Musculoskeletal tumors and tumor-like conditions: common and avoidable pitfalls at imaging in patients with known or suspected cancer

Part A: benign conditions that may mimic malignancy

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Abstract A wide range of musculoskeletal tumors and tumor-like conditions may be encountered when patients undergo radiological examinations. The imaging features of certain normal, reactive, benign neoplastic, inflammatory, traumatic, and degenerative processes in the musculoskeletal system may mimic malignant tumor; misinterpretation of the imaging findings can lead to inappropriate clinical management of the patient. This review describes and illustrates a number of such mimics that we have commonly encountered in our oncological imaging practice, and provides suggestions for avoiding each of these pitfalls. Because many orthopaedic surgeons interpret radiological images themselves, they need to be as aware as radiologists about these issues.

Introduction

At various points in the medical timeline of a patient with known or suspected cancer—ranging from initial detection of tumor to post-treatment follow-up—radiological examinations may depict a lesion in the musculoskeletal system. Some such lesions may be metastases, but others represent benign or other malignant tumors, or tumor-like conditions. For example, studies of patients with one known cancer and a suspicious bone lesion at imaging [1, 2] have found that in two to eight percent of patients, the bone lesion was the

initial manifestation of a second, previously unknown malignancy; in zero to four percent of patients, the lesion was benign. If a suspicious lesion is automatically assumed to represent a metastasis, those patients in whom the lesion is benign may be overtreated, and those in whom the lesion actually represents an unsuspected second type of cancer probably will not receive appropriate treatment for that second cancer. As in all of oncological imaging, accurate characterisation of lesions is essential for proper clinical management.

A prior review [3] described pitfalls in MR image interpretation that resulted in referral to an orthopaedic oncology clinic for suspected malignancy. In this first part of a different, two-part review, we present several other interpretive pitfalls that we have commonly encountered in the musculoskeletal system during radiographic, CT, MRI, or PET/CT evaluation of patients with known or suspected cancer, focusing specifically on benign conditions that may mimic malignancy. These pitfalls have been selected based on the authors' collective experience working in a dedicated cancer centre. Increased awareness of such pitfalls is particularly helpful because they often are avoidable.

Benign conditions that may mimic malignancy

Myositis ossificans

Myositis ossificans (MO) is a non-neoplastic and self-limiting calcified mass that is typically found in skeletal muscles. A history of preceding trauma may or may not be present. The imaging appearance of MO varies with the stage of its evolution [4]. Radiography and CT (Fig. 1a, b) may show calcifications within two to six weeks of the onset

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Fig. 1 Myositis ossificans. **a** AP view of left hip shows a well-circumscribed calcified mass (M) in the left buttock. **b** Axial CT image shows dense calcification (arrows) in the periphery of the mass (M), a characteristic finding in myositis ossificans. **c** Axial fat-suppressed T2-weighted MR image shows extensive inflammatory changes (arrows) surrounding the mass (M) in the left gluteal muscle. Note that the mass does not invade the adjacent acetabulum (A)

of symptoms, and sharply circumscribed ossification in the periphery of the mass within six to eight weeks [4]. The peripheral location of the ossification reflects the zonation phenomenon that is characteristic of MO at histopathological examination; in contrast, calcifications within other tumors are most dense in the central portions of those masses. At MRI (Fig. 1c), MO shows heterogeneous and high signal intensity in fluid-sensitive sequences due to proliferating fibroblasts and myxoid stroma in the centre of MO. Soft tissue oedema surrounding MO may persist for months in the early and intermediate stages; in the late stage, oedema around MO is no longer seen, and high T1 signal appears in MO, reflecting internal fatty maturation [4]. Since MO may simulate juxtacortical bone tumors such as osteochondroma or parosteal osteosarcoma, correlation with CT or MRI (Fig. 1b, c) helps to identify the soft tissue origin of MO separate from the subjacent bone.

