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Surgical procedure for pelvic periacetabular bone tumor defects

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Pelvic bone tumor and traumatic injuries are causes to a numeric of diagnostic, treatment and subsequent obtaining of positive functional results problems, which significantly affects the patient's quality of life. The most prognostically difficult are acetabulum areas defects. Its adequate restoration affects the further walking function. Goal. To develop a surgical reconstruction of the periacetabular tumor resection defects. Methods. A new surgical reconstruction procedure of the pelvic periacetabular defects were developed and submitted. It consists in using of artificial material polyethyleneterephthalate («Attachment tube») replacing, which is pre-filled with bone allograft and sutures transosseously fixed to the pubic bone or to the pubic/ischial bones. Another «Attachment tube» fragment is used to fix the femur head to the indicated allograft implant. The strength and bioactive characteristics of the «Attachment tube» in combination with bone allograft make it possible to obtain the equivalent of the acetabulum and restore the full weight bearing and walking function with a certain range of motion in the restored acetabulum area. Results. The proposed method was clinically tested on 9 patients with evaluated follow up. Satisfactory functional results were obtained: (52.6 ± 20.0) % on the MSTS scale. Complications were analyzed. Conclusions. The use of novel surgical procedure for pelvic periacetabular bone tumor defects has a number of advantages over the existing ones. The biological materials using, restoration of anatomical relations in the «hip joint» makes it possible to restore the lower limb function with a good range of motion. The obtained results prove author's method using can give acceptable results in the treatment of periacetabulum tumor leasions patients.

Ураження кісток таза в разі травм або пухлинних процесів призводить до великої кількості проблем у діагностиці, лікуванні та подальшому отриманні позитивних функціональних результатів, що значно впливає на якість життя пацієнтів. Найбільш прогностично складними є ушкодження ділянки кульшової западини. Адекватне її відновлення впливає на подальшу функцію опори та ходьби пацієнтів. Мета. Розробити метод реконструкції післярезекційного пухлинного дефекту періацетабулярної ділянки таза. Методи. Розроблено та подано нову методику реконструкції дефекту періацетабулярної ділянки таза. Вона полягає в його заміщенні штучним матеріалом у вигляді трубки з поліетилентерефталату («Attachment tube»), яку попередньо наповнюють кістковими алоімплантатами, та фіксують трансосально швами до зпилів здухвинної кістки та лобкової або сідничної кісток. Іншим фрагментом трубки фіксують головку стегнової кістки до зазначеного імплантата з алокісткою. Міцність і біоактивні характеристики «Attachment tube» у поєднанні з кістковими алоімплантатами дають змогу отримати еквівалент кульшової западини та відновити функцію опори та ходьби кінцівки з певним обсягом рухів у ділянці видаленої кульшової западини. Результати. Проведено клінічну апробацію запропонованої методики й оцінено результати хірургічного лікування 9 пацієнтів з її використанням. Отримано задовільні функціональні результати: (52,6 ± 20,0) % за шкалою MSTS. Проаналізовано ускладнення. Висновки. Використання розробленої методики заміщення дефектів періацетабулярної ділянки таза має низку переваг перед наявними, а саме: застосування біологічних матеріалів, відновлення анатомічних взаємовідношень у «кульшовому суглобі» дає змогу відновити функцію нижньої кінцівки. Отримані результати доводять, що застосування авторської методики може дати прийнятні результати лікування хворих на пухлини таза з ураженням кульшової западини. Ключові слова. Пухлини ацетабулярної западини, хірургічне лікування, реконструкція, кісткова алопластика, поліетилентерефталат.

Key words. Periacetabular bone tumors, surgical treatment, reconstruction, allograft, polyethyleneterephthalate

Introduction

The pelvis is a complex anatomical structure. Damage to the bones of the pelvis in the case of tumor processes significantly complicates treatment and obtaining positive functional results, which severely affects the quality of life of patients. This is due to the peculiarities of the anatomy of the bones of the pelvis (especially the acetabulum), as well as the adjacent organs of the pelvis and vascular and nervous stuctures.

One of the most complex abnormalities of the pelvic bones is malignant tumor processes. About 10 to 15 % of all primary malignant bone neoplasms are located there. The most common nosological forms of the disease are chondrosarcoma, osteosarcoma, and Ewing's sarcoma [1]. The ilium is affected in 65 % of cases, the pubic bone in 20 %, and the ischium and sacrum in 8 % each.

