Original Article

Orthopaedic tumors: What problems are we solving, and are universities and major medical centers doing enough?

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This work is dedicated to the spirit of physicist Abdul Jabbar Abdullah for his pioneering work in vibrations of the hurricane.

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ABSTRACT

Little has been published about the complexity of orthopaedic tumors compared to others tumors. The current study in the literature treated this problem in terms of classification, surgical intervention and impact on the patient. In this article, factors risks of tumors will be we identified. A strategy based on three dimensional simulations will be explained in order to improve the clinical trials.

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1. Orthopaedic tumors: a high urgency

According to the American Cancer Society, 3300 new cases will be diagnosed and 1490 deaths from these cancers are expected annually.¹ In adults, chondrosarcomas represents 40% of primary bone cancers, this is followed by osteosarcomas (28%), chordomas (10%), Ewing tumors (8%), and malignant fibrous histiocytoma/fibrosarcomas (4%). Osteosarcoma represents (56%) of primary bone tumors in children and teenagers (those younger than 20 years). The classification of bone tumor remains a complex process.² Improved diagnostic criteria are needed to pass from a broad classification to a more accurate classification. Further, accurate diagnosis of the biological cell type of a tumor presents a meaningful guide for best treatment options for the patient. In order to meet this challenge, we need to identify and understand specific phenotypes and genetic alterations.³ Many researchers agree that the cell of origin in mesenchymal tumors is often not identified.⁴ Recently, important genetic data become available for bone tumors which can help orthopaedists to understand the diagnosis and prognosis.⁵ For example, the identification of translocations in Ewing's sarcoma⁶ increases the opportunity to

more specifically classify the tumors based on pathogenesis. In the next section, we will focus on the importance of medical images to localize cartilage and skull based tumors.

Cartilage tumors vary in severity from a benign enchondroma to low-grade malignant chondrosarcoma to the highest-grade dedifferentiated chondrosarcoma.^{7,8} It is very difficult to distinguish the grade of a cartilage tumor in term of 1) location i.e. cartilage tumors of pelvis and scapula are typically more dangerous compared to hands and foot cartilage lesions, 2) size i.e. enchondromas over 5 cm are uncommon, 3) pain and 4) the nature of radiographic imaging used i.e. CT⁹ is particularly useful in evaluating the relation of an endosteal cartilage tumor spread beyond the adjacent cortex. MRI signal characteristics can help to delineate the malignancy of tumors based on features such as the lack of intralesional mineralization. Some studies^{10,11} recommend the use of intralesional curettage as an effective solution for diagnosis and treatment of low grade and borderline tumors. Unfortunately the cartilage tumors in the case studies described above resulted in an unexpectedly poor outcomes.

There are many types of skull based tumors which can be classified by their location in the skull base including meningiomas,¹² schwannomas,¹³ pituitary adenomas,¹⁴ angiofibromas,¹⁵ and chordomas.¹⁶ In these example cases, the resection is controversial and nearly impossible because the internal carotid artery (ICA) is frequently, partially or completely encased by tumor. Some researchers advocate the resection of skull base meningiomas.¹⁷

Abbreviations: MRI, Magnetic Resonance Imaging; CT, computed tomography; O3DC, orthopaedic 3D collection.

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For others skull based tumors, stereotactic radiosurgery represents a treatment option to improve the clinical management. Meningiomas and schwannomas are very sensitive to radiation therapy. To overcome the limitation of carotid artery involvement, revascularization techniques¹⁸ are among the methods used to overcome this problem. The revascularization can be performed by these surgical methods: 1) the carotid artery can be bypassed with an interposition saphenous vein graft, 2) a saphenous vein graft can be placed from the ICA or external carotid artery (ECA) to the middle cerebral artery (MCA) or other intracranial vessel and 3) the superficial temporal artery (STA) can be anastomosed to the MCA. Preoperative evaluation of invasion of the carotid is unreliable by computed tomography (CT), magnetic resonance imaging, or conventional angiogram. In addition, the location of carotid involvement by the tumor is a challenge. At the end of surgery, the exposure of the carotid artery to the nasopharynx can reportedly result in a carotid rupture or a vascular wall infection.^{19,20}

We have seen that conventional radiologic studies have a limitations place in their ability to identify tumors but they are a starting point. Scanners provide images where the differentiation of tissue components is small and tumor delimitation is approximate. The surgeon will not hesitate to ask for additional information to guide his surgical plan in the area where the tumor appears, or to specify the relationship between the tumor and some adjacent critical anatomical structures. Tumor resection requires good cutting accuracy to achieve satisfactory margins.^{21–24} The treatment of these cartilaginous lesions should involve a multidisciplinary team including a musculoskeletal surgeon, a radiologist, and a pathologist.