Elastofibroma dorsi

Elastofibroma dorsi is a reactive process, not a true neoplasm, and nearly always occurs in a characteristic location, namely, deep to the serratus anterior muscle near the scapular tip [5]. The lesion often has a lenticular shape, and interdigitates with surrounding fat (a finding that should not be misinterpreted as representing an invasive, aggressive tumor) (Fig. 2a, b). The lesion enhances due to its fibrous content, and is bilateral in about one third of patients. Elastofibroma dorsi demonstrates mild to moderate FDG-avidity at PET [6] (Fig. 2c, d).

Calcific tendinitis

Calcific tendinitis produces extensive inflammation, which can cause bony erosions subjacent to the insertion of the affected tendon [7] (Fig. 3a, b). In addition, marrow oedema

Fig. 2 Elastofibroma dorsi, clinically suspected to represent desmoid tumour or sarcoma. Axial **a** contrast-enhanced CT image and **b** gadolinium-enhanced fat-suppressed T1-weighted MR image show similar-appearing masses deep to each scapular tip (arrows). The masses are lenticular in shape, and infiltrate the surrounding fat deep to the serratus anterior muscles. **c** Axial hybrid FDG PET/CT image in a different patient. The mildly FDG-avid mass deep to the right serratus anterior muscle represents elastofibroma dorsi (arrowheads). The FDG-avid left breast mass represents the primary breast malignancy (curved arrows)

Fig. 3 Calcific tendinitis in a patient with hepatocellular carcinoma, simulating a bone metastasis. Axial **a** CT image and **b** gadolinium-enhanced fat-suppressed T1-weighted MR image show a well-defined lytic lesion in the right ischial tuberosity (arrows). Lesion was new since preoperative CT, and was initially considered suspicious for metastasis. However, scrutiny of the overlying hamstring tendon shows a focus of calcification within it, consistent with calcific tendinitis. **c** Axial CT image obtained 17 months later shows nearly complete resolution of the right ischial lesion and the calcification within overlying tendon. Patient was treated only with non-steroidal anti-inflammatory medication in the interval

can be observed at MRI, sometimes at a considerable distance from the tendon insertion. Bone scan will show increased activity in every case in which the bone is involved. These findings can be misinterpreted as a bone tumor unless the relationship to the overlying abnormal tendon is appreciated, and the calcification in that tendon is demonstrated at radiography or CT. The erosions heal after treatment with nonsteroidal anti-inflammatory agents (Fig. 3c).

Osteoporosis

Multiple myeloma typically manifests on radiographs as diffuse osteopenia or as discrete, punched-out, lytic lesions. Such osteopenia cannot be readily distinguished from the more common senile or postmenopausal osteoporosis by radiography. In an older patient, small, poorly defined, rounded lucent foci are far more likely to be caused by osteoporosis than multiple myeloma [8] (Fig. 4). Patients with multiple myeloma and recognisable osseous disease on a skeletal survey are considered to have end-organ damage, and are generally referred for treatment; thus, it is critical not to over interpret every small, vague lucency as being due to myeloma.

Fig. 4 A 67-year-old male with multiple myeloma. **a** Radiograph of the left hip demonstrates a small lytic lesion (arrow) in the intertrochanteric region of left femur, which was considered suspicious for myeloma. **b** Corresponding coronal T1-weighted image from a whole-body MRI demonstrates no underlying osseous lesion. Finding at radiography was consistent with focal osteopenia

Red marrow

In healthy adults, patchy areas of red marrow are commonly seen within the proximal metaphyses of humeri and femora [9] and in the distal femur [10]. Red marrow reconversion frequently occurs in chronic illnesses that cause an increased haematopoietic demand, such as patients with cancer or myeloproliferative disorders, or after administration of marrow-stimulating medication.

Red marrow should not be mistaken for an infiltrative marrow process at MRI. Red marrow typically contains small amounts of interspersed fat, yielding a "feathery" appearance [11] (Fig. 5a), whereas tumors do not contain such fat (Fig. 5b). T1-weighted spin-echo MR images are thus essential for evaluation of bone marrow. On such images, the signal from a tumor is more homogeneous and nearly equivalent to that of adjacent skeletal muscle, whereas red marrow shows higher signal than muscle.