At the same time, patients with pelvic bone sarcomas are given a worse prognosis than those with localization of the same tumors in long bones, which is associated with untimely diagnosis, primary oncological neglect (late referral for specialized care), peculiarities of the blood supply of the pelvic area, anatomical and topographic connection of pelvic bones with adjacent organs, vascular-nerve bundles and tissues. As a result, performing radical operations and timely complex treatment is difficult, and in some cases impossible [2].

Given the complex anatomical structure, reconstruction of the pelvic ring after tumor removal is a challenging task for the surgeon. Therefore, it is also necessary to restore the bearing capacity of the lower limb and the function of the hip joint. Therefore, it is this localization of pelvic lesions that is the most difficult and requires thorough study. There are a number of surgical reconstructive techniques using various endoprostheses and materials and, accordingly, a significant percentage of complications if they are used [3].

Recently, various techniques of organ-sparing treatment of patients with tumors of the periacetabular region have been developed and used. Reconstruction of the acetabulum is carried out with the help of bone grafts and autografts; mega endoprostheses; 3D printing; endoprostheses of pelvic bones, different in design and ideology (individual, saddle-shaped, modular); and also with the use of transposition of the femur with the formation of neoarthrosis, iliofemoral or ischiofemoral pseudoarthrosis or ankylosis [4–7].

Today, there is no universal model of reconstruction of the pelvis or its segments, and known methods do not ensure successful rehabilitation in all patients. This is related not only to tumor size, anatomical localization, histological type, range of resection, but also to a high risk of intra- and postoperative complications, which are found in 55–77 % of cases [8–9].

Postoperative complications in patients after reconstructive interventions for pelvic bone tumors include:

1) surgical (infection, hematoma in the area of operation, vascular thrombosis);

2) orthopedic (instability of nodes and loosening of endoprosthesis legs, periprosthetic fractures);

3) oncological (tumor recurrence in the area of operation) [10].

F. Zeifang et al. [11] proposed a classification of complications after reconstructive operations for tumor lesions of the pelvic bones, which includes 5 types:

– A — local wounds (wound infections, fistulas, gray matter, impaired wound healing, skin necrosis and infected hematomas);

– B — mechanical (periprosthetic fractures, mechanical disruption of nodes and dislocation of the implant, pseudarthrosis);

– C — systemic (thromboembolism of the pulmonary artery, cardiovascular insufficiency, thrombosis, infectious complications in the area of catheter installation);

– D — other (neurological disorders, limb shortening, lymphatic edema, bedsores, ulcers);

– E — local recurrence of the tumor.

Neurological disorders resulting from radical tumor resection are not considered complications [11].

A significant level of postoperative complications (mainly infectious) and low functional results in case of application of most methods of pelvic reconstruction are characteristic factors of surgical treatment of patients with tumors in it. That is why it is currently impossible to single out a unique universal technique for the reconstruction of post-resection pelvic defects.

All of the above indicates the absence of a solution to the problem in modern clinical onco-orthopedics. Therefore, the search for the most adequate, least traumatic and functionally beneficial method of reconstruction of post-resection defects of the pelvic bones, including the acetabulum, continues.

Purpose: to develop a method of reconstruction of a post-resection tumor defect of the periacetabular part of the pelvis by creating a new method of surgical treatment of patients with pelvic bone tumors with

damage to the acetabulum and carrying out its clinical approbation.

Material and methods

The research materials were reviewed and approved by the Bioethics Committee at the State Institution Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine (Protocol No. 202 dated 13.04.2020).

Characteristics of patients

The study involved data analysis of 9 patients who underwent surgical or combined treatment at Professor M. I. Sytenko Institute of Spine and Joint Pathology for the period from 2017 to 2021 regarding primary malignant tumors of the pelvic bones with damage to the acetabulum. Among them were 7 men and 2 women. The average age of patients at the time of initial application to the institute was (44.7 ± 14.6) years (from 19 to 67). The average body mass index was (24.8 ± 3.1) kg/m^2 (men — (24.4 ± 3.5) kg/m^2, women — (26.0 ± 0.4) kg/m^2).

