Bone Destruction and Soft-tissue Masses of the Knee

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Case Presentation

A 56-year-old African American man presents with knee pain and palpable masses.

FIGURE 1. *Lateral (A) and AP (B) radiographs of the left knee demonstrate well-marginated erosions in the distal femur, proximal tibia and inferior patella. High-density, soft-tissue masses around the knee and a dense suprapatellar joint effusion are also present.*

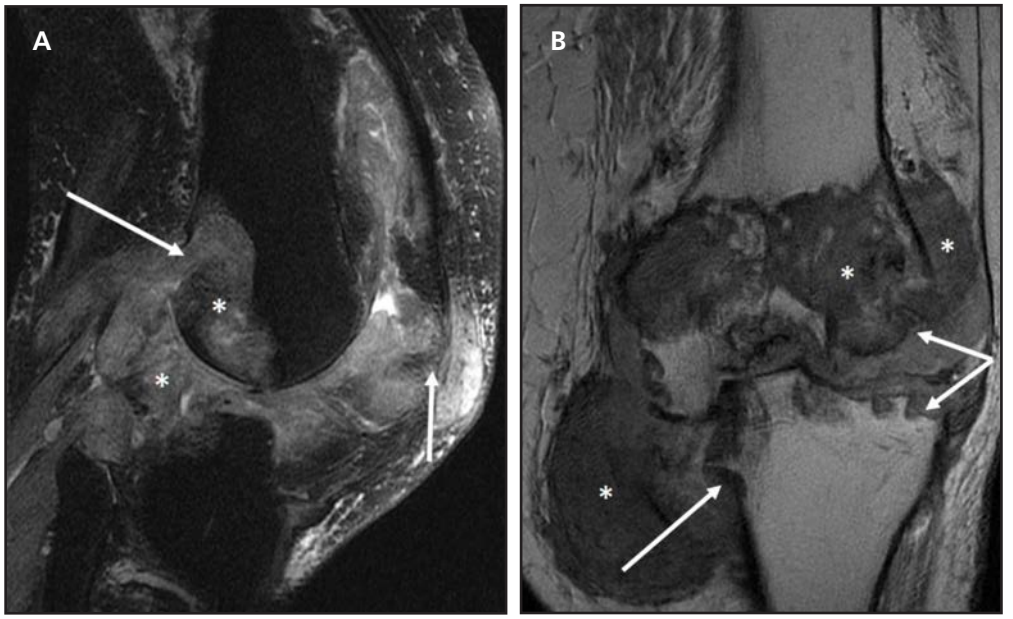

FIGURE 2. *Sagittal T2-weighted (A) and coronal T1-weighted (B) MRI images demonstrate multifocal erosions involving the femoral condyles, proximal tibia and patella (arrows) with multiple heterogeneously T2 hyperintense and T1 hypointense soft-tissue masses within the osseous structures, juxta-articular soft tissues and the prepatellar bursa (asterisks).*

Key Imaging Finding

Multifocal osseous erosions with intraosseous, intra-articular and juxta-articular soft-tissue masses

Differential Diagnosis

Gout
Calcium pyrophosphate deposition disease
Rheumatoid arthritis
Septic arthritis
Metastases

Discussion

Gout

Gout is a common deforming inflammatory polyarthropathy, the most common crystalline arthropathy, and is associated with significant morbidity.[1,2] It most commonly affects middle-aged to elderly white men with a 20:1 male to female predilection.[1,3] When afflicted, women are typically postmenopausal.[1,3]

Clinical presentation includes intermittent acute joint pain with associated redness and swelling, which may mimic septic arthritis.[1] Gout is often suspected during the clinical presentation. The diagnosis is supported by imaging findings combined with clinical and laboratory findings including hyperuricemia, monosodium urate (MSU) crystal formation (which is negatively birefringent) in the aspirate, and/or rapid resolution of symptoms following colchicine administration.[1]

Radiographic findings of gout are pathognomonic and include well-defined juxta-articular erosions that may extend outward secondary to reactive new bone formation to produce "overhanging edges."[1-4] In order to cause erosions, tophi must be present over an extended period, which differs from the earlier onset bone destruction seen with more aggressive processes such as septic arthritis.[3,4] When intraosseous tophaceous deposition occurs, it may demonstrate a more destructive appearance, emulating infection.

