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**O. DROBOTUN [1, *], V. PROTSENKO [2], N. TERNOVYY [3]**

1 O.O. Bogomolets NMU, Kyiv, Ukraine
[2] SI "Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine" Kyiv, Ukraine
[3] R.E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology, National Academy of Sciences of Ukraine, Kyiv, Ukraine

* Correspondence: Email: olegdrobotun@gmail.com

# IMPROVING PATIENTS' QUALITY OF LIFE AFTER SURGICAL TREATMENT OF PRIMARY MALIGNANT BONE TUMORS USING A TRAINING 3D MODEL

**Background**. Bone neoplasms significantly reduce the patient's quality of life (QoL) not only during the manifestation of the primary disease but also at various treatment stages. **Aim**. To study the QoL indicators in patients with primary malignant bone tumors before and after surgical treatment using a training 3D model. **Materials and Methods**. 44 patients with primary malignant tumors of the lower extremities (osteosarcoma and chondrosarcoma) were treated by surgery. 3D modeling was used to plan the surgical intervention. 3D printing of the models of the pathological foci was performed by the method of layer-by-layer deposition (Fused Deposition Modeling, FDM) using a Creatbot D600 3D printer. The QoL index of patients before and 3 weeks after surgical treatment was measured by the arithmetic sum of the scores of the QLQ-C30 simplified version questionnaire. **Results**. The surgical removal of a tumor using a training 3D model had a positive effect on the QoL of patients. Before treatment, the QoL index was on average 7.4 ± 1.2 points, and after treatment 9.4 ± 1.3 points, that is, by 27% higher. **Conclusions**. The use of training 3D models not only implements a strategy of personalized treatment and improves the QoL of patients but also contributes to optimization of the postoperative rehabilitation.

**Keywords**: bone tumors, osteosarcoma, chondrosarcoma, treatment, 3D-models, personalized treatment, quality of life.

The incidence of cancer is increasing worldwide, and research and clinical work in the fight against cancer continue. Treatment of both primary and secondary bone tumors is challenging as conventional treatment regimens (e.g., chemotherapy, radiotherapy, surgical resection) face the problems such as drug resistance and disease recurrence [1]. In this regard, considerable attention is paid to the research, development, and implementation of better methods of treatment of bone neoplasms [2].

Bone tumors can be localized in any part of the human skeleton but more often develop in the long tubular bones and pelvic bones. Despite their small specific weight in the structure of cancer morbidity,

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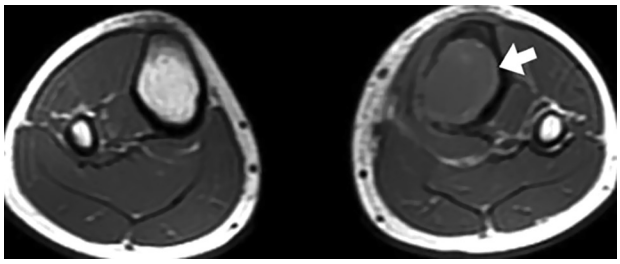

Computed tomography. Patient F., 23 years old. Osteosarcoma of the left tibial bone. Hypointense structure (arrow)

the difficulty of diagnosis and treatment requires constant improvement of available methods of clinical management [3, 4]. The analysis of the domestic and foreign clinics experience shows that the primary malignant and metastatic bone tumors are one of the least studied groups of human neoplasms, in the diagnosis and treatment of which there are significant difficulties, and a large number of mistakes are made [5—9]. Bone neoplasms significantly reduce the patients' quality of life (QoL). Unfortunately, this happens not only during the manifestation of the primary disease but also at various stages of the treatment process [10—15].

The aim of the study was to determine the QoL index of patients with primary malignant bone tumors before and after surgical treatment using a training 3D model.

## Materials and Methods

Surgical treatment of 44 patients with primary malignant tumors of the lower extremities, osteosarcoma and chondrosarcoma, was carried out. CT examination of the pathological foci in patients was performed by scanning with a step of < 1 mm and obtaining tomograms (digital 2D images) with isotropic voxels in the DICOM format (Fig. 1).

Next, the processed 2D images were registered and brought to a single coordinate system followed by segmentation for the formation of an accurate anatomical computer 3D model and conversion of DICOM files into the STL format. Then the model was imported into the CreatBot CAD system to design a perfectly personalized 3D model. 3D printing of pathological foci models was performed by the method of layer-by-layer deposition (Fused Deposition Modeling, FDM). As a material for creating a physical 3D model, polylactide (PLA) was selected and used as biodegradable, biocompatible, thermoplastic, and aliphatic polyester.

