УДК 617.582:616.718.4-033.2-001.5]-089.843](045)

DOI: http://dx.doi.org/10.15674/0030-59872024153-58

The use of a training 3D-model in the treatment of a patient with a pathological fracture of the proximal part of the femur (case from practice)

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Prostate cancer is the second most common cause of malignancy in men, with bone metastases being a significant source of morbidity and mortality in advanced cases. Objective. To give a clinical example of a patient with a pathological transtrochanteric fracture of the right femur with displacement of fragments, the presence of metastasis at the fracture site, to emphasize the importance of 3D-training before surgery. Methods. A clinical example with a significant impairment of the function of the right lower extremity against the background of a significant pain syndrome is given. The diagnosis was established: pathological transtrochanteric fracture of the right femur with displacement of fragments, the presence of metastasis at the fracture site. Pre-surgical training was carried out using a 3D-model and total endoprosthetics of the right hip joint with a revision individual implant of the cement fixation type was carried out. The patient fully recovered the function of the right lower limb and hip joint, the pain syndrome was eliminated, and sleep normalized. The use of a 3D-model for preoperative training of surgeons made it possible to rationally limit traumatization of healthy tissues during tumor removal, prevent possible complications and optimize the time of surgical intervention and thus minimize blood loss. Conclusions. The use of a training 3D-model before surgery followed by prosthetics with a special oncological endoprosthesis provided satisfactory functional results and restoration of the patient's quality of life in the given clinical case. The use of a 3D-model is the key to careful preparation for surgical intervention, taking into account the individual anatomical features of the pathological process and adjacent tissues, which allows you to significantly optimize the terms of the operation and reduce blood loss, and also provides valuable experience for further surgical practice.

Онкологічне ураження передміхурової залози є другою за поширеністю причиною злоякісних новоутворень у чоловіків, причому метастази в кістки є значним джерелом захворюваності та смертності в запущених випадках. Мета. Навести клінічний приклад пацієнта з патологічним черезвертлюговим переломом правої стегнової кістки зі зміщенням відламків, наявністю метастазування в місці перелому, акцентувати увагу на важливості 3D-тренінгу перед хірургічним втручанням. Методи. Наведено клінічний приклад із порушенням функції правої нижньої кінцівки на тлі значного больового синдрому. Встановлено діагноз: патологічний черезвертлюговий перелом правої стегнової кістки зі зміщенням відламків, наявність метастаз в місці перелому. Проведено тренування перед хірургічним втручанням із використанням 3D-моделі та здійснено тотальне ендопротезування правого кульшового суглоба ревізійним індивідуальним імплантом цементного типу фіксації. У хворого повністю відновлено функцію правої нижньої кінцівки, кульшового суглоба, усунуто больовий синдром, відбулася нормалізація сну. Застосування 3D-моделі для передопераційного тренінгу лікарів дозволило раціонально обмежити травматизацію здорових тканин під час видалення пухлини, запобігти можливим ускладненням та оптимізувати час хірургічного втручання і, таким чином, мінімізувати крововтрату. Висновок. Застосування тренувальної 3D-моделі перед хірургічним втручанням, із подальшим проведенням протезування спеціальним онкологічним ендопротезом, забезпечило в наведеному клінічному випадку задовільні функціональні результати й відновлення якості життя пацієнта. Використання 3D-моделі є запорукою ретельної підготовки до оперативного втручання з урахуванням індивідуальних анатомічних особливостей патологічного процесу і прилеглих тканин, що дозволяє значно оптимізувати терміни операції та скоротити крововтрату, а також допомагає набути досвіду для подальшої хірургічної практики. Ключові слова. Онкологія, метастази в кістки, патологічний перелом, 3D-моделювання, ендопротезування, персоніфіковане лікування, якість життя.

Keywords. Oncology, bone metastases, pathological fracture, 3D-modeling, endoprosthesis, personalized treatment, quality of life

Introduction

Metastatic bone lesions are complex clinical conditions resulting from the migration and colonization of cancer cells from their primary site in the bone microenvironment, where they naturally develop a metastatic niche [1]. Oncological lesions of the prostate gland are the second most common cause of malignant neoplasms in men, and bone metastases are a source of morbidity and mortality in advanced cases [2, 3]. Many years of experience confirm that lymph nodes near the primary site are the initial sites of metastasis, followed by bone metastases [4]. Numerous studies have shown that people with bone metastases caused by prostate cancer have a worse prognosis and reduced quality of life [5, 6].

Many cancers metastasize to bone and lead to complete pathologic fracture or the threat of pathologic fracture, which may be associated with a worse prognosis and decreased overall survival [7]. It has been proven that preventive stabilization of bones before a possible fracture improves the prognosis of the course of the disease, is clinically justified and more cost-effective [8], but, unfortunately, it is not always possible to prevent a pathological fracture.

Purpose: to present a clinical example of a patient with a pathological transtrochanteric fracture of the right femur with displacement of fragments and metastases at the fracture site, to emphasize the importance of 3D-training before surgery.

