Polyarthritis, Musculoskeletal Masses, and Osteoporosis
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This chapter reviews imaging of “generalized” conditions of the musculoskeletal system. Chapter 14 deals with “particular” conditions of the musculoskeletal system. The three main points of this chapter are:

1. Evaluation of polyarthropathy relies on history, physical exam findings, and laboratory evaluation, with radiographs serving a minor, supporting role.
2. Most extremity masses are benign and not clinically significant. Imaging should be performed when malignancy is suspected or the cause is unclear on clinical evaluation.
3. Women over the age of 65 should have DXA to evaluate bone mineral density.

While this is a book on imaging, and while radiographs in arthritis may be dramatic and highly characteristic of specific diseases, imaging plays only a minor, supporting role in the initial diagnosis of polyarthropathy. Part of the reason for this is that while advanced rheumatoid arthritis (Figure 1), psoriatic arthritis, ankylosing spondylitis (Figure 2), calcium pyrophosphate dihydrate deposition disease (CPPD) (Figure 3), gout (Figure 4), and osteoarthritis (Figure 5) may have dramatic, obvious, and characteristic features, early in the course of these diseases (when the diagnosis is first made) the radiographic findings are usually much more subtle or even absent (Figure 6).
Figure 1. Severe rheumatoid arthritis in a 70 year old woman with chronic hand pain. “Ball-catcher’s” view of the hands shows multiple classic features of rheumatoid arthritis including extensive multilevel metacarpophalangeal joint subluxation/dislocation, extensive erosions, demineralization, and carpal collapse.

Figure 2. Ankylosing spondylitis in a 42 year old man with chronic back pain. A. AP plain film of the sacro-iliac joints shows erosions and loss of sharp definition along the inferior margins of the joints (arrows). B. Lateral plain film of the lower lumbar spine shows marginal syndesmophytes (black arrow) and “shiny corners” (white arrows) along the vertebral body margins.
Figure 3. Calcium pyrophosphate dihydrate crystal deposition disease (CPPD) in a 75 year old man with knee pain. A. AP plain film shows chondrocalcinosis of both menisci (arrows). B. Lateral plain film shows a small joint effusion in the suprapatellar bursa as well as synovial calcification (arrow).

Figure 4. Gout in a 62 year old man with longstanding pain and swelling along the index finger proximal interphalangeal joint. A. AP plain film of the hand confirms soft tissue swelling of the index finger and shows several underlying cysts (arrow). B. AP plain film at a higher magnification confirms several cysts, which show overhanging edges (arrows) typical of gout.
Figure 5. Osteoarthritis in a 58 year old woman with chronic knee pain. A. AP plain film of the knee shows osteophytic spurring, subchondral sclerosis, and medial compartment joint space narrowing (arrows). B. Lateral plain film shows extensive osteophytic spurring along the patellofemoral articulation (arrows).

Figure 6. Early rheumatoid arthritis in a 49 year old woman with recent onset of morning stiffness and polyarthropathy. A. AP plain film (taken two years prior to the onset of symptoms because of post-traumatic pain) shows a normal appearance of the metatarsal bones and metatarsal-phalangeal joints. B. AP plain film (taken following the onset of symptoms) shows joint space narrowing at the second toe MTP (black arrow) and subtle erosions along the third and fourth metatarsal heads (white arrows).
The first step of evaluation in a patient with polyarthropathy needs to exclude the “must not miss” diagnosis of septic arthritis. Some of these patients may have a characteristic clinical history: a sexually active young woman with skin lesions (and gonococcal arthritis), a Wisconsin patient with a history of a tick bite (and Lyme disease), or a patient who has had a total joint replacement which now hurts following a skin infection elsewhere in the body (with hematogenous spread of organisms to the prosthesis). Most patients with septic arthritis and polyarthropathy will show at least some findings of systemic illness (e.g., fever and weight loss), with laboratory values of elevated white blood cell count (WBC), erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Diagnosis typically relies on aspiration of joint fluid with demonstration of greater than 10,000 WBC/mcL consisting of at least 75% polymorphonuclear white cells. Since the joint aspiration may show turbid, worrisome fluid but not yield a positive culture, blood cultures done at the same time may be helpful. Plain film findings typically lag well behind the clinical features of septic arthritis: early films show only a nonspecific joint effusion, while such dramatic features as destruction of cartilage or erosion of adjacent bone occur only late in the disease process (Figure 7).