The QoL index before and 3 weeks after the surgical treatment was measured by the arithmetic sum of the points of the QLQ-C30 simplified version questionnaire [13], in which the patients self-assessed their sleep, appetite, attention, memory, and work capacity in points from "0" to "3", where 0 is "bad", 1 is "satisfactory", 2 is "good", and 3 is "excellent". Statistical analysis of the results was performed using the Statistica 6.0 software package (StatSoft Inc., USA). $p \leq 0.05$ was taken as the critical level of reliability when testing statistical hypotheses.

## Results and Discussion

The obtained data make it possible to conclude that primary malignant tumors of the lower extremities in general significantly affect the QoL index, which was also noted in the studies of other authors [2, 4, 16].

On the other hand, after surgical treatment, in particular, with the installation of special oncological prostheses that fully restore the functional range of joints, a significant increase in the QoL index of patients is observed. In particular, before treatment, the QoL index amounted to an average of 7.4 ± 1.2 points, and after treatment to 9.4 ± 1.3 points, i.e., by 27% higher than the value before treatment ($p < 0.05$).

Studies have found that symptoms that can be associated with pain syndrome, immunosuppression, and intoxication play a significant role in reducing the QoL of patients [14, 15]. Various authors have also confirmed that after tumor removal and pain syndrome elimination, the QoL of most patients improves [2, 5, 7, 16].

In this context, it should be emphasized that the surgical interventions using training 3D models not only implement a strategy of personalized treatment and improve the QoL of patients but also, via reducing the operation duration and thus minimizing blood loss, create conditions for more complete and earlier postoperative rehabilitation. According to our observations, patients stay in the hospital by 4—6 days lesser. Such results are important for optimizing the spending of public funds, especially during the extremely difficult period of martial law in the country.

In conclusion, surgical treatment of patients with primary malignant bone tumors of the lower extremities, osteosarcoma and chondrosarcoma, with the involvement of 3D printing of pathological foci

and training before surgery, led to a significant increase in the QoL index, and allows to optimize the operation time and reduce blood loss. Shortening the stay of patients in the inpatient treatment returns them to an active life earlier and preserves the economic resources of the medical institutions.

REFERENCES


1. Panagi M, Pilavaki P, Constantinidou A, Stylianopoulos T. Immunotherapy in soft tissue and bone sarcoma: Unraveling the barriers to effectiveness. *Theranostics*. 2022;12:6106-6129. https://doi.org/10.7150/thno.72800
2. Mettmann VL, Blattmann C, Friedel G, et al. Primary multi-systemic metastases in osteosarcoma: presentation, treatment, and survival of 83 patients of the Cooperative Osteosarcoma Study Group. *Cancers (Basel)*. 2024;16(2):275. https://doi.org/ 10.3390/cancers16020275
3. Ren J, Zhao C, Sun R, et al. Augmented drug resistance of osteosarcoma cells within decalcified bone matrix scaffold: The role of glutamine metabolism. *Int J Cancer*. 2024;154(9):1626-1638. https://doi.org/10.1002/ijc.34841
4. Zhu Y, Wu X, Zhang W, Zhang H. Limb-salvage surgery versus extremity amputation for early-stage bone cancer in the extremities: a population-based study. *Front Surg*. 2023;10:1147372. https://doi.org/10.3389/fsurg.2023.1147372
5. Panez-Toro I, Muñoz-García J, Vargas-Franco JW, et al. Advances in Osteosarcoma. *Curr Osteoporos Rep*. 2023;21(4):330-343. https://doi.org/10.1007/s11914-023-00803-9.
6. Leng Y, Li J, Long Z, et al. Osteoblast-derived exosomes promote osteogenic differentiation of osteosarcoma cells via URG4/Wnt signaling pathway. *Bone*. 2024;178:116933. https://doi.org/10.1016/j.bone.2023.116933
7. Gerrand C, Athanasou N, Brennan B, et al. UK guidelines for the management of bone sarcomas. *Clin Sarcoma Res*. 2016;6:7. https://doi.org/10.1186/s13569-016-0047-1
8. Wang L, Li W, Pan Y. The Eph/Ephrin system in primary bone tumor and bone cancer pain. *Aging (Albany NY)*. 2023;15(14):7324-7332. https://doi.org/10.18632/aging.204852
9. Zhang Q, Yang Y, You X, et al. Comprehensive genomic analysis of primary bone sarcomas reveals different genetic patterns compared with soft tissue sarcomas. *Front Oncol.* 2023;13:1173275. https://doi.org/10.3389/fonc.2023.1173275
10. Roberts RD, Lizardo MM, Reed DR, et al. Provocative questions in osteosarcoma basic and translational biology: A report from the Children's Oncology Group. *Cancer*. 2019;125:3514-3525. https://doi.org/10.1002/cncr.32351
11. Salom M, Chiari C, Alessandri JMG, et al. Diagnosis and staging of malignant bone tumours in children: what is due and what is new? *J Child Orthop*. 2021;15(4):312-321. https://doi.org/10.1302/1863-2548.15.210107
12. Bartelstein MK, Boland PJ. Fifty years of bone tumors. *J Surg Oncol*. 2022;126(5):906-912. https://doi.org/10.1002/jso.27027.
13. de Ligt KM, Aaronson NK, Liegl G, Nolte S; EORTC Quality of Life Group. Updated normative data for the EORTC QLQ-C30 in the general Dutch population by age and sex: a cross-sectional panel research study. *Qual Life Res*. 2023;32(9):2477-2487. https://doi.org/ 10.1007/s11136-023-03404-2.
14. Gazendam A, Popovic S, Parasu N, Ghert M. Chondrosarcoma: A clinical review. *J Clin Med*. 2023;12(7):2506. https://doi.org/10.3390/jcm12072506
15. Paulino Pereira NR, Janssen SJ, et al. Physical function and quality of life after resection of mobile spine chondrosarcoma. *Global Spine J*. 2019;9(7):743-753. https://doi.org/ 10.1177/2192568219830330
16. Fernando-Canavan L, Abraham P, Devlin N, Tran-Duy A. Health-related quality of life in patients with extremity bone sarcoma after surgical treatment: a systematic review. *Qual Life Res*. 2024;33(5):1157-1174. https://doi.org/10.1007/s11136-023-03554-3