Sacral stress fractures

Sacral stress fractures are common, especially in the elderly or following pelvic irradiation. An "H"-shaped pattern of poorly defined sclerosis in the bilateral sacral ala paralleling the sacroiliac joints and extending across the central portion of sacrum is typical of sacral insufficiency fractures, and may be recognised on bone scintigraphy, PET, and MRI [12, 13] (Fig. 6). No associated soft tissue mass is present, unlike a bone metastasis or primary bone tumor. A lesion with these imaging features developing in the sacrum after radiation therapy for pelvic malignancy is highly likely to represent a postradiation pelvic insufficiency fracture, even if associated with increased FDG uptake at PET.

Fig. 5 Comparison of normal red marrow versus osseous metastasis at MRI. **a** Coronal T1-weighted MR image demonstrates irregular shaped, low signal regions in left acetabulum and proximal femur (*arrows*). These lesions are higher in signal than adjacent skeletal muscle and have a feathery and patchy morphology, reflecting the presence of foci of fatty marrow interspersed with reconverted red marrow. **b** Coronal T1-weighted MR image in a patient with thyroid cancer demonstrates a sharply defined, homogeneous subtrochanteric metastasis with signal similar to that of adjacent skeletal muscle (*arrowhead*)

Hill-Sachs lesion

The Hill-Sachs lesion is a complication of anterior shoulder dislocation; impaction and friction of the posterosuperior humeral head against the anteroinferior glenoid leads to

Fig. 6 Sacral insufficiency fractures. Coronal CT **a** and hybrid FDG PET/CT **b** images obtained after pelvic radiation for vulvar cancer. FDG-avidity in the sacrum could be mistaken for osseous metastases. However, the symmetrical distribution of FDG-avidity (*arrows*) and subtle fracture lines on CT (*arrowheads*) indicate that the findings are due to sacral insufficiency fractures

inflammation and cortical destruction [14]. Inflammation often is intensely FDG-avid, and thus can be mistaken for malignancy on PET/CT (Fig. 7). The posterosuperior location of the humeral head lesion together with a clinical history of recurrent anterior shoulder dislocations helps avoid misdiagnosis of tumor. Knowledge of patterns of metastatic spread is also valuable; for example, only rarely is bone the first metastatic site in a patient with colon cancer [5], so a solitary osseous lesion in a colon cancer patient with no other site of metastasis is unlikely to represent a metastasis.

Sternomanubrial arthritis

Osseous lesions that are FDG-avid at PET often raise the suspicion of malignancy. However, correlation with CT images sometimes can reveal a benign cause for the FDG-avid focus. Degenerative arthritis, for example, is readily recognisable when occurring in a shoulder, hip, or knee joint, but can represent a diagnostic dilemma in other sites such as the sternomanubrial joint [15] (Fig. 8). This pitfall has been previously described in MDP bone scintigraphy [16, 17]. The FDG-avid focus can be localised to the joint based on the concomitant CT images, and thus the benign aetiology of the FDG-avidity can be appreciated.

Pigmented villonodular synovitis

Tumors that contain abundant giant cells show considerable FDG activity at PET scanning [18]. One such tumor, pigmented villonodular synovitis (and its extra-articular

Fig. 7 Hill-Sachs lesion causing false-positive PET/CT in a woman with stage IIIB colon cancer. Axial CT **a** and hybrid FDG PET/CT **b** images performed for surveillance after right hemicolectomy and chemotherapy show an FDG-avid, lytic lesion in proximal right humerus that could be mistaken for metastasis (*arrows*). However, bone is a very unlikely first site of metastasis in colon cancer. The characteristic posterosuperior location in humeral head, in conjunction with a clinical history of right shoulder dislocations, allowed for confident diagnosis of a Hill-Sachs lesion