Figure 7. Septic arthritis and osteomyelitis in a 69 year old diabetic man with a draining ulcer along the base of the small toe metatarsal. A. AP plain film early in the course of the symptoms demonstrates an intact small toe metatarsal head. B. AP plain film six weeks later shows destruction of the metatarsal head (arrow) and proximal aspect of the proximal phalanx. C. Sagittal T1 weighted MR image shows dislocation of the proximal phalanx and decreased signal of the proximal phalanx (compare to the middle phalanx) and distal metatarsal, indicating osteomyelitis. D. Sagittal T2 weighted image shows fluid in the metatarsal-phalangeal joint (arrow) from septic arthritis.
If the history and physical examination do not strongly suggest septic arthritis, then multiple diagnostic considerations come into play. The ultimate diagnosis rests on a constellation of findings, since no one clinical feature, laboratory, or imaging test is definitive. The usual first step is to determine whether the disease is inflammatory or not, which is established by the presence of morning stiffness (especially prolonged morning stiffness), and redness, warmth, and swelling of the afflicted joints. While crystal arthropathies (gout and CPPD) may cause inflammation, they typically present with monoarthritis (see page 195) rather than polyarthritis. Inflammatory polyarthritis are much more likely to represent infections or postinfectious processes, or a rheumatologic disease, particularly rheumatoid arthritis, systemic lupus erythematosus (SLE), or psoriatic arthritis. In patients with inflammatory arthropathy, therefore, blood tests are helpful: rheumatoid factor and antibodies to citrullinated peptides may be positive in patients with rheumatoid arthritis, whereas antinuclear antibody is sensitive (but not specific) for SLE. Note that experts caution against indiscriminate use of laboratory testing since, for example, up to 25% of patients with rheumatoid arthritis may be seronegative, and many patients without rheumatoid arthritis will have a positive serum rheumatoid factor. The American College of Rheumatology has provided diagnostic criteria for the diagnosis of rheumatoid arthritis, with the presence of any four of the following seven features (generally present for at least six weeks) required for diagnosis: morning stiffness lasting one hour before maximal improvement; soft tissue swelling of 3 or more joint areas; arthritis of the hand joints; symmetric arthritis; rheumatoid nodules; serum rheumatoid factor; and typical radiographic changes of the hand and wrist. As noted above, the radiographic findings play a minor and supportive role, representing only one of seven features and not representing an absolute requirement for the diagnosis (the patient may have any combination of four of the seven features for the diagnosis).

To confuse matters further (at least radiographically) patients with psoriatic arthritis may present in any of at least three different fashions, one of which bears a strong clinical (and radiographic) resemblance to rheumatoid arthritis (the other two are dactylitis with a “sausage digit” and spinal arthritis). While the characteristic skin changes and/or nail pitting of psoriasis precede (or occur about the same time as) the arthritis in 85% of cases, in 15% of cases the skin manifestations only occur after the onset of the arthropathy.

Noninflammatory polyarthritis almost always represents osteoarthritis, in which case the diagnosis is usually straightforward since the clinical features including lack of morning stiffness, aggravation with motion, and improvement with rest, are relatively characteristic. Plain films may document joint narrowing, osteophytic spurring, subchondral sclerosis, and subchondral cyst formation (Figure 5).

MOST EXTREMITY MASSES ARE BENIGN AND NOT CLINICALLY SIGNIFICANT

Ganglia and nodules represent most soft tissue masses and are benign, of little clinical consequence, and do not require imaging. Ganglia represent collections of cystic or gelatinous material located near a joint or tendon, and likely represent an outpouching of joint synovium or the tendon sheath containing thickened or solidified fluid, particularly after communication is lost with the parent structure. Ganglia typically transilluminate, and surgeons will usually resect such lesions on the basis of the clinical examination without imaging. Even prior to surgical resection, office methods including aspiration and injection of steroids should be performed, as this may be successful in over 80% of patients. One location where imaging may be useful in the evaluation of ganglia is in the wrist, as MR may reveal occult ganglia in patients with chronic wrist pain (see Figure 26 page 209) – although in this instance the patient really does not have a palpable lesion (as the ganglia are occult).

Soft tissue nodules arise in a variety of conditions including repetitive trauma, silicone injection, rheumatoid disease, sarcoidosis, and vasculitis.
Nodules may also represent epidermoid cysts or gouty tophus (Figure 8). Multiple lesions tend to be infectious or inflammatory while solitary lesions may represent a noninflammatory nodule or tumor (Figure 9).

