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Results of arthroplasty in oncological patients with primary and metastatic bone tumours around the knee

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Relevance Knee joint replacement is the main method of surgical treatment in patients with oncological lesions of the distal femur and proximal tibia. The article presents the results of the use of this technique in Herzen Moscow Research Institute for Oncology. **Purpose** To evaluate the results of arthroplasty in patients with tumour lesions of the distal femur and proximal tibia. **Materials and methods** Between 2011 and 2019, primary knee replacement due to oncology was performed in 106 patients. Distal femoral resection was performed in 70 (66 %), proximal tibia resection in 36 (34 %) patients. Primary bone tumors were detected in 70 (66 %) patients. Metastases of various solid tumors were observed in 36 (34 %) patients. **Results** In the group of patients with primary malignant bone tumours (49 patients), 36 (73.5 %) patients survived without signs of tumour progression, 3 (6 %) were alive with disease manifestations, 10 (20.5 %) patients died from progression. Relapse was diagnosed in 6 (12 %), metastatic lung damage in 13 (26%). All patients with a giant cell tumour survived without signs of disease progression. In the group of patients with metastatic lesions (36 patients), 25 patients (69 %) died from disease progression. The average value of the functional result on the MSTS scale was 78% for all endoprostheses. The incidence of postoperative complications was 30 %, among which the prevailing was infection (9.5 %). **Conclusion** The main adverse event in arthroplasty of large joints in oncologic patients remains the frequency of postoperative complications, which can develop in 20 to 30 % of the patients. Further research on the possibility of using various designs and types of implants is necessary in order to reduce the incidence of postoperative complications and improve long-term functional outcomes in such patients.

Keywords: bone tumors, surgical treatment, joint arthroplasty

INTRODUCTION

Oncological arthroplasty has become a worthy successor to amputation oncosurgery and today it is the standard of treating patients with long bone tumours [1]. This organ-saving surgical technique is technically convenient in performance, provides early activation of patients and allows achieving good functional and oncological results after treatment [2–6]. Also, if there are no complications, this type of reconstruction does not require long-term special rehabilitation. The patient may continue the necessary systemic medication treatment without significant prolongation of drug therapy [7].

The first oncological arthroplasty was performed in 1940 by American surgeons Austin Moore and Harold Bohlman in a patient with a giant cell tumor in the proximal femur [8]. In the USSR in 1967, similar operations were performed at the CITO by S.T. Zatsepin and at the Blokhin ORC by N.N. Trapeznikov [9, 10]. The first modular system for oncological replacement was used by Martin Salzer, who developed a ceramic modular shoulder joint endoprosthesis [11].

Today, thanks to modern methods of systemic pharmacological treatment, developed transfusion service, provision of adequate anesthesia and improvement of oncological arthroplasty techniques, limb salvage treatment with both curative and palliative purposes can be performed in 85–95 % of patients with bone tumours [12, 13]. The beginning of oncological arthroplasty was the introduction of a metal implant for the hip joint. The evolution of this organ-preserving surgical technique now enables to replace all types of large joints of the extremities, pelvic bones, shoulder girdle and foot [14, 15].

One of the most frequent locations of primary malignant bone tumours and bone metastases of other solid tumours are the distal femur and proximal tibia, which form the knee joint [16, 17]. Initially, oncological implants for the knee joint were made individually for each patient with specified parameters, which required significant time and financial costs, and also limited the surgeon in choosing the necessary amount of bone resection during the intervention [18].

Since the 80s of the last century, modular knee arthroplasty systems have been introduced into orthopaedic oncology. They are distinguished by easy installation and are able to simulate a metal implant intraoperatively, which undoubtedly improved the

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functional results of treatment [19, 20]. Today, the overall five-year survival rate of oncological knee endoprostheses reaches 80–90%, while at the beginning of their use it did not exceed 30–40 % [6, 21]. This study presents the experience of the Herzen Moscow Oncological Research Institute in oncological arthroplasty of the knee joint in patients with tumours located in the femur and tibia.

MATERIAL AND METHODS

The study included patients with primary malignant and metastatic tumours, as well as patients with a giant cell tumor localized in the distal femur and proximal tibia. They underwent oncological knee arthroplasty with a modular endoprosthesis on a rotary platform.