Distribution is often polyarticular and asymmetric, typically involving small joints.[1,5] The feet are most commonly involved with the greatest predilection for the first metatarsophalangeal (MTP) joint.[1,5] Other commonly involved joints include the interphalangeal joints of the feet and the interphalangeal and intercarpal joints of the hands. Bone mineral density and cartilage are generally preserved in contrast to other entities such as rheumatoid arthritis (RA) or septic arthritis, thereby generally preserving the joint space until later in the disease course.[3,5] Larger joints are less commonly afflicted, but when involved, the surrounding bursa (ie, prepatellar or olecranon bursa) are often affected.

Dual-energy CT and MRI may play a role when the presentation is atypical and can help demonstrate the soft tissue burden of the disease, but they should not be routinely used to diagnosis gout. On MRI imaging, tophi will demonstrate intermediate- or low-signal intensity on T1-weighted sequences and can show variable T2 signal intensity.[1] Enhancement patterns of tophi are also variable. Due to this variability, correlation with radiographs and the patient's clinical presentation is imperative as the MRI appearance is nonspecific and can be misinterpreted as infection or tumor.

Dual-energy CT scanners can acquire information at different energy levels (eg, 140 kVp and 80-100 kVp). The datasets from the low and high x-ray energies contain different information on the x-ray attenuation characteristics of the region imaged, allowing for the creation of a decompensation algorithm of the datasets. This algorithm uses soft tissue as a baseline, and the differences in attenuation between low and high energy allows for accurate and specific characterization and separation of calcium and monosodium urate.[6] While dual-energy CT can be useful in challenging cases, it should not be relied upon routinely to diagnose gout.

Ultrasound (US) may demonstrate underlying bony erosive changes and tophi.[1] The combination of joint effusion, tophus, bony erosions and a double contour sign (hyperechoic MSU crystals layering over hypoechoic hyaline cartilage) is reported as diagnostic in 97% of cases.[7]

CPPD Arthropathy

Calcium pyrophosphate deposition (CPPD) disease is the second most common arthropathy of the knee, predominantly in elderly patients.[3,8] Clinically, CPPD may be asymptomatic or mimic other entities due to acute, episodic attacks of joint pain.[3,8] Calcification of hyaline or fibrocartilage, known as chondrocalcinosis, is a hallmark finding in CPPD. Of the imaging modalities, radiographs are the most important when evaluating for CPPD, as diagnosis requires chondrocalcinosis deposition in two or more areas of the skeletal system.[1,3]

Severe degenerative changes isolated to the patellofemoral compartment in the knee, with associated chondrocalcinosis and preservation of medial and lateral joint space, are highly suggestive of CPPD arthropathy.[1,8] The crystal deposition inevitably accelerates breakdown of cartilage, resulting in joint space narrowing, osteophyte formation and subchondral cystic change, which can become so severe that CPPD may be mistaken for neuropathic (Charcot) joint. The lack of true erosions differentiates CPPD from gout and rheumatoid arthritis (RA). Preservation of bone mineralization differentiates CPPD from septic arthritis and RA. Extra-articular CPPD may occur focally in the soft tissues presenting as large soft-tissue masses adjacent to any joint.

CT and MRI are not usually obtained in the workup of CPPD arthropathy. US may be helpful in detecting CPPD cartilage deposits, which appear as linear hyperechoic foci within the hypoechoic cartilage, as opposed to hyperechoic foci layering on top of the cartilage as seen with gout.[1]

Rheumatoid Arthritis

RA is a systemic inflammatory disease of unknown etiology that primarily affects the musculoskeletal system. In RA the pathologic process targets the synovium of joints and tendon sheaths with involvement of the adjacent bone, tendons, joint capsule(s) and ligaments.[9] RA is a generally symmetric, polyarticular inflammatory arthropathy

with predilection for the distal extremities. Diagnosis is based on clinical and imaging findings and biochemical markers, such as elevated rheumatoid factor or anti-cyclic citrullinated peptide (anti-CCP/ACPA) antibodies.[1]

Radiographs are the imaging modality of choice for the initial workup. Early radiographic findings include soft-tissue swelling, joint distension, and tenosynovitis, as well as periarticular osteopenia and edema. The hallmark of RA is pannus formation that leads to cartilage loss and the classic marginal erosions at the intracapsular articular margins or "bare areas." As the disease progresses, osteopenia becomes more generalized and further cartilage loss results in worsening joint space narrowing.[1,3] Joint derangement progresses with ankylosis and/or joint subluxation/dislocation with eventual end-stage joint destruction.