In cases where imaging is contemplated (again, not necessary unless the diagnosis is uncertain or malignancy is suspected), the three main imaging modalities to consider are:

**Plain film evaluation**

Plain film evaluation of bone tumors has traditionally been the method of choice for evaluation of suspected bone tumors, since it allows histologic characterization of many tumors (e.g., osteosarcoma, benign exostosis). In palpable lesions arising in soft tissue, plain films may also provide useful additional information by showing either calcification of the lesion or characteristic changes in the adjacent bone or joint allowing a diagnosis. Plain films may also show features of a lipoma or a cluster of phleboliths characteristic of hemangioma.

Acute inflammatory processes may be associated with periostitis of the adjacent bone, while chronic indolent masses may produce smooth remodeling of the adjacent bone, usually a feature associated with slow-growing, benign lesions. Frequently, however, plain films obtained for a palpable soft tissue mass are unremarkable.

**Ultrasound**

Ultrasound is most helpful in those situations where it is necessary to differentiate a cystic lesion from a solid one, since ultrasound is nearly 100% accurate in this task. Ultrasound may also be helpful in distinguishing lesions with internal flow on color Doppler imaging (e.g. tumors) from those without internal flow (e.g. blood clots), and for demonstration of suspected vascular malformations. Unfortunately, distinguishing one histologic type of tumor from another is usually not possible with ultrasound, and evaluation of adjacent bones and joints for secondary helpful diagnostic features is not as easy as with plain films (see above).
Figure 9. Giant cell tumor of the tendon sheath in a 50 year old woman with a palpable wrist mass. A. Axial T1 weighted MR study shows a soft tissue mass (arrows) between flexor tendons along the anterior aspect of the distal forearm near the radiocarpal joint. B. Axial T2 weighted image demonstrates the mass, which shows some T2 prolongation (increased signal intensity on the T2 weighted image). C. Coronal fat-suppressed proton density image demonstrates the mass (arrows) interposed between flexor tendons. D. Sagittal T1 weighted image demonstrates the isointense mass (arrow) deep to the marker, along the ventral aspect of the wrist superficial to the distal radius and the lunate bone.

**Magnetic resonance imaging**

Magnetic resonance imaging has supplanted CT in the evaluation of extremity soft tissue masses. It may allow a histologic diagnosis in the case of lipomas and allows near certainty in many other lesions (e.g. cysts and arteriovenous malformations). MR does not always allow histologic characterization, however, and in general cannot
determine with complete accuracy whether a lesion is malignant or benign. However, using available tables breaking down tumor types by location versus age and comparing the frequently seen lesions with the imaging features, it is usually possible to provide a brief differential diagnosis which contains the correct diagnosis. In addition, MR allows determination of important anatomic features of the tumor such as whether it is confined to its compartment of origin and whether it displaces or invades critical adjacent structures (for example, the neurovascular bundle). These factors figure into the orthopedic oncologist’s determination of the optimal approach or even whether the tumor is resectable.

One important caveat regarding apparent primary musculoskeletal tumors: it is best to proceed with biopsy of these lesions only after consultation with an orthopedic oncologist. Surgery for malignancy involves the resection of any tissue which may have come into contact with (and been seeded by) the neoplastic tissue. In the event that the tumor is malignant (which you won’t know until after the biopsy is performed), the orthopedic oncologist will need to resect the tract leading from the skin to the biopsy location. The surgeon will therefore want to direct the biopsy path to optimize results.

**WOMEN OVER THE AGE OF 65 SHOULD HAVE DXA TO EVALUATE BONE MINERAL DENSITY**

Osteoporosis is largely a silent disease without symptoms prior to (what may be a devastating) hip fracture. Indeed, fragility fractures of the spine are often asymptomatic and discovered when imaging the skeletal system for another purpose, for example, the thoracic spine fracture found on a chest radiograph (Figure 10) or the lumbar spine fracture found on an abdomen and pelvic CT (Figure 11).

Figure 10. Thoracic spine fragility fracture from osteoporosis in an 89 year old asymptomatic woman incidentally discovered on a lateral CXR done for admission to a nursing home. A. Lateral from a prior CXR (cropped to show detail better) done 8 years previously shows normal vertebral body heights. B. Lateral from the admission CXR shows wedging of a thoracic vertebral body, classic for an osteoporotic compression fracture.
At the same time, osteoporosis is an important disease to diagnosis. It is a widespread condition: in the USA there are over 1,500,000 fractures annually, including over 250,000 hip fractures\(^1\), numbers which will only increase with the aging of baby boomers and the associated shift of the “demographic bulge” to a higher age. It is associated with significant morbidity and mortality: 50% of hip fracture patients will not be able to walk without assistance, 25% will require long-term assistance, and there is a 10-20% mortality rate in the six months following fracture\(^1\). It is a source of tremendous medical expense: estimates of cost were $10 billion in 1995\(^1\). Finally, there is effective treatment for the condition, with nonpharmacologic and pharmacologic therapy resulting in a considerable decrease in the risk of fracture\(^10\).