Examination methods

In order to assess the visceral dissemination of the oncological process, all patients underwent ultrasound examination of the organs of the abdominal cavity and extraperitoneal space, contrast-enhanced spiral computed tomography (SCT) examination of this area and chest organs, and, if necessary, CT of the brain. Osteoscintigraphy, MRI or additional types of CT studies were performed to assess bone dissemination of cancer.

According to the surgical classification of primary malignant tumors (Enneking, 1980), stage IIV was established in 9 (100 %) patients [12]. All the patients underwent a detailed examination of the local status (X-ray examination, SCT, ultrasound, SCT-angiography). For histological verification of the diagnosis, a biopsy of the pathological focus of the affected part of the pelvic bones was performed.

Among the diagnosed nosological units, chondrosarcoma was the most frequent — 77.8 % (7 cases). Osteosarcoma was detected in 22.2 % (2) of patients.

Treatment

Patients were examined and treated according to protocols for each individual nosology: according to the indications, neoadjuvant and adjuvant polychemotherapy and surgical treatment were performed.

In 2 patients, preoperative and postoperative courses of polychemotherapy were carried out according to the treatment protocols of the relevant nosologies: central osteosarcoma, mesenchymal chondrosarcoma.

Operations to remove the tumor-affected area of the pelvic bones with resection were performed in 9 patients. The distribution of pelvic bone resections according to Enneking types was as follows: type II in 44.4 % (4) of cases, type II–III in 55.6 % (5).

Functional results of organ-sparing surgical treatment of patients with malignant pelvic bone tumors were evaluated using the Musculoskeletal Tumor Society Score (MSTS) (Musculoskeletal Tumor Society Score, 1993) [13].

Results and their discussion

Development of a method of surgical treatment of patients with malignant tumors of the pelvic bones with damage to the acetabulum

Modern surgical technologies for the treatment of patients with pelvic bone defects involving the acetabulum of various origins have many shortcomings, resulting in a number of complications, which, in turn, significantly reduce the outcomes of patient treatment. In order to improve the effect of surgical treatment of the specified category of patients, taking into account the results obtained at the previous stages of the study, we defined the task: to develop a new method of bioreconstruction of the post-resection tumor defect of the periacetabular area of the pelvis.

The main requirements for the created methodology were defined as follows:

– biomechanical — fixation of the head of the femur with minimal values of cranial displacement (shortening of the lower limb), medialization and dorsal displacement of the center of rotation of the hip joint, preservation of femoral-lumbar continuity and mobility in the femoral-pelvic joint;

– technical — ablastic removal of the pelvic tumor, anatomical replacement of the defect, the possibility of intraoperatively changing the size of the reconstruction of the pelvic bone defect without the use of massive metal devices;

– clinical - using the technique after resections of type II, II–III and I–II, ensuring a satisfactory clinical and cosmetic result of surgical treatment, restoring the bearing capacity of the lower limb, improving the quality of life of patients.

Taking into account the defined criteria for methods of replacing defects of the periacetabular area, a new technique for this has been developed [14]. It involves the replacement of the post-resection defect of the pelvic bone area and ensures the function of support and walking of the lower limb, movements in the hip joint, which, in turn, increases the effectiveness of treatment of patients with post-resection tumor defects by improving their functional

capabilities and reducing the risk of various types of complications.

The task is solved in the method of replacement of the post-resection defect of the pelvic area, which is based on the resection of part of the pelvic bone (type II), removal of the tumor within healthy tissues, connection of the implant with the remaining areas of the pelvic bone. To replace the post-resection defect of the pelvic region, a tissue tube made of polyethylene terephthalate (attachment tube, manufactured by Implantcast, Germany) is used, which is previously filled with bone allo-implants in the form of chips (State Institution Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine) and fixed transosseously with sutures to the ends of the pubic bone and the pubic or ischial bones. The second fragment of the attachment tube fixes the head of the femur to the above-mentioned first part of the tube with allo-implants.

Allo-implants are prepared using a technique developed at the State Institution Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine. After taking the bone material, the first stage was its mechanical processing, followed by chemical processing: in various solutions to remove adipose tissue, saturation with saline solutions, and lyophilization. The material was sterilized with γ-radiation using the LU-10 accelerator at a dose of 17.8 kGy at Kharkiv Physical and Technical Institute, research complex «Accelerator» [15].

