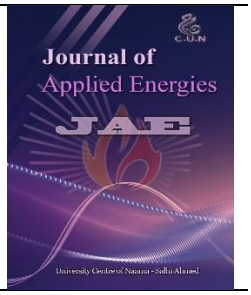
Journal of Applied Energies 2 (2023) 56-64

Journal of Applied Energies



Using TDM lower energy to exploring knee tumor morphology; a novel anatomical perspective by 3D imagery

Zahra REHALA[1], Mohamed SAIDI[1]

Oran University Hospital 01 November 1954 (EHU)

.Correspondence. Email Address: zahrarehala@gmail.com, saidimedsam@hotmail.fr

Abstract: This study focused on three-dimensional modeling of a specific tumoral process affecting the knee of a 30-year-old patient obtained by CT (computed tomography) using lower energy. To this end, we utilized the advanced digital software HOROS in conjunction with CT lower energy imaging data. The main objective of this research was to highlight the crucial importance of the CT lower energy, digital tools and 3D imaging in the medical field. The study of the results obtained highlights the intimate anatomical relationships of the tumoral process of the knee and its extension using the data obtained by the vectorial reconstruction of the series sections of the lower limb. The analysis and processing of this data clearly demonstrated the substantial contribution of technological advancements in 3D modeling to our understanding and ability to diagnose tumors. Therefore, we now have more precise, immersive, and sophisticated means to explore and understand pathological conditions. This advancement translates into a significant improvement in patient care, thus offering better prospects in terms of treatment and surgical intervention.

Keywords: anatomical morphology; 3D; vector modeling; tumoral process; knee.

1. INTRODUCTION

The CT (computed tomography) is a medical imaging technique that uses x-rays to produce detailed images of the inside of the body [1], the X-rays produced by CT scanners have different level of energy, In general, X-rays used in medical imaging have energies ranging from 20 kiloelectron volts (keV) to 150 keV. This energy range is considered to be low to medium energy [2].

It is important to note that the radiation dose received by the patient during a CT scan depends on several factors [2], such as the type of scanner used, the scan parameters, and the specific body part being examined. Scanner manufacturers and healthcare professionals implement measures to minimize radiation exposure and ensure that the diagnostic benefits outweigh potential risks, it is crucial to discuss the benefits and risks associated with any type of scan with your healthcare professional to make an informed decision regarding your diagnostic needs [3]

New computer and multimedia techniques have recently provided valuable tools for the study of human morphological sciences. Indeed, alongside classical techniques such as anatomical dissection, injections, or the study of anatomical sections combined with specific preparations or staining; the use of virtual reality has opened new fields of investigation through 3D modeling of anatomical structures.

In the current context where digital technologies are transforming healthcare, the importance of utilizing new technologies for processing medical images in the diagnosis and treatment of tumors is increasingly recognized.

Various studies have highlighted the effectiveness of these technologies in terms of diagnostic accuracy and treatment planning. For instance, a study by [4] demonstrated how digital medical imaging can help identify subtle tumor characteristics that cannot be detected by physical exams or traditional imaging methods. The authors also suggested that digital analysis of medical images could enhance the accuracy of cancer diagnosis compared to traditional methods. A subsequent study by [5] showed that machine learning and artificial intelligence applied to medical imaging can help predict tumor progression and personalize treatment plans.

Moreover, 3D technology has been widely used to visualize and understand the complex anatomy of tumors, which directly impacts treatment planning. In a study by [6] [7], researchers utilized 3D printing technology to create tumor models that were subsequently used to plan complex surgeries. These models allowed surgeons to better understand the relationship between the tumor and surrounding anatomical structures, thereby improving surgical accuracy

and reducing potential complications. Furthermore, a study by [8] showed that augmented reality, in combination with 3D modeling, can assist surgeons in more precisely visualizing the location and extent of tumors, thereby enhancing the precision of interventions.

These new technologies also play a crucial role in monitoring patients with cancer. For example, a study by [9-11] showed that magnetic resonance imaging (MRI) and positron emission tomography (PET) can be used to monitor the response of tumors to treatment, and a study by [12] demonstrated that the use of "radiomics", which involves extracting a large amount of image features, can provide valuable information about disease progression, thus offering more personalized and predictive means of tracking.

In sum, the integration of new medical image processing technologies in the care of cancer patients has not only improved the precision of diagnosis and treatment but also had a positive impact on patient monitoring.