Material and methods

Commission on Bioethics of R. E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the National Academy of Sciences of Ukraine, according to the results of the evaluation of the ethical and moral and legal aspects of the study, confirmed that the research was performed in compliance with the main requirements of the Helsinki Declaration of the World Medical Association (2008), which ensures informed consent for participation in relevant research and complies with general ethical principles, adopted by the First National Congress on Bioethics (2001), the materials do not contain information prohibited for publication, the article is submitted for publication for the first time (Protocol No. 1 dated 15.02.2024).

Clinical case

In August 2021, a 56-year-old patient N. was referred to Kyiv Clinical City Hospital No. 3 from Kyiv City Clinical Oncology Center with a suspected fracture of the neck of the right femur. Main diagnosis: cancer of prostate p T3N1M1 — IV stage, clinical group IV (acinar adenocarcinoma of the prostate gland, Gleason score 5 + 5 = 10, undifferentiated (G4), prognostic group V). Associated diseases: mild anemia, coronary heart disease, diffuse cardiosclerosis, CHF-I, erythematous gastropathy.

Clinical examination revealed a significant impairment of the function of the right lower limb, its forced position in bed, almost no active movements due to a significant pain syndrome, the intensity of which was estimated at 9 points on the VAS scale. There were no obvious violations of muscle functions and muscle tone of the lower limbs, but muscle atrophy was rather significant. The patient subjectively noted fatigue due to sleep disturbances because of pain, according to his words, he fell while walking and immediately felt a sharp pain in the area of the right hip joint, and later he was unable to move freely, he felt numbness of the right lateral surface of the thigh, later he had to hold a forced position in bed to avoid aggravation of pain.

Laboratory examination revealed a serum alkaline phosphatase level of 688 units/L (normal range 50–135 units/L) and a C-reactive protein level of 12.2 mg/mL (normal range 0–8 mg/L), while the sedimentation rate erythrocytes and tumor markers (including levels of α-fetoprotein and carcinoembryonic antigen) were within normal limits.

Radiography of the upper third of the right thigh showed a transtrochanteric fracture with fragments and destructive changes in the bone tissue of the thigh similar to a metastatic lesion (Fig. 1).

At the clinical examination, a collegiate diagnosis was agreed upon: a pathological transtrochanteric fracture of the right femur with displacement of the fragments, metastases at the fracture site.

A decision was made: using spiral computed tomography (SCT) data, to create a 3D-model of the re-

Fig. 1. Photo of the radiograph of the upper third of the right thigh. Pathological fracture and metastases

production of the pathological fracture process (Fig. 2); conduct a training surgical intervention on an artificial bone in the area of the future operation and draw up an intervention plan; perform surgical treatment, namely total endoprosthesis of the right hip joint.

3D-modeling and training were carried out with the participation of two surgeons who subsequently performed the operation: during the training, the spatial characteristics and volume of the tumor lesion of the hip joint were evaluated, the risks were analyzed and preventive tactics were developed to prevent possible damage to blood vessels and nerves during the intervention, surgical approaches to the tumor were worked out.

Surgical intervention. The patient was placed on the operating table in a position on the healthy side, continuous spinal dural anesthesia was used. Surgical access up to 20 cm long was performed. The underlying tissues were opened layer by layer: skin, subcutaneous tissue, fascia. Careful hemostasis was performed during the intervention. The underlying muscle structures were bluntly and acutely separated, the site of the pathological fracture was exposed. Fragments were mobilized. In the field of view of surgical intervention, the tumor affected the surrounding soft tissues and had unclear boundaries. Subsequently, it (Fig. 3) and adjacent tissues (surrounding affected muscles) were carefully removed to visually healthy tissue. The wound was washed with antiseptic solutions and dried.

A total endoprosthetic repair of the right hip joint was carried out with a non-modular prosthesis — a revision individual implant of the cement type of fixation (EVOLUTIS), intended for use in case of significant tumor lesions. The prosthesis was implanted in the medullary canal of the femur and fixed with bone cement. After appropriate preparation of the acetabulum, a plastic liner of the appropriate size was placed on the bone cement, taking into account all the angles of the relationship in the acetabulum to prevent further dislocation of the endoprosthesis. After recovery, the hip joint was checked for fullness and satisfactory range of motion. The wound was repeatedly washed with hydrogen peroxide and saline solution. Drainage tubes were installed under the muscle layer of the wound and tightly sutured in layers.

Fig. 2. 3D-model of the upper third of the right thigh. Pathological fracture and metastases

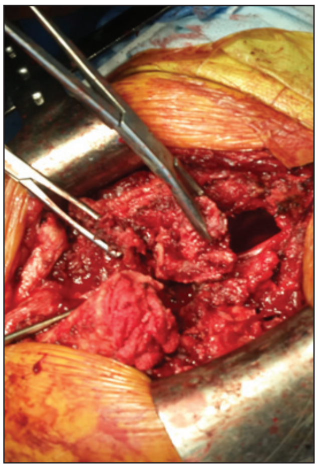

Fig. 3. Removal of a metastatic tumor of the proximal part of the femur

Results

The use of a 3D-model for preoperative training of surgeons made it possible to rationally limit traumatization of healthy tissues during tumor removal, prevent possible complications and optimize the time of surgical intervention, and thus minimize blood loss.