The method of replacing the post-resection defect of the pelvic bones involving the acetabulum is performed in the following way. In the inguinal area, a skin incision of 15 cm or more is made, depending on the size of the tumor lesion. Subcutaneous fatty tissue and fascia are dissected, muscles are separated, gluteus maximus is dissected. The vascular-nerve bundle (femoral artery, vein and nerve) is isolated and removed laterally. The hip joint is isolated, the capsule of the joint, the ligament itself is dissected, and the head of the femur is displaced. The acetabulum is exposed. The body of the pubic bone is separated; the zone of its transition into the pubic and ischial bones is exposed. Osteotomy of the pubic bone is performed at the specified levels (type II pelvic resection). The gluteal ligaments, muscles and soft tissues surrounding this area are dissected. The tumor is removed en block (Fig. 1, a). Hemostasis is performed. At the reconstructive stage of the intervention, a tissue tube is sewn transosseously to the edges of the pubic (buttock) bone (Fig. 1, b), which is previously densely filled with bone allo-implants (chips) (Fig. 2, a). Next, the second end of the attachment tube is also sutured transaxially to the area of the cut of the pubic bone (Fig. 2, b). The head and neck of the femur are placed and fixed in the second attachment tube fragment (Fig. 3, a). The head of the femur is brought to the previously formed acetabulum. The edge of the last fragment of the tube is sewn to the tube with allo-implants, which forms the acetabulum (Fig. 3, b). After hip joint capsule plastic surgery, tubular drains are left in the wound. All the soft tissues remaining after the removal of the tumor are restored. The wound is sutured in layers.

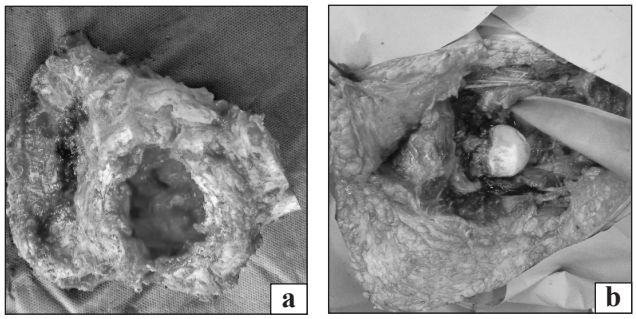

Fig. 1. Intraoperative photos of the removed tumor with damage to the acetabulum and the body of the pubic bone en block (a), the stage of fixation of the attachment tube to the pubic bone fracture (b)

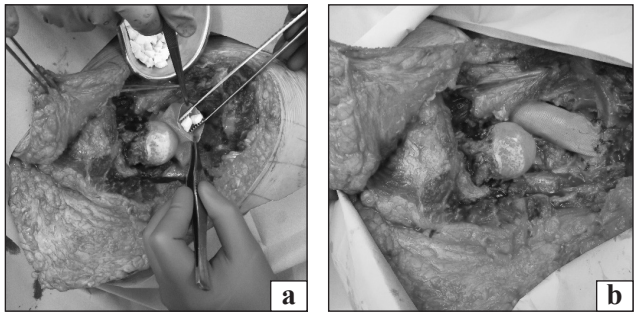

Fig. 2. Intraoperative photos of the stage of filling the attachment tube with bone allo-implants in the form of chips (a), fixing the attachment tube to the iliac crest (b)

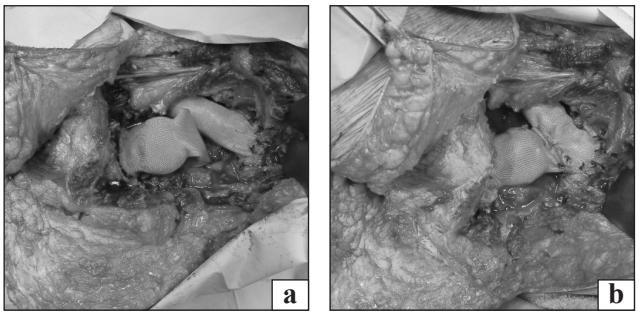

Fig. 3. Intraoperative photos of the stage of fixation of the second attachment tube fragment on the head and neck of the femur (a) and its fixation by suturing to the tube with allo-implants (b)