2. The newest direction: from complexity to precision

Precision in oncologic surgery is essential to achieve adequate margins in bone tumor resections. To preserve as much unaffected tissue as possible without invading tumor margins. With the advent of high-speed, high-capacity computers, commercial simulators are now available that provide a good environment for surgical training and tumor mapping,^{25–27} with few applications reported for orthopedic surgery. Mediouni et al.^{28–33} proposed a platform O3DC which contain all 3D bone and surgical instruments which aims to help software designers to construct their simulators with many details. Handels et al.³⁴ presents a software VIRTOPS (VIRTual Operation Planning in Orthopaedic Surgery) which aims to simulate a modular prostheses in bone tumor surgery for a hip joint. In the case of a pelvic tumor, three-dimensional models of the patient's hip are generated based on CT image data. During the 3D planning process, the orthopaedist defines the position and geometry of the custom-made endoprosthesis for complete join replacement. The benchside work of Cartiaux et al.³⁵ focused on pelvic bone tumor surgery using a CT-scanner in order to improve limited visibility and restricted working space of pelvic surgery. In the work of Shi³⁶ CT imaging data were transferred and integrated in a Dextroscope to produce a Virtual Reality simulation. However, the simulation has been limited in terms of the clarity of anatomy. A Three-dimensional full-scale model of the cervical spine was produced using CT angiography data.³⁷ The model clearly showed the anatomical relationship between the destroyed vertebral bony structures and deviations in the paths of the Vertebral Arteries. According to Ritacco et al.³⁸, precision in oncologic surgery is essential to achieve adequate margins in bone tumor resections. A 3D model of images are also well visualized through (3D OrthoMap navigation software version 1.0; Stryker Navigator, Freiburg, Germany).³⁹ The accuracy of the procedure may be measured by matching the preoperative virtual planning with the 3-D virtual surgical specimen obtained after tumor resection. Ding et al.⁴⁰ explained

the outcomes of the use of computer-aided design for the resection of tumors around the knee. This technique allows the surgeons to remove precisely the tumor from a pre-operative 3-D map. Several steps must be identified to achieve a good surgical tumor resection outcome several critical steps are noted: (1) the identification of the tumor's anatomical boundaries using two types of data: the 2D CT to reconstruct a 3D anatomical model of bone and the 2D MRI to reconstruct a 3D model of the tumor's extent and involvement of critical structures region. (2) These templates guide the most accurate tumor resection.

Scientists are also finding that bone tumors can hijack normal cells and tissues growing. For that purpose, tumor orthopaedic community must focus on many points that include:

- Improving the accuracy and precision of tumor resections, these tasks are very complicated, especially in lieu of the adjacent neurovascular structures. Various methods are being investigated using three dimensional medical images that include CT and fluoroscopy to aide intra-operative progress.
- Improving the localization of tumors using the best method of reconstruction.
- Providing an overview for this strategy for all bone include pelvis, spine, and sacrum.
- Providing a navigation system for the skull which help surgeons in training in order to understand the exact treatment for tumors.
- Developing software that helps to operate include 3D dose calculation, dose-volume histogram analysis, and tumor dose escalation.

3. Conclusions

3D tumor simulation is a requirement to create precise anatomical visualization with added benefits for radiologists, referring physicians and patients and their surgeons and to reduce costs for the healthcare system. By producing a concise detail, 3-D tumor mapping can minimize damage to healthy tissue, facilitate diagnoses, treatment and surgical planning and Increase clinical productivity. Further study is required to quantitate the overall economic and social benefits of computer simulation for surgical training and computer tumor mapping in improving patient outcomes. Finally, we conclude based upon the forty articles in the reference section all of which are in the last decade that universities and major medical centers are doing enough to improve the clinical management of Orthopaedic tumors. There is still much to be done to improve the survivorship in this challenging oncologic population.

Conflict of interest

The authors have none to declare.

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