The aim of this study is to highlight how the use of HOROS, an open-source software, can enhance our ability to optimize the study of the intimate anatomical relationships of the tumoral process of the knee and its extension. Based on the data obtained by the vectorial reconstruction of sequential sections of the lower limb, we seek to improve patient care.

2. MATERIALS AND METHODS

Our study relies on a combination of Computed Tomography (CT) imaging and image analysis via the open-source software HOROS to examine an osteosarcoma in the knee of a 30-year-old patient. Osteosarcoma is a type of cancer that tends to manifest in areas of rapid bone growth, notably the knee [13, 14].

We began by obtaining CT sections of the patient's knee. CT, also known as scanography or CT scan, is a medical imaging technique that uses a combination of X-ray technology and computer techniques to produce cross-sectional images of the body. It is a valuable tool for diagnosing tumors, monitoring the response to treatment, and guiding surgeons during operations. As [15] highlight, the use of CT was instrumental in our understanding of pathological processes.

This CT data was then imported into the HOROS software for further analysis. HOROS is an open-source medical imaging platform, offering capabilities for visualizing and analyzing medical images. Notably, HOROS can take CT images and reconstruct them in 3D through a process called surface reconstruction and Virtual Reality (VR). This approach provides a more

comprehensive and detailed perspective of the tumor, allowing clinicians to visualize the size, shape, and position of the tumor relative to surrounding structures.

Thus, by combining CT data with image analysis via HOROS, we were able to obtain a detailed three-dimensional representation of the patient's osteosarcoma. This provided a better understanding of the tumor, thus facilitating more precise and personalized treatment planning.

3. RESULTS AND DISCUSSIONS

The use of three-dimensional volumetric modeling to analyze knee CT slices has proven to be a valuable tool in our evaluation of a 30-year-old patient with a tumor in the left knee. Biopsy results confirmed it as osteosarcoma, a form of cancer that typically affects long bones in the body, such as the femur [16].

With 3D imaging technology, we were able to visualize in detail the neoplastic process affecting the lower end of the patient's left femur. The obtained images provided us with a comprehensive perspective on the relationships between the tumor and the surrounding soft tissues, a crucial feature for understanding the impact of the disease and planning surgical interventions.

Our analysis also revealed the infiltration of the tibial plateau by the tumor, a factor that can have significant implications for the patient's mobility and available treatment options [17]. Additionally, we observed signs of malignant osteocondensation, a characteristic commonly associated with osteosarcomas.

This approach allowed us to obtain a detailed spatial representation of the disease's extension, thus facilitating a better understanding of the patient's condition. It is important to note that 3D imaging goes beyond mere visual representation; it provides valuable clinical information that can significantly influence patient management.

Figure 1 illustrates a reconstruction based on slices obtained through Computed Tomography (CT), specifically surface and vector-based reconstructed slices, detailing the structure of the knee joint in a 30-year-old patient. The patient was admitted with an aggressive osteosarcoma that had spread to the lower end of the femur and upper end of the tibia. This visualization offers a detailed and precise representation of the affected area, allowing for a more thorough diagnosis and optimal treatment planning.



Figure 1: 3D reconstruction of knee osteosarcoma from CT slices



Figure 2: 3D modeling of the femoro-tibial joint skeleton

Figure 2 illustrates an advanced volumetric 3D modeling constructed from CT slices for the same patient. This modeling was performed in the context of an advanced assessment of a neoplasm in the left knee, already diagnosed in the patient. The model clearly reveals infiltration of neighboring structures and the tibial plateau. Additionally, it highlights signs of malignant osteocondensation at first glance. These findings may indicate disease progression, underscoring the severity of the situation for the patient and the need for surgical intervention.



Figure 3: Vectorial segmentation of soft tissue invasion

The three-dimensional reconstruction depicted in Figure 3 provides optimal visualization of the tumor process. It allows for a meticulous study and comparison of normal and pathological anatomical structures. This 3D modeling technique also facilitates precise localization of the tumor and assessment of its relationship with surrounding molecular structures. Such three-dimensional visualization is particularly useful in guiding surgical intervention more effectively and safely, offering a better understanding of the anatomomorphological context of the disease.



Figure 4: Exploration of knee osteosarcoma

Figure 4 illustrates how three-dimensional modeling provides an innovative perspective on tumor progression. This advanced tool not only allows observation of structural changes occurring in the affected anatomical elements but also enables a more accurate visualization of the extent of neoplastic proliferation. This approach greatly enhances understanding of the tumor process by providing a more comprehensive and detailed visual representation of the interaction between the tumor and adjacent tissues.