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COMPLIANCE WITH ETHICAL STANDARDS

The study was conducted in compliance with the principles of the Declaration of Helsinki of the World Medical Association "Ethical principles of medical research involving human subjects"

*О. Дроботун [1], В. Проценко [2], Н. Терновий [3]*

[1] НМУ ім. О.О. Богомольця, Київ, Україна
[2] ДУ «Інститут травматології та ортопедії НАМН України», Київ, Україна
[3] Інститут експериментальної патології, онкології і радіобіології ім. Р.Є. Кавецького НАН України, Київ, Україна

# ПОКРАЩЕННЯ ЯКОСТІ ЖИТТЯ ХВОРИХ ПІСЛЯ ХІРУРГІЧНОГО ЛІКУВАННЯ ПЕРВИННИХ ЗЛОЯКІСНИХ ПУХЛИН КІСТОК З ВИКОРИСТАННЯМ ТРЕНУВАЛЬНОЇ 3D МОДЕЛІ

**Актуальність**. Новоутворення кісток значно знижують якість життя пацієнтів. Це відбувається не тільки під час маніфестації первинного захворювання, але й на різних етапах лікувального процесу. **Мета**. Вивчити показники якості життя хворих на первинні злоякісні пухлини кісток до та після хірургічного лікування з використанням тренувальної 3D моделі. **Матеріали та методи**. Проведено хірургічне лікування 44 хворих на первинні злоякісні пухлини нижніх кінцівок — остеосаркому та хондросаркому. Для планування хірургічного втручання використовували 3D моделювання. 3D-друк моделей патологічних вогнищ виконано методом пошарового наплавлення (Fused Deposition Modeling — FDM). Для друку використовувався 3D принтер Creatbot D600 (Китай). Індекс якості життя пацієнтів до та через 3 тижні після хірургічного лікування вимірювали за арифметичною сумою балів спрощеної версії опитувальника QLQ-C30. **Результати**. Хірургічне видалення пухлини з використанням тренувальної 3D моделі позитивно вплинуло на якість життя пацієнтів. До лікування індекс якості життя складав у середньому 7,4 ± 1,2 бали, а після — 9,4 ± 1,3 бали, тобто був на 27,0% вище за значення до лікування. **Висновки**. Використання тренувальних 3D-моделей не тільки реалізує стратегію персоніфікованого лікування та покращує якість життя пацієнтів, але також сприяє оптимізованій післяопераційній реабілітації, що приводить до економії державних коштів.

**Ключові слова**: пухлини кісток, остеосаркома, хондросаркома, лікування, 3D моделі, персоніфіковане лікування, якість життя.