6. You are shown an AP radiograph (Figure 1A), T1- (Figure 1B) and T2- (Figure 1C) weighted MR images of the left knee in a 14-year-old male with knee pain. Which one of the following is the MOST likely diagnosis?
   A. Osteosarcoma
   B. Ewing's sarcoma
   C. Giant cell tumor
   D. Chondroblastoma
   E. Aneurysmal bone cyst
Section I – Musculoskeletal

Question 6

Findings: AP radiograph of the knee shows a lytic lesion located entirely within the epiphysis of a skeletally immature individual. Coronal T1 and T2 weighted images of the knee show a small, well-defined lesion within the epiphysis with a low signal intensity margin on both sequences. The T1 weighted images show central decreased signal and decreased signal in the surrounding marrow fat. T2 weighted images show mildly heterogeneous increased T2 signal with increased T2 signal in the marrow fat. No aggressive features such as a soft tissue mass or aggressive periostitis are seen.

Rationales:

A) Incorrect. Osteosarcoma is a common malignant tumor in this age group, and the most common location is at the knee. Osteosarcomas of all types are usually metaphyseal. 75% of osteosarcomas are of the conventional or classic type. Although most conventional osteosarcomas are lytic, they are typically more destructive in appearance and are usually associated with aggressive periostitis rather than the benign appearance shown here. Cross-sectional imaging shows best any associated soft tissue mass. MRI is useful in showing any skip lesions, seen in approximately 10% of cases. CT scan of the chest is part of the usual staging process, with pulmonary metastases seen in approximately 15% at presentation.

B) Incorrect. Ewing's sarcoma is an aggressive malignancy of bone commonly seen in young children. It is one of the round blue cell tumors (like lymphoma and rhabdomyosarcoma) and is primarily a disease of the marrow. Ewing's sarcoma is most commonly located in the diaphysis of a tubular bone. Radiographs show the permeative, moth-eaten appearance of the tumor and the malignant “star-burst” periostitis of Ewing's. MRI best demonstrates the associated soft tissue mass and the extent of the tumor within the marrow. These tumors often are diagnosed late due to the constitutional symptoms (fever, malaise) which may be seen in the early phases of disease, mimicking infection.

C) Incorrect. Giant cell tumor is a tumor of bone which occurs in the epiphysis of long bones in skeletally mature individuals. It is most common at the knee. Giant cell tumor extends to an articular surface, and is classically completely lytic without mineralization within it or sclerosis around it. Although giant cell tumors may metastasize to the lung, malignant giant cell tumor is extremely rare. These tumors are treated with curettage and exothermic methylmethacrylate. Giant cell tumors are rarely multicentric; when this occurs, they are often associated with Paget's disease.

D) Correct. Chondroblastoma is a rare benign chondrogenic primary bone tumor seen in children before epiphyseal closure. Most occur around the knee or in the proximal femur. Radiographically, these epiphyseal lesions are eccentric and lucent, with well-defined sclerotic margins. Periosteal reaction is common. On MRI, chondroblastoma appears as well-defined areas of low to intermediate signal intensity on T1-weighted images and have intermediate or high signal intensity on T2-weighted images. A low-signal intensity rim, corresponding to a sclerotic margin, can also be seen.

E) Incorrect. Aneurysmal bone cyst (ABC) is a tumor-like lesion of bone consisting of eccentrically located in the metaphysis of a long bone. Pathologically the lesion has large blood filled spaces with a thin epithelial lining. ABC may be primary or secondary; blood filled spaces with loculation, and marked expansion of the bone. When secondary, they are most commonly seen in association with benign lesions such as chondroblastoma. MRI and CT will show the fluid-fluid levels with hemorrhage which are typical of these lesions. Soft tissue mass in association with ABC is extremely uncommon, and they rarely show any aggressive features.

Citations:

7. This 22-year-old male presents with knee locking and pain after an injury while playing basketball. You are shown sagittal proton density (Figure 2A) and T2- (Figure 2B) weighted MR images of the knee. Which one of the following is the MOST likely diagnosis?

A. Posterior cruciate ligament tear
B. Meniscal tear
C. Bone bruise
D. Patellar tendonopathy
E. Osteochondritis dissecans
Findings: Proton density and T2 weighted sagittal images of the knee at the level of the intercondylar notch show a small (5mm) focus of decreased signal on both sequences just inferior and parallel to the posterior cruciate ligament. This is the so-called “double PCL” sign, indicating a free meniscal fragment. The PCL itself is normal in appearance, as is the visualized bone marrow.

Rationales:
A) Incorrect. Tears of the posterior cruciate ligament are unusual. The PCL is an extremely strong structure, with twice the tensile strength of the anterior cruciate ligament. Injuries of the PCL represent only about 5-20% of knee injuries. The most common mechanism of injury of the PCL is a dashboard injury during a motor vehicle accident or contact sports such as football. Isolated injuries of the PCL are extremely rare, and there are usually associated injuries of the ACL, collateral ligaments or the menisci. Unlike the ACL, which consists of posterolateral and anteromedial bands, the PCL is a solid and highly organized band of collagen fibrils. On MRI, the PCL is solidly black on all sequences. Any increased signal