union is justified.

Functional results were evaluated on a 48-point OHS scale 12 and 24 months after total cemented arthroplasty and compared with preoperative baseline data. Patients showed statistically significant improvement in

functional parameters after 12 months (mean value of 29.8 SD = 3.3 points) and 24 months (mean value of 33.1 SD = 2.5 points) in all groups compared with preoperative results (mean value of 12.5 SD = 0.6 points) (Fig. 3).

Along with functional indicators, the results of assessing the severity of pain on a 10-point VAS scale were analyzed. The average score before surgery was 7.35 (SD = 0.1). 12 months after total cemented arthroplasty, the average pain score decreased by 72.6% and was 2.01 (SD = 0.74) points.

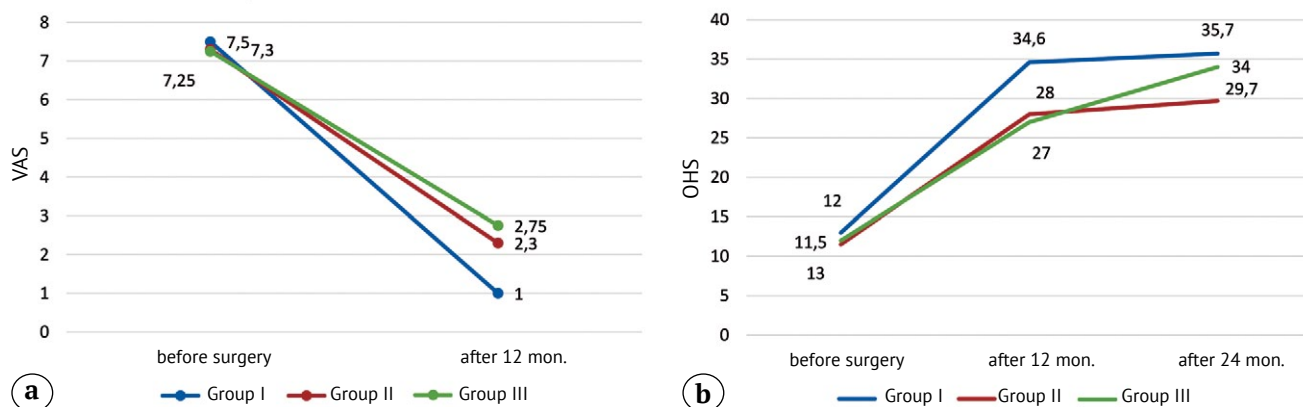


Fig. 3. Preoperative and postoperative results assessment in the study groups: a — pain severity according to VAS; b — functional results according to OHS

Discussion

The results obtained by us are quite difficult to interpret due to the small number of domestic and foreign publications on this narrowly focused topic. Nevertheless, if we talk about the occurrence of femoral neck non-union, then, according to G.P. Slobogean et al, this indicator is only 9.3% among young and middle-aged patients (up to 60 years old) [19], while among elderly and senile people (over 60 years old) this indicator increases 10 times and amounts to 92.6% [20]. In the presence of a patient with severe concomitant pathology, such as rheumatoid arthritis or end-stage CKD, which decreases the quality of bone tissue, the incidence of non-union is 28%, regardless of age [21].

The number of unsatisfactory outcomes after various variants of osteosynthesis of intraarticular fractures in patients undergoing chronic hemodialysis is 66.7%, which is significantly more than in patients with the usual population [22]. However, the main cause of the development of femoral neck non-union in patients with end-stage CKD is conservative treatment of intracapsular fractures of femoral neck [23].

In this regard, further treatment of the consequences of these fractures is a difficult task for orthopedic surgeons and requires not only expensive implants, including for the replacement of bone defects, but also special tools, equipment and the presence of bone bank.

It should be noted that the development of femoral neck non-union aggravates the manifestation of local osteoporosis as a result of a prolonged lack of weight-bearing of the lower limb according to Wolf's law. In the study of A.N. Reshetnikov et al, data of densitometry of 34 patients with a diagnosis of "femoral neck non-union" in the preoperative period are presented [24]. In 100% of patients, a decrease in bone mineral density was diagnosed. The authors also point to an increase in bone mineral density a year after total hip replacement, without specifying at the same time what type of implant was applied. In our study, the number of satisfactory outcomes after total hip cemented arthroplasty with non-union in patients with hemodialysis profile was 69.3% in all study groups, which is an acceptable result for this category of patients.

Double mobility cement cups have significant advantages over standard acetabular components in patients with the consequences of fractures. H. Favreau et al, published the results of the use of double mobility cement cups in arthroplasty in 40 patients with the consequences of fractures of the trochanter region with an average follow-up period of 54 months. The authors note the absence of dislocations of the endoprosthesis for the specified period of time [25]. In our study, the use of acetabular components of double mobility also did not lead to postoperative dislocations of the endoprosthesis, regardless of the classification type of femoral neck non-union, while the use of standard cement cups led to 15.3% of dislocations.

The frequency of revision interventions after total hip arthroplasty in patients undergoing renal replacement therapy varies from 5% to 40%, but these indicators are significantly higher compared to patients in the general population [26]. In our study, the total revision rate was 30.7%, while in 26.9% of cases revision arthroplasty was performed after obviously complex cases of primary arthroplasty (types B and C of non-union, implying pronounced retraction of the femur, osteolysis of the femoral head, low indicators of the morphocortical Barnett index – Nordina or the presence of metal implants that led to the formation of a bone defect). The main reason for revision hip replacement in the study was deep PJI (6 cases – 23.07%), which fully corresponds to the global data on infectious complications after total arthroplasty in patients with end-stage CKD [12].

Conclusions

The proposed working classification of femoral neck non-union in patients undergoing chronic hemodialysis allows determining the tactics of surgical treatment. Cement acetabular components of double mobility are effective in primary hip replacement in all types of femoral neck non-union.

Informed consent

The patients gave their voluntary written informed consent to participate in the study and publish its results.

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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 work to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

Conflict of interest

The authors declare that there is no conflict of interest.