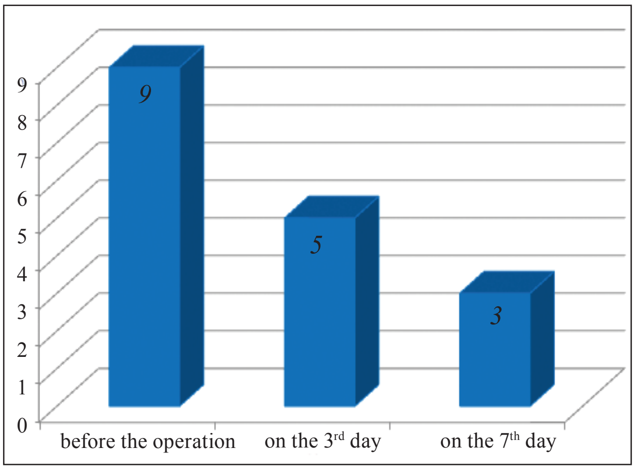

Fig. 4. Assessment in the time course of the intensity of the pain syndrome, points (VAS)

After the operation, the patient fully recovered the function of the right lower limb and hip joint. The pain syndrome has been eliminated, as evidenced by the indicators of the visual analog pain scale (VAS); a decrease in the intensity of the pain syndrome was observed in the time course (Fig. 4); normalization of sleep occurred; the patient felt the return of cheerfulness; ability to work was restored.

After the operation, the control radiograph showed a satisfactory anatomical relationship of the implant and the absence of complications from the side of the bone tissue (Fig. 5). On the 7th day after the intervention, the patient was transferred to Kyiv City Clinical Oncology Center for further treatment of the underlying disease.

Discussion

The greatest burden of morbidity and mortality resulting from malignancy is caused by metastases. The most frequent place of their location is the lungs, followed by the liver and bones. Bone metastases occur in almost all types of oncological diseases, for the most part, they are diagnosed as a result of oncology of the prostate, lungs, and mammary gland [9, 10]. The presence of metastatic bone disease dramatically affects the patient's quality of life due to increased pain, impaired mobility, pathological fractures and their consequences, or compression of the spinal cord. Individuals with late-stage breast or prostate cancer will sooner or later suffer from bone metastases as the disease progresses. In the case of breast or prostate cancer, symptoms associated with metastases are often the first sign of the disease [11, 12]. Some patients may have pathological fractures and complications due to them: for example, neurological disorders due to metastases in the spine (since it is well known that the spine is the most common site of metastases) [13, 14].

Fig. 5. Photo of an X-ray of the hip joint area after prosthetic repair with a special oncological implant installed

Pain is the main symptom in patients with metastases, and in the case of pathological foci, it is the most common symptom of metastatic bone lesions [15]. It is experienced by 30–50 % of all cancer patients, and 75–90 % suffer from changes in the quality of life [16, 17].

In the case of metastatic bone lesions, the most severe degree of disability can be caused by fractures of long bones and the spread of the tumor to the spinal cord. Pathological fractures occur as a result of stress injuries, which negatively affect the quality of life of patients with an advanced disease. Therefore, if we can predict the location of fractures in metastatic bone disease, prophylactic surgery can be performed to overcome any possible complications [9, 17, 18]. In the event that it is impossible to prevent a fracture and it has occurred, treatment tactics require a complex approach taking into account the individual characteristics of the patient, the architecture of damaged and surviving tissues and vessels around them, focusing on restoring not only the anatomical integrity, but also the functional capabilities of the damaged bone [19, 20]. In this context, the use of CT and the production of a training 3D-model is a clinically justified and successful solution, which allows the surgeon to immerse himself in reality as much as possible with a pronounced practical emphasis; focus on specific components of a complex skill to improve it with the desired duration and frequency of training (for example, the skill of developing a femoral canal and acetabulum, personalized installation of endoprosthesis components). And most importantly, training allows you to gain clinical experience without risk for the patient, giving the right to make mistakes without limiting the number of repetitions of practicing skills at a convenient time, and at the same time minimizes stress during the first independent manipulations [20, 21].

Conclusions

The use of a training 3D-model before surgery followed by prosthetic repair with a special oncological implant provided satisfactory functional results and restoration of the patient's quality of life in the given clinical case.

The use of a 3D-model is the key to careful preparation for surgical intervention, taking into account the individual anatomical features of the pathological process and adjacent tissues, which significantly optimizes the operation time and reduces blood loss, as well as gives valuable experience for further surgical practice.

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

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The article has been sent to the editors 21.01.2024

THE USE OF A TRAINING 3D-MODEL IN THE TREATMENT OF A PATIENT WITH A PATHOLOGICAL FRACTURE OF THE PROXIMAL PART OF THE FEMUR (CASE FROM PRACTICE)

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