4. CONCLUSION

In conclusion, our study has demonstrated the importance of applying advanced imaging techniques to enhance the understanding and treatment of pathological conditions, particularly knee osteosarcoma. Through the use of Computed Tomography (CT) lower energy imaging and the image analysis software HOROS, we were able to obtain an accurate three-dimensional representation of the tumor in a 30-year-old patient.

The 3D modeling allowed for clear visualization of the tumor process and its anatomical relationships, both normal and pathological. This greatly facilitated tumor localization in space,

thereby enabling better patient management. The information obtained was invaluable in treatment planning and optimizing therapeutic decisions.

Furthermore, this study highlighted the importance of modern imaging technologies in improving our understanding of structural changes in anatomical elements. By providing practitioners with a different perspective on the tumor process, these advanced visualization tools have the potential to transform how we approach and treat tumor conditions.

Overall, these results underscore the potentially revolutionary role of digital imaging technologies in tumor diagnosis and treatment. Their integration into daily clinical practice holds the promise of significantly improving the quality of care provided to patients, offering a level of precision and understanding that was previously unattainable. Further exploration of these techniques represents a promising research direction for the future of medicine.

REFERENCES

1. Beckmann, E.C., *CT scanning the early days.* The British journal of radiology, 2006. **79**(937): p. 5-8.
2. Shrimpton, P. and S. Edyvean, *CT scanner dosimetry.* The British journal of radiology, 1998. **71**(841): p. 1-3.
3. Dierick, M., et al., *Recent micro-CT scanner developments at UGCT.* Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 2014. **324**: p. 35-40.
4. Madabhushi, A. and G. Lee, *Image analysis and machine learning in digital pathology: Challenges and opportunities.* Medical image analysis, 2016. **33**: p. 170-175.
5. Liu, X., et al., *A comparison of deep learning performance against health-care professionals in detecting diseases from medical imaging: a systematic review and meta-analysis.* The lancet digital health, 2019. **1**(6): p. e271-e297.
6. Dipaola, M., *3D printing in orthopaedic surgery*. 2018: Elsevier Health Sciences.
7. Wong, R.M.Y., et al., *3D printing in orthopaedic surgery: a scoping review of randomized controlled trials.* Bone & Joint Research, 2021. **10**(12): p. 807-819.
8. Kersten-Oertel, M., et al., *Augmented reality in neurovascular surgery: feasibility and first uses in the operating room.* International journal of computer assisted radiology and surgery, 2015. **10**: p. 1823-1836.
9. Aerts, H.J., et al., *Decoding tumour phenotype by noninvasive imaging using a quantitative radiomics approach.* Nature communications, 2014. **5**(1): p. 4006.
10. Sala, E., et al., *Unravelling tumour heterogeneity using next-generation imaging: radiomics, radiogenomics, and habitat imaging.* Clinical radiology, 2017. **72**(1): p. 3-10.
11. Yoon, H.J., et al., *Decoding tumor phenotypes for ALK, ROS1, and RET fusions in lung adenocarcinoma using a radiomics approach.* Medicine, 2015. **94**(41).
12. Gillies, R.J., P.E. Kinahan, and H. Hricak, *Radiomics: images are more than pictures, they are data.* Radiology, 2016. **278**(2): p. 563-577.
13. Widhe, B. and T. Widhe, *Initial symptoms and clinical features in osteosarcoma and Ewing sarcoma.* JBJS, 2000. **82**(5): p. 667.

14. Dorfman, H.D. and B. Czerniak, *Bone cancers.* Cancer, 1995. **75**(S1): p. 203-210.
15. Scarfe, W.C., A.G. Farman, and P. Sukovic, *Clinical applications of cone-beam computed tomography in dental practice.* Journal-Canadian Dental Association, 2006. **72**(1): p. 75.
16. Ferguson, J.L. and S.P. Turner, *Bone cancer: diagnosis and treatment principles.* American family physician, 2018. **98**(4): p. 205-213.
17. Bacci, G., et al., *Prognostic factors for osteosarcoma of the extremity treated with neoadjuvant chemotherapy: 15-year experience in 789 patients treated at a single institution.* Cancer: Interdisciplinary International Journal of the American Cancer Society, 2006. **106**(5): p. 1154-1161.