Fig. 8 Sternomanubrial arthritis, simulating metastasis. Axial CT **a** and hybrid FDG PET/CT **b** images in a woman with breast cancer and newly elevated CEA levels. An FDG-avid lesion in the sternum on the axial images is suspicious for an osseous metastasis (*arrows*). However, evaluation of the sagittal hybrid FDG PET/CT image localises the FDG-avidity to the sternomanubrial joint (*arrowheads*), a location with corresponding degenerative changes shown on CT **c**. This sternomanubrial arthritis was mistakenly interpreted as an osseous metastasis at an outside facility, and led to a bone biopsy (which yielded benign results)

counterpart, giant cell tumor of the tendon sheath), may be discovered incidentally during evaluation of a cancer (Fig. 9). Particularly if the location of a lesion would be atypical for the metastatic pattern of the known cancer, further evaluation with another imaging modality should be performed. In most cases of pigmented villonodular synovitis/giant cell tumor of the tendon sheath, MRI shows low signal intensity throughout much of the lesion due to the presence of haemosiderin [19], thus avoiding misdiagnosis of the lesion as a metastasis.

Fibrous cortical defect/nonossifying fibroma

A fibrous cortical defect, or the larger version called non-ossifying fibroma, is a common benign bone lesion typically detected in the second decade of life. The lesion undergoes remodelling and healing during adolescence or early adulthood, processes that may be associated with increased FDG-avidity [20, 21]. When an FDG-avid, lytic lesion in the cortex of a long-bone metaphysis is encountered in a young patient, radiographs can confirm the typical appearance of a

Fig. 9 Pigmented villonodular synovitis in knee, simulating metastasis in a patient with suspected lung cancer. **a** Coronal maximum-intensity projection image from PET scan shows foci of avidity in a small left lung nodule (*arrow*) and in an unsuspected mass in the right knee (*arrowhead*; SUV=10.2). Sagittal T1-weighted **b** and fat-suppressed T2-weighted **c** MR images show a well-defined mass in Hoffa fat pad, with low signal intensity on both images consistent with haemosiderin content (*curved arrows*). Biopsy results confirmed pigmented villonodular synovitis in right knee, and metastatic melanoma in left lung nodule (from patient's prior melanoma of left chest wall)

benign fibrous cortical defect/non-ossifying fibroma (Fig. 10), and avoid misdiagnosis of malignancy.

Conclusion

In conclusion, it is important for physicians reviewing the radiological images of patients with cancer to remind

Fig. 10 Benign fibrous cortical defect showing FDG avidity at PET, simulating a metastasis. **a** Sagittal hybrid FDG PET/CT image in a teenager after treatment for high grade pleomorphic sarcoma of left shoulder. An FDG-avid lytic lesion in the distal left femoral metaphysis (*arrow*) could be mistaken for an osseous metastasis. **b** Lateral radiograph of the knee demonstrates a well-circumscribed lytic lesion with a sclerotic border in the distal metaphysis (*arrowhead*), representing a benign fibrous cortical defect

themselves of various normal, reactive, benign neoplastic, inflammatory, traumatic, and degenerative processes that can mimic malignant tumors at imaging. The various common pitfalls described in this review can be avoided through careful evaluation of imaging features, and considering both benign and malignant processes when formulating a differential diagnosis. Particular caution is advised before ascribing every imaging abnormality to a malignant aetiology.