Thus, the method of replacement of the post-resection defect of the pelvic area involving the acetabulum with the help of attachment tube and bone allo-implants makes it possible to perform reconstruction of the acetabulum, reduce the duration and trauma of surgical intervention, and create conditions for restoring the function of support and walking of the lower limb with a certain range of motion in area of the removed hip joint without the use of endoprostheses and other structures, significantly reduce the risk of mechanical postoperative complications. This is due to the significant strength characteristics of the attachment tube, the growth of connective tissue in it and the combination with bone allo-implants. The combined implant has the properties of osseointegration and fairly pronounced tissue adhesion due to the presence in its composition of bone alloimplants and the synthetic material polyethylene terephthalate, which creates conditions for improving the mechanical properties of the «femur bone-implant-pelvic bone» system over time.

In order to determine the specifics of the application of the developed technique, identify its advantages and disadvantages, and carry out preliminary evaluation of clinical and oncological results, a clinical trial was conducted involving 9 patients with primary malignant tumors of the acetabulum.

Results of the clinical approbation of the developed method of surgical treatment of patients with malignant tumors of the pelvic bones with abnormalities of the acetabulum

All patients underwent primary organ-sparing surgical interventions. All of them were radical in relation to tumors, in the process of removal of which the level of wide resection was achieved. The primary characteristics of the patients are given in Table 1.

The average period of observation of patients was (29.0 ± 13.8) months (from 11.4 to 52.6).

Some results of treatment of patients are shown in Table 2.

In all patients, the post-resection defect of the pelvic bones was replaced using the attachment tube, which was previously filled with bone allo-implants in the form of chips and fixed with transosseous sutures to the joints of the pubic and pubic or ischial bones, with the second fragment of the tissue tube fixed to the first head of the femur [14].

Complications of surgical treatment were evaluated according to F. Zeifang et al. [11]. Local complications of the wound process (type A) were found in 44.4 % of cases (4). Among them, problems with wound healing that did not require revision interventions were found in 2 (22.2 %) patients. Cases of deep infectious complications accounted for 22.2 % (2) and required repeated medical measures and surgical procedures aimed at eliminating the inflammatory process.

Type B includes complications of a mechanical nature (periprosthetic fractures, mechanical disruption of nodes and dislocation of the implant, joint instability, fractures of bone implants).

No complications of this type were found in the studied group.

Type C consists of systemic complications (PE, acute cardiovascular failure, etc.). There were no complications of this type in the studied group.

Type D mainly involves neurological complications, which were also not identified in our patients.

Local recurrence of the tumor belongs to type E complications. It was established in 22.2 % (2) of cases.

Functional results were evaluated in all 9 patients in the period from 11 months up to 4.4 years using the MSTS scale. Median survival in patients was 24.7 months. The mean MSTS score for all patients was (52.6 ± 20.0) % (range 20.0 to 70.0 %). In men, this indicator was (56.2 ± 18.2) % (from 33.3 to 83.3 %), in women (40.0 ± 28.3) % (from 20.0 to 60.0 %).

Table 1

Characteristics of patients for clinical approbation of the developed method of surgical treatment of patients with malignant tumors of the pelvic bones affecting the acetabulum

Full name	Age at the time of initial application, years	Gender	Diagnosis	BMI, kg/m^2	Type of resection (according to Enneking)
Ch. O. V.	35	male	chondrosarcoma	23.7	II–III
L. T. O.	50	female	osteosarcoma	25.8	II–III
P. V. N.	67	male	chondrosarcoma	24.2	II–III
Sh. S. A.	54	female	chondrosarcoma	26.3	II
Z. K. V.	45	male	chondrosarcoma	24.1	II
R. V. V.	19	male	osteosarcoma	19.8	II
Ch. V. A.	46	male	chondrosarcoma	21.4	II–III
Sh. V. Ye.	56	male	chondrosarcoma	27.8	II–III
T. O. V.	30	male	chondrosarcoma	29.9	II

In patients with chondrosarcoma of the pelvic bones, the functional results were equal to (52.9 ± 14.1) % (from 33.3 to 70.0 %), with osteosarcoma (51.7 ± 44.8) % (from 20.0 to 83.3%).

A clinical example

A 19-year-old patient R. was admitted to the clinic of the State Institution Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine with pain in the area of the left hip joint.