Fortunately, there is an excellent tool for reproducible, cost-effective measurement of bone mineral density (BMD) with a minimum of radiation exposure: dual energy x-ray absorptiometry (DXA). While other methods of measurement of bone mineral density (for example, quantitative ultrasound and quantitative CT) exist\(^12\), DXA is preferred because the World Health Organization reference data were obtained by DXA\(^13\) and DXA measurements are incorporated into the WHO diagnosis and treatment guidelines. Prospective cohort studies have demonstrated a strong relationship between fracture risk and BMD.
measured by DXA\textsuperscript{14}, and randomized trials have shown a reduction of fracture risk with drug therapy based on DXA results\textsuperscript{15}.

To determine which patient may benefit from DXA, it is necessary to assess multiple factors including age, sex, menopausal status, body mass index, cigarette smoking, family history of osteoporotic fracture in a first degree relative, and use of oral corticosteroids\textsuperscript{16}. Women with elevated risk factors should be screened at least by age 60, and all women should probably undergo screening by age 65 even if they have no risk factors for osteoporosis\textsuperscript{16}. Screening in men is less well established, but men account for approximately 20-30% of all hip fractures with an associated high mortality rate\textsuperscript{16}, so screening should probably be considered for men over the age of 75 and for those with a history of oral corticosteroid use, alcohol abuse, or hypogonadism\textsuperscript{16}.

Regarding which part of the body to study, the patient’s overall risk of fracture may be estimated by measurement of any location, but fracture risk of a particular location (spine, hip, or forearm) is best estimated by measurement at that location\textsuperscript{17}. Therefore, hip measurement best predicts the likelihood of a hip fracture (more likely to be disabling). However, spine measurements are more sensitive to both loss of bone mineral density and regained density following treatment\textsuperscript{17}. Therefore, both hip and spine measurements are typically included in evaluation for osteoporosis. The report for a DXA study typically includes the BMD, a “Z-score” which is the number of standard deviations that the patient’s BMD is from an age matched cohort, and a “T-score” which is the number of standard deviations that the patient’s BMD is from peak bone mineral density in a young person. In addition, some reports may include a FRAX score, which is the 10-year likelihood of fracture based on a risk assessment tool developed by the WHO in 2008\textsuperscript{12}. Further evaluation and treatment must, of course, be individualized, but triggers for treatment consideration include a T-score of \(< -2.0\), or (if FRAX is available) a 10-year hip fracture risk of 3.0% or 10-year overall fracture risk of 20%\textsuperscript{10}. Note that using FRAX instead of the T-score as the basis of treatment will result in treating more older patients with higher (better) T-scores versus younger patients with lower (worse) T-scores because age is an independent predictor of fracture\textsuperscript{12}. This makes sense, particularly considering that more fractures occur in osteopenic (defined as a T-score between -1.0 and -2.5) rather than osteoporotic (defined as a T-score of less than -2.5) patients, simply because there are so many more osteopenic patients than there are osteoporotic ones\textsuperscript{12}. Nonetheless, for a given patient, decreases in BMD (and lower T-scores) are associated with increases in fracture risk. Note that a low Z-score (more than 2 standard deviations below the age-matched control group) should prompt investigation of an underlying cause beyond simply postmenopausal osteoporosis, e.g. glucocorticoid therapy or alcoholism\textsuperscript{10}.

Since up to one-sixth of patients taking bisphosphonates may continue to lose bone\textsuperscript{10} following institution of therapy, follow-up studies should be performed, usually at a two year interval. Follow-up studies should typically be performed on the same machine, because it is not possible to evaluate changes in BMD unless cross-calibration has been performed\textsuperscript{13}. In patients with a significant BMD decrease following treatment, further evaluation may include evaluation of therapy adherence, gastrointestinal absorption of medication, adequacy of vitamin D and calcium intake, or work-up for the development of another disease which may adversely affect bone mineral density\textsuperscript{10}.

**SUMMARY**

In patients with polyarthropathy, plain films play a minor, supportive role. Most extremity masses are benign, self-limited, and do not require imaging. Women over the age of 65 should have DXA to evaluate bone mineral density.
REFERENCES

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