General Principles of Imaging

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7.1 Bone Tumors

Bone imaging has undergone significant changes during the last decades. Ultrasounds, CT, MR imaging, and PET have been added to arteriography, scintigraphy, and radiographs. At the same time, survival of primary malignant tumors has improved with chemotherapy and local results with conservative surgery. Imaging plays a major role in diagnosis, local and general staging, monitoring the treatment, and detecting recurrences.

7.1.1 Diagnosis

Patient age, location (bone or part of the bone involved), size (small is usually benign), calcifications and ossifications, limitation (the better seen, the slower the lesion growth), periosteal bone formations, and soft tissue involvement must be added to reach a reliable diagnostic probability. Combining clinical information, imaging and histology lead to the most accurate results. Diagnosis of a bone tumor must be teamwork.

Radiographs remain the mandatory first step. They allow diagnosis of "leave-me-alone" lesions, and nothing more is usually added. If the lesion on radiographs is probably malignant, the next step should be immediate MR to stage the lesion.

Radiographs have limitations: superimpositions, partial cortex destruction could be overlooked, flat and short bones and soft tissues are poorly analyzed.

CT is used in case of a diagnostic problem on radiographs. It allows a better study of the cortex, to detect and analyze small calcifications and thin periosteal bone formations. The nidus of an osteoid osteoma is well found (much better than on MR). Measuring tissue density can help characterize fat, fluid, blood, and calcification. After injection of contrast medium, soft tissue extension and vessels are well located.

The contrast remains however much lower than on MRI, which is the main modality for local staging. Its diagnostic role is limited, as calcifications and periosteal bone formations are more difficult to analyze (a black signal on MRI may be a calcification, but also fibrous tissue or chronic bleeding with hemosiderine). Fluid-fluid levels are better depicted than on CT, because of higher contrast and longer examination time. They are frequently seen in aneurysmal bone cysts, but are non-specific. Peritumoral imflammatory reaction is very well detected and frequent in some benign tumors (osteoid osteoma, osteoblastoma, chondroblastoma, Langerhans cell histiocytosis), and infections are rarer and more limited in malignant tumors.

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P. Picci et al. (eds.), *Diagnosis of Musculoskeletal Tumors and Tumor-like Conditions*,
https://doi.org/10.1007/978-3-030-29676-6_7

7.1.2 Local Staging

On MRI, the precise location of the tumor is well analyzed.

Intramedullary extension (and the level of surgical resection), skip metastases, soft tissue involvement, and extension to vessels and nerves are easily and reliably detected. The main limitation is articular extension, which could change the surgical technique: if the tumor abuts on the cartilage, joint involvement cannot be reliably predicted.

In case of contraindications (pace makers and metallic ocular foreign bodies), CT is used, but has a lower accuracy.

7.1.3 Distant Spread

Bone metastases and multiple lesions are detected on scintigraphy. Total body MRI is more sensitive without irradiation. Pulmonary metastases are seeked by chest CT. Its sensitivity is good, but specificity is lower (or if we detect a lesion, we are not sure that it is actually a metastasis).

PET, now combined with CT, or even MRI allows a global study of the patient, studying the tumor metabolic activity as well as the distal extent. Its spatial resolution is limited (lesions of less than 5 mm may be overlooked), and some malignant lesions are not very active metabolically (such as sclerotic metastases).

7.1.4 Evaluation of Treatment Effectiveness

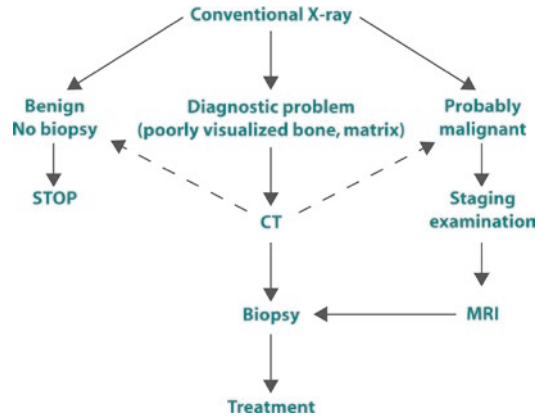
Most primary malignant tumors are treated with preoperative chemotherapy. Decrease of lesion size, ossification, and decrease of early contrast medium uptake on scintigraphy and most of all dynamic MRI are signs of an efficient treatment. They become reliable only late after the beginning of chemotherapy. The initial results of PET are not (yet?) much better.

7.1.5 Detection of Local Recurrences

In case of suspicion, a local MR can be performed if the prothesis is non-paramagnetic (that is in titanium).

7.1.6 Summary

Radiographs remain the first step to image a bone tumor. In case of diagnostic problems, the next step is CT. MR is the main imaging modality for local staging, treatment evaluation, and detection of recurrences. PET is still under evaluation.



7.2 Soft Tissue Tumors

Imaging problems are completely different from bone tumors. The main responsibility of the radiologist is to think of a possible sarcoma in front of a big (more than 5 cm of diameter), deep, or pediatric mass and refer it to a reference center before the first biopsy. That would prevent inadequate treatments with sometimes disastrous local or general consequences.

Radiographs are the first imaging modality. They detect calcifications and check the state of the underlying bone and fracture risk.

Ultrasound examinations are used very often; the improvements of machines and level of radi-

ologists make them an useful tool. They are cheap, easily available, and safe. They confirm the mass, its exact location, help diagnose typical benign lesions, and guide biopsy. But they are difficult to reproduce and analyze for surgeons.

CT detects calcifications and local extension and can guide needle biopsy.

MRI is the main imaging modality. Its contrast is much higher. Thanks to its high contrast resolution and multiplanar imaging capability, MRI provides an anatomic and topographic depiction of the lesion, defining with great precision the relationship to muscle compartments, fascial planes, bones, and neurovascular structures. The usual tumor that has a low signal on T1-weighted sequences, high on T2, is heterogeneous. A different signal, high on T1w sequences, helps diagnose fat, blood, or melanin, a low signal on T2 calcium, fibrous tissue, or hemosiderin. A rapid and strong uptake of contrast medium is very sensitive and specific of malignancy.

Modern imaging techniques are not only of great importance for differential diagnosis of STT, they also play an important role in monitoring the effects of nonsurgical treatments and are sometimes useful in the detection of local and distant recurrence during postoperative follow-up.

Most recent developments are the introduction of positron emission tomography (PET) often combined with CT and the application of new MRI modalities (spectroscopy, perfusion, and diffusion). Although experience with these new techniques is still rather limited for STT, it is likely that they will have an increasing role in diagnosis, monitoring, and follow-up of these lesions in the nearby future.

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