MRI is excellent for detecting soft-tissue involvement, synovial inflammation and bone marrow edema signal, which are typically present early in the disease course.[1,8] US is an effective modality to detect synovial thickening, active synovitis and early erosions and can be used to monitor treatment response.

Septic Arthritis

In adults, joint infections usually result from hematogenous spread. The most common offending nongonococcal infectious agent is *Staphylococcus aureus*. Initial clinical presentation includes acute onset of monoarticular joint pain and swelling.[9] Laboratory evaluation typically shows elevated white blood cell count, erythrocyte sedimentation rate, and C-reactive protein levels. Urgent arthrocentesis should be performed to identify causative agent(s) and exclude other entities with similar clinical presentations such as crystalline and inflammatory arthropathies.[10] Septic arthritis in a native joint is a medical emergency and requires antibiotic administration as well as surgical washout within 24-48 hours. If untreated, the proteolytic enzymes in the bacteria can lead to permanent joint destruction and loss of function.

Conventional radiographs may be normal initially, or may demonstrate a joint effusion, juxta-articular osteopenia, or early erosive change with indistinctness of the cortex. Over time, as the cartilage and bone are destroyed, radiographs may demonstrate joint space narrowing and progressive bone destruction.

US allows for real-time imaging guidance for joint aspiration to facilitate diagnosis and treatment. CT and MRI do not play a role in imaging septic arthritis, as the diagnosis should be based on the patient's clinical picture, with emergent aspiration performed prior to any advanced imaging.

Metastatic Disease

Osseous metastases are common in the adult population and may be purely lytic, purely sclerotic, or mixed lytic/sclerotic in appearance. Most bone metastases occur in areas rich in vascularized red marrow such as the skull, spine, ribs, pelvis and proximal long bones.[11] Since the small bones of the hands and feet are filled with fatty marrow, metastatic lesions are rarely found in these locations.[11]

Lytic osseous metastases generally have ill-defined margins and adjacent periosteal reaction, in contrast to the well-defined sclerotic margins common in benign bone lesions or in the setting of erosive/crystalline arthropathy.[11] Malignant bone tumors, whether primary or metastatic, may extend into a joint, but almost never begin in an intra-articular location.

Diagnosis

Tophaceous gout of the knee

Summary

Extensive osseous articular erosions with associated juxta-articular soft-tissue masses on radiographs may be caused by several entities, but attention to key radiographic characteristics and disease distribution often aids diagnosis, although correlation with clinical history and tissue sampling provides confirmation. The well-defined erosions, preserved bone mineralization, and surrounding increased soft-tissue density seen in this case help differentiate gout from other arthritides, as well as from more aggressive etiologies including septic arthritis and metastatic disease.

REFERENCES

1. Weissman B. Imaging of Arthritis and Metabolic Bone Disease. Philadelphia, PA: Saunders Elsevier; 2009:506-511.
2. Girish G, Melville DM, Kaeley GS, et al. Imaging appearances in gout. Arthritis 2013;2013:673401.
3. Brower AC, Flemming DJ. Arthritis in Black and White. Philadelphia: Elsevier Saunders; 2012: 293-308.
4. Thiele RG, Schlesinger N. Diagnosis of gout by ultrasound. Rheumatology 2007;46(7):1116-1121.
5. Hossaini M, Tetteroo E, Slaats FMA, Beumer A. The pathognomic radiologic features of gout in the fingers and review of the literature, including the latest drug therapy. Open J Radiol 2013:3(3):108-111.
6. Nicolaou S, Liang T, Murphy DT, Krozan JR, Ouellette H, Munk P. Dual-energy CT: a promising new technique for assessment of the musculoskeletal system. Am J Roentgenol 2012;199:S78-S86.
7. Jacobson JA. Musculoskeletal Ultrasound: 3rd Ed. Philadelphia: Elsevier; 2017:30-31,313-314.
8. Rosenthal AK, Ryan LM. Calcium pyrophosphate deposition disease. N Engl J Med 2016;374: 2575-2584.
9. Sommer OJ, Kladosek A, Weiler V, Czembirek H, Boeck M, Stiskal M. Rheumatoid arthritis: a practical guide to state-of-the-art imaging, image interpretation, and clinical implications. Radiographics 2005;25(2):381-398.
10. Horowitz D, Katzap E, Horowitz S, Barilla-LaBarca ML. Approach to septic arthritis. Am Fam Phys 2011;84(6):653-660.
11. O'Sullivan GJ, Carty FL, Cronin CG. Imaging of bone metastasis: an update. World J Radiol 2015:7(8):202..