References

1. Cronin CG, Cashell T, Mhuirheartaigh JN, Swords R, Murray M, O'Sullivan GJ, O'Keefe D (2009) Bone biopsy of new suspicious bone lesions in patients with primary carcinoma: prevalence and probability of an alternative diagnosis. *AJR Am J Roentgenol* 193: W407–W410
2. Toomayan GA, Major NM (2011) Utility of CT-guided biopsy of suspicious skeletal lesions in patients with known primary malignancies. *AJR Am J Roentgenol* 196:416–423
3. Stacy GS, Dixon LB (2007) Pitfalls in MR image interpretation prompting referrals to an orthopedic oncology clinic. *RadioGraphics* 27:805–828
4. Kransdorf MJ, Meis JM, Jelinek JS (1991) Myositis ossificans: MR appearance with radiologic-pathologic correlation. *AJR Am J Roentgenol* 157:1243–1248
5. Naylor MF, Nascimento AG, Sherrick AD, McLeod RA (1996) Elastofibroma dorsi: radiologic findings in 12 patients. *AJR Am J Roentgenol* 167:683–687
6. Onishi Y, Kitajima K, Senda M, Sakamoto S, Suzuki K, Maeda T, Yoshikawa T, Ohno Y, Sugimura K (2011) FDG PET/CT imaging of elastofibroma dorsi. *Skeletal Radiol* 40:849–853
7. Flemming DJ, Murphey MD, Shekitka KM, Temple HT, Jelinek JJ, Kransdorf MJ (2003) Osseous involvement in calcific tendinitis: a retrospective review of 50 cases. *AJR Am J Roentgenol* 181:965–972
8. Dinter DJ, Neff WK, Klaus J, Bohm C, Hatks J, Weiss C, Schoenberg SO, Metzgeroth G (2009) Comparison of whole-body MRI imaging and conventional X-ray examination in patients with multiple myeloma and implications for therapy. *Ann Hematol* 88:457–464
9. Richardson ML, Patten RM (1994) Age-related changes in marrow distribution in the shoulder: MR imaging findings. *Radiology* 192:209–215
10. Lang P, Fritz R, Majumdar S, Vahlensieck M, Peterfy C, Genant HK (1993) Hematopoietic bone marrow in the adult knee: spin-echo and opposed-phase gradient-echo MR imaging. *Skeletal Radiol* 22:95–103
11. Hwang S, Panicek DM (2007) Magnetic resonance imaging of bone marrow in oncology, Part 1. *Skeletal Radiol* 36:913–920
12. Salavati A, Shah V, Wang ZJ, Yeh BM, Costouros NG, Coakley FV (2011) F-18 FDG PET/CT findings in postradiation pelvic insufficiency fracture. *Clin Imaging* 35:139–142
13. Tsuchida T, Kosaka N, Sugimoto K, Itoh H (2006) Sacral insufficiency fracture detected by FDG-PET/CT: report of 2 cases. *Ann Nucl Med* 20:445–448
14. Cetik O, Uslu M, Ozsar BK (2007) The relationship between Hill-Sachs lesion and recurrent anterior shoulder dislocation. *Acta Orthop Belg* 73:175–178
15. Nakamoto Y, Cohade C, Tatsumi M, Hammoud D, Wahl RL (2005) CT appearance of bone metastases detected with FDG PET as part of the same PET/CT examination. *Radiology* 237:627–634
16. Fink-Bennett DM, Shapiro EE (1984) The Angle of Louis. A potential pitfall ("Louie's Hot Spot") in bone scan interpretation. *Clin Nucl Med* 9:352–354
17. Puig S, Staudenherz A, Steiner B, Eisenhuber E, Leitha T (1998) Differential diagnosis of atypically located single or double hot spots in whole bone scanning. *J Nucl Med* 39:1263–1266
18. Aoki J, Watanabe H, Shinozaki T, Takagishi K, Ishijima H, Oya N, Sato N, Inoue T, Endo K (2001) FDG PET of primary benign and malignant bone tumors: standardized uptake value in 52 lesions. *Radiology* 219:774–777
19. Llauger J, Palmer J, Rosón N, Cremades R, Bague S (1999) Pigmented villonodular synovitis and giant cell tumors of the tendon sheath: radiologic and pathologic features. *AJR Am J Roentgenol* 172:1087–1091
20. Igaru A, Henderson R (2006) PET/CT follow-up in nonossifying fibroma. *AJR Am J Roentgenol* 187:830–832
21. Goodin GS, Shulkin BL, Kaufman RA, McCarville MB (2006) PET/CT characterization of fibroosseous defects in children: 18F-FDG uptake can mimic metastatic disease. *AJR Am J Roentgenol* 187:1124–1128