As a result of the comprehensive examination, the diagnosis was established: central osteogenic sarcoma of the supraacetabular area of the left iliac bone $T_2N_0M_0$, stage II, classification group II (Fig. 4, a, b). The patient underwent a course of neoadjuvant polychemotherapy according to the scheme of doxorubicin (75 mg/ m²), cisplatin (120 mg/m²). Subsequently, the operation was performed: removal of the pubic bone tumor en block (Fig. 5, a, b) by resection ofthe pelvic bones type II, replacement of the postresection defect with bone allo-implants and attachment tube (Fig. 5, c). The postoperative period passed without complications, the wound healed with primary tension. The patient received adjuvant polychemotherapy taking into account the degree of medical pathomorphosis according to the scheme: doxorubicin

Table 2

Outcomes of treatment of patients with malignant tumors of the pelvic bones affecting the acetabulum using the developed method of surgical treatment

Full name	Complication		Functional evaluation of the results according to the MSTS scale						MSTS, score	MSTS, %
	infectious	oncological	pain	function	mood	the need for support	walking	pace		
Ch. O. V.	no	no	4	4	3	3	4	3	21	70.0
L. T. O.	так	no	2	1	1	0	1	1	6	20.0
P. V. N.	no	no	3	2	4	1	2	2	14	46.7
Sh. S. A.	no	no	4	3	4	2	3	2	18	60.0
Z. K. V.	так	no	2	4	2	1	3	1	13	43.3
R. V. V.	no	no	4	4	4	5	4	4	25	83.3
Ch. V. A.	no	local relapse	4	3	2	0	3	2	14	46.7
Sh. V. Ye.	no	local relapse	2	1	3	0	2	2	10	33.3
T. O. V.	no	no	4	3	4	4	3	3	21	70.0

Fig. 4. Radiograph (a) and CT image (b) of the pelvis of a 19-year-old patient R., central osteogenic sarcoma of the left iliac bone (white arrow indicates the area of tumor involvement)

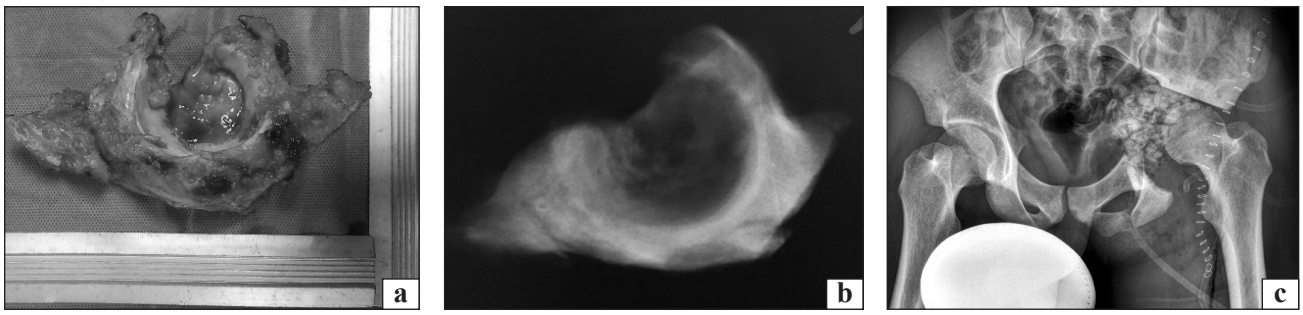

Fig. 5. Photo (a) and radiograph (b) of the removed specimen of the pelvic bones, postoperative radiograph of the pelvis (c) of a 19-year-old patient R.