In the Herzen Moscow Research Institute for Oncology which is a branch of the Federal State Budgetary Institution of the National Medical Research Centre for Radiology of the Ministry of Health of Russia, primary oncological knee joint arthroplasty due to tumours of the femur and tibia was performed in 106 patients in the period from 2011 to 2019. Mean follow-up was 53 months (range, 6-96 months). There were 46 men (43 %) and 60 women (57 %). The average age was 38 years (range, 18-72 years). Distal femur resection was performed in 70 (66 %) patients, proximal tibial resection in 36 (34 %) patients (Fig. 1 and Fig. 2).

Primary bone tumours were detected in 70 (66 %) patients. Forty-nine (46 %) patients had primary malignant tumours of bone tissue: 24 osteosarcomas, 16 chondrosarcomas, 8 Ewing's sarcomas, adamantinomas in 1 patient, respectively. Twenty-one (20 %) patients had giant cell bone tumours. Metastases of various solid tumours were diagnosed in 36 (34 %) patients: metastases of kidney cancer in 17, breast cancer in 13 and lung cancer in six patients.

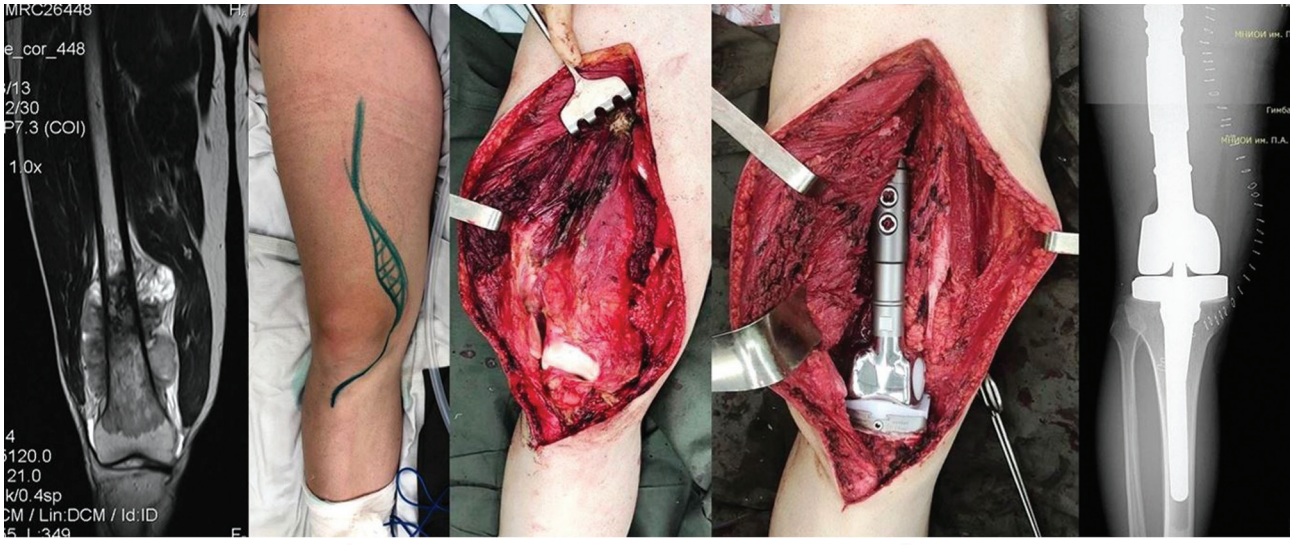

Fig. 1 MRI of osteosarcoma of the distal femur (a); surgical access (b); tumour mobilized from surrounding soft tissues (c); knee joint implant (d); radiograph after surgery (e)

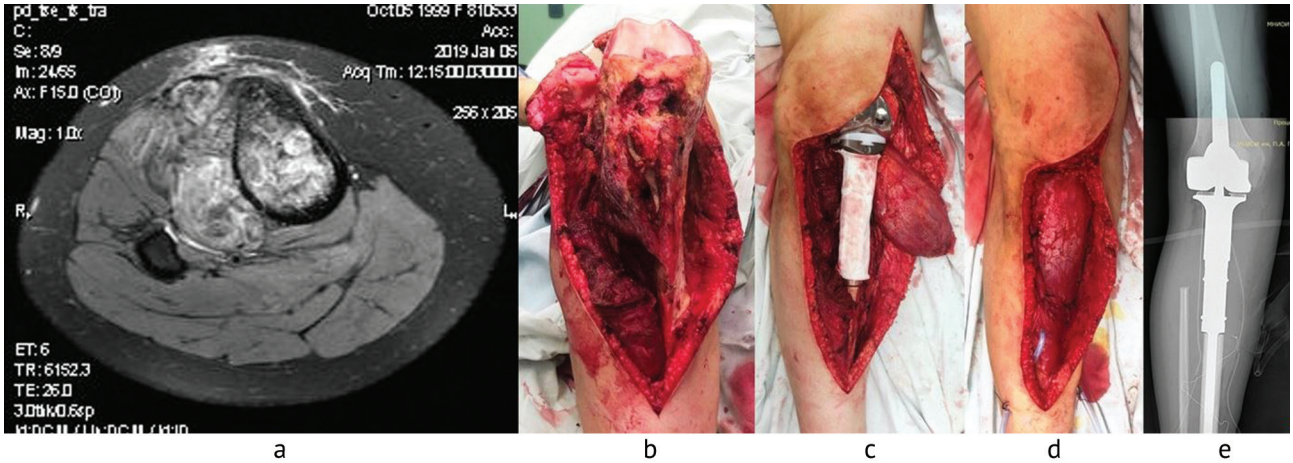

Fig. 2 MRI of chondrosarcoma in the proximal tibia (a) ; tumour mobilized from surrounding soft tissues (b); knee endoprosthesis with a mobilized portion of the calf muscle (c); bed for endoprosthesis (d); radiograph after surgery (e)

All patients with high-grade primary bone tumours received combined treatment with a special drug therapy. In patients with metastatic lesions, the surgical stage was included in the complex of recommended treatment, depending on the morphological structure of the primary tumour and the extent of the tumour process.

Assessment of the resection margin along the bone marrow canal after tumour removal was performed using an urgent cytological study of bone marrow from the bone sawdust after resection. All patients with lesions of the proximal tibia had plasty with a transferred flap of the gastrocnemius muscle in order to reduce the risk of developing infectious complications.

Depending on the type of metal stem implantation, cementless fixation was performed in 86 (81 %) patients and cemented fixation in 20 (19 %) patients. Installation of cemented implant stem was performed for metastatic bone lesions in adult patients. Cementless fixation was preferred in primary tumours.

All patients were encouraged to be active on days 2 or 3 after the operation wearing a fixing orthosis and supported with crutches.

RESULTS

Oncological results

Resection edges were estimated as R0 in all patients according to the results of a planned morphological study. At the time of evaluating the results of this study in the group with primary malignant bone tumors (49 patients), 36 (73.5 %) patients were alive without signs of tumour progression, 3 (6 %) were alive with manifestations of the disease, 10 (20.5 %) died from progression. Recurrence was diagnosed in 6 (12 %) patients, metastatic lung disease in 13 (26 %) patients, respectively, within 7 to 33 months. All patients with giant cell tumor are alive with no signs of disease progression. In the group of patients with metastatic lesions (36 patients), 25 (69 %) patients died from disease progression.

Functional results

The functional results were assessed using the MSTS scale 2–3 months after surgical treatment [22]. Excellent functional result (76-100 % on the MSTS scale) was in 74 (70 %), good (51-75 % on the MSTS scale) in 23 (22 %), satisfactory (26-50 % on the MSTS scale) in 9 (8 %) patients, respectively. The average value of the functional outcome was 78 % for all endoprostheses, 72 % in patients after resection of the proximal tibia and 80 % after distal resection of the femur, respectively.

Surgical results

The average duration of the operation was 165 minutes (range, 75–268 minutes). The average volume of intraoperative blood loss was 540 ml (range, 210–3100 ml). The duration of hospitalization was 10 days (5–18 days).

The overall five-year survival of endoprostheses was 77 % (Fig. 3), 80 % after distal resection of the femur and replacement and 76 % after proximal resection of the tibia.

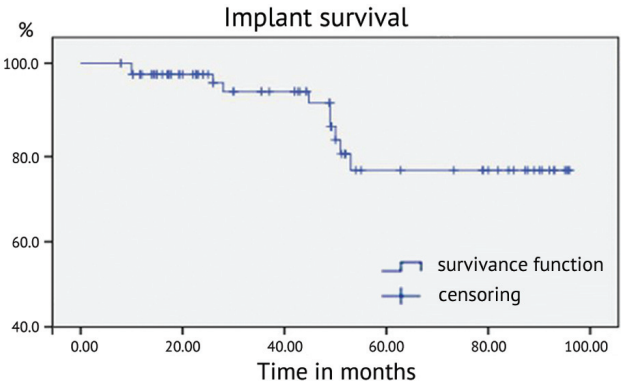

Fig. 3 Knee implant survival

Complications

Postoperative complications were assessed according to the classification proposed by Henderson E.R. et al. in 2014 [23]. The incidence and types of complications are presented in Table 1.

In the group of patients after proximal tibial resection andh knee arthroplasty, the total number of complications was 36 %. In the group of patients after distal femoral resection, it was 27 %. The most common complication in both groups was infection of the metal implant (Type IV): 8.5 % in the group of patients with femur involvement and 11 % in patients with tibial tumours. All patients had delayed infection, manifested from 6 to 38 months. Amputation was recommended for four patients. Five patients underwent two-stage revisions, one patient underwent one'stage replacement. Re-infection was detected in one out of five patients after two-stage revision, and therefore amputation was performed.

Table 1

Rates and types of complications according to Henderson E.R.

Arthroplasty type	Types of complications					Total
	Type I	Type II	Type III	Type IV	Type V	
Distal femur, 70 (66 %)	2 (3 %)	4 (5.7 %)	3 (4.2 %)	6 (8.5 %)	4 (5.7 %)	19 (27 %)
Proximal tibia, 36 (34 %)	2 (5.5 %)	3 (8 %)	2 (5.5 %)	4 (11 %)	2 (5.5 %)	13 (36 %)
Total 106	4 (3.7 %)	7 (6.6 %)	5 (4.7 %)	10 (9.5 %)	6 (5.6 %)	32 (30 %)

Such as complication as marginal necrosis of the postoperative wound (Type I) were least often diagnosed, in 3 % of patients with femoral lesions and 5.5 % of patients with tibia lesions. Instability of the metal implant stems (Type II) and mechanical complications due to implant (Type III) were more often diagnosed after resection of the tibia (8 % and 5.5 %, respectively) versus 5.7 % and 4.2 % after resection of the femur. Periprosthetic fracture was occurred in two patients (Fig. 4).

Three patients had instability of the hinge mechanism of the endoprosthesis. In all cases, these complications required revision operations. The number of recurrences (Type V) was comparable, 5.5 % and 5.7 % in both groups, respectively. They underwent amputation.

Revision operations were performed in 18 (17 %) patients, including stem instability in 7, infection in 6 and mechanical complications in 5 patients.

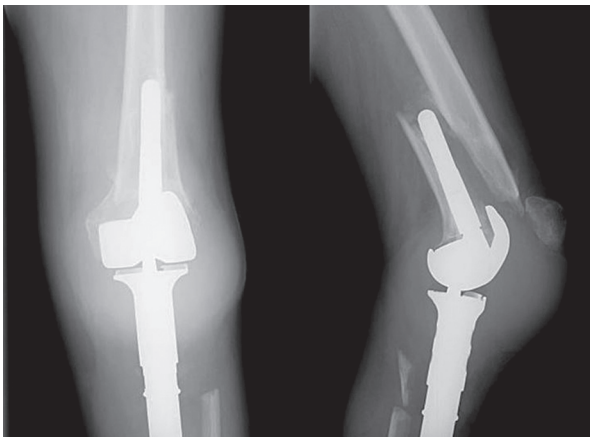

Fig. 4 Radiographs of the femur (periprosthetic fracture)

DISCUSSION

Oncological arthroplasty is the main method of surgical treatment in patients with primary malignant and metastatic tumours of long bones, which enables to achieve relapse-free and overall survival comparable to amputation surgery and significantly exceeds it in functional results [3, 24]. To date, oncological orthopaedics uses implants of various manufacturers, but complications such as infection, instability and mechanical failure of the implant are still encountered in clinical practice. Postoperative complications significantly affect the overall survival of metal implants and the functional outcome of treatment. Their total number, according to reports, may reach 40 % in the first five years after surgery and 70 % fifteen years after treatment [12, 25].

In our study, postoperative complications were detected in 30 % of patients, among which infection prevailed (9.5 %). Complications were more frequent in patients after resection of the proximal tibia (36 %) than after resection of the femur (27 %). According to some authors, this is due to less developed muscle envelope in this anatomical region compared to the femur [26, 27].

In order to reduce the risk of infectious complications after resection of the proximal tibia, we additionally covered the metal implant with the transferred head of the calf muscle and formed the bed for the implant with it. This technique may reduce the incidence of infectious complications in resection of the proximal tibia and then arthroplasty from 30 to 16 % [12]. The number of complications identified by us correlates with the results of other studies.

Pala E. et al. evaluated the results of knee replacement in 247 patients with malignant tumors of the distal femur and proximal tibia. Femoral resection with further implantation was performed in 187 (76 %), and of the tibia in 60 (24 %) patients. Over the analyzed time, complications were diagnosed in 29 % of the patients, and they were more common in patients after resection of the tibia (36.2 %) than in patients after resection of the femur (26.7 %). According to the classification of Henderson E.R. complications of type I amounted to 8.5 %, type II to 5.7 %, type IV to 9.3 % and type V to 5.7 %, respectively. Complications of type III like mechanical damage to the metal implant were not noted in the study. The overall four-year survival rate of endoprostheses was 70 %, and eight-year survival was 58 %. The statistical analysis did not reveal the effect of the type of operation performed on the incidence of complications and the overall survival of endoprostheses [28].

Nakamura T. et al present similar results on the incidence of postoperative complications. The authors analyzed the results of surgical treatment of 82 patients with sarcomas of the distal femur. Postoperative complications were noted in 34 % of patients, among which infection prevailed (8.5 %). The overall five-year survival rate of metal implants was 80 % [29].

Haijie L. et al. conducted a meta-analysis of the results of the works on oncological knee replacement and analyzed 40 publications on this topic, published between 1985 and 2015.

The total number of patients with distal femoral resection was 4748 patients. Henderson Type I complications happened in 8.5 % of cases, type II in 8.9 %, type III in 6.9 %, type IV in 8.5 % and type V in 5.6 %. The overall five-year survival rate for endoprostheses was 78 %, and the 20-year survival rate was 38 %.

The results of proximal tibial resection with knee replacement were evaluated in 1632 patients. Henderson type I complications were observed in 5.1 % of cases, type II in 7.3 %, type III in 5.0 %, type IV in 16.8 % and type V in 5.5 %. The overall five-year survival rate of endoprostheses was 75 %, and the 20-year survival rate was 25 % [30].

In general, from the beginning of the use of large joint arthroplasty due to tumours of long bones,

infection of the endoprosthesis bed remains the most common and significant type of complications, which in some cases can even lead to amputation of the limb. The factors predisposing to the development of this complication in oncology surgery in comparison with standard orthopedics are previous surgery, systemic pharmaceutical treatment, radiation therapy, soft tissue deficiency after tumour removal, long duration of surgery and blood loss [12, 26, 27].

Instability of the stem is also a common complication in large joints replacement in oncological patients and accounts for 3 to 15 % resulting in revision intervention mostly[6, 7, 12, 21]. In our study, instability was detected in 7 (6.6 %) patients. The main risks of instability are young age, a small diameter of the medullary canal and a large extension of bone resection [12, 23].

The total five-year survival rate of endoprostheses in our study was 77 %, 80 % after femoral resection of and after resection of the tibia 76 %. In general, the average five-year survival rate of oncological endoprostheses of the knee joint ranges from 53 to 94 % according to the results of various studies [7, 12, 25, 28].

CONCLUSION

The distal femur and proximal tibia, adjacent to the knee joint, are the most frequent locations of both primary bone tumors and metastases to long bones of various solid tumors. Today, the use of joint arthroplasty in bone oncology enables to carry out organ-preserving surgical treatment in 85–95 % of patients with tumor pathology of the bones that form the knee joint, and the overall five-year survival rate of metal implants has increased from 30 % in the 1980s to 80–85 % at present. Despite all the objective advantages and widespread use of this surgical technique in modern oncological orthopaedics, its main drawback is the frequency of postoperative complications that develop in 20-30 % of the patients treated. Despite the fact that the overall survival of endoprostheses exceeds that in patients with primary malignant bone tumors and, especially, in patients with bone metastases, which makes this technique optimal for use, further research is needed on the possibility of using different designs and types of implants with the aim to reduce the incidence of postoperative complications and improve long-term functional outcomes of treatment.

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