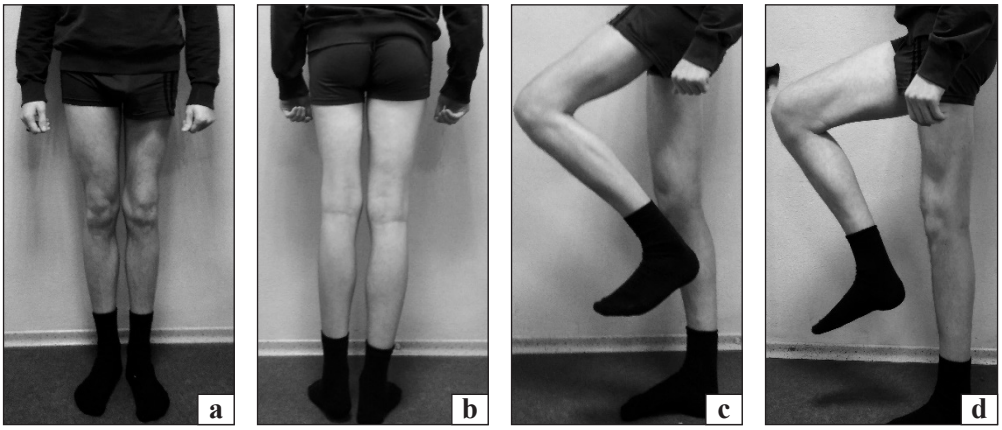

Fig. 6. Photo of a 19-year-old patient R., 6 months after surgical treatment: anterior view (a) and posterior view (b), demonstration of flexion in the left hip joint (c), single-support standing on the left lower limb (d)

Fig. 7. X-ray (a) and SCT 3D reconstruction (b) of the pelvis of patient R. 1.5 years after surgical treatment

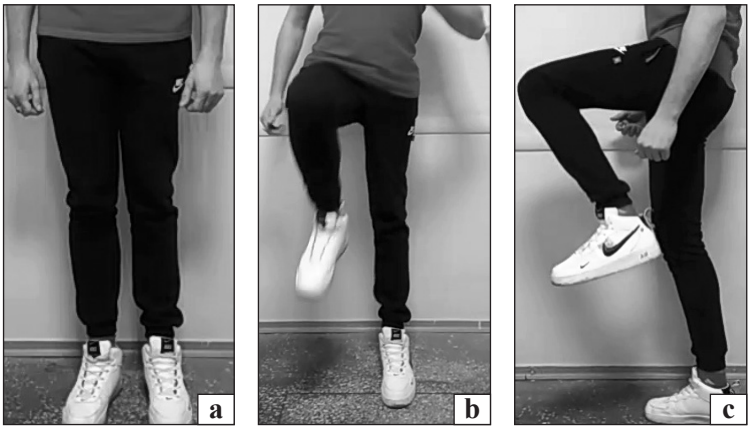

Fig. 8. Photo of patient R. 1.5 years after surgical treatment: anterior view (a), single-support standing on the left lower limb (b), demonstration of flexion in the left pelvic-femoral joint (c)

(75 mg/m²), cisplatin (120 mg/m²). After 3 months after surgery, he walked with the help of a cane with full weight on the left lower limb, 5 months later without additional support (Fig. 6). The function in the pelvic-femoral joint is preserved to a satisfactory extent. Functional results on the MSTS score were 25 points (83.3%) (Fig. 7; 8). No oncological and orthopedic complications were detected during the observation period.

Evaluation of the functional results in patients with resection of the acetabulum showed that the indicated area had high functional significance in the surgery of pelvic bone tumors. The proposed and clinically tested technique of bioreconstruction of pelvic bone defects involving the acetabulum determined satisfactory results in terms of complications and functional results. This indicates the possibility of obtaining acceptable outcomes under the conditions of applying the proprietary technique both for the treatment of pelvic tumors with damage to the acetabulum, and for pelvic bone defects of other origin.

Conclusions

The developed new method of replacement of the defect of the acetabular part of the pelvic bones in patients with tumor impressions of the part of the pelvic bones with the involvement of the acetabulum involves the replacement of the post-resection defect and ensures the function of support and walking of the lower limb. This increases the effectiveness

of the treatment of the specified category of patients with tumor post-resection defects by improving functional capabilities. The use of the developed technique makes it possible to reduce the duration and trauma of surgical intervention, restore the function of support and walking of the lower limb without the use of endoprostheses and other structures, and significantly reduce the risk of mechanical postoperative complications.

As a result of the clinical approbation of the method of reconstruction of pelvic bone defects in the acetabulum area, the results of complications and functioning according to the MSTS score (52.6 ± 20.0) % were obtained. This indicates the possibility of obtaining acceptable results in the treatment of patients with primary malignant bone tumors of the pelvis with damage to the acetabulum under the conditions of using the proposed method.

Conflict of interest. The authors declare no conflict of interest.

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SURGICAL PROCEDURE FOR PELVIC PERIACETABULAR BONE TUMOR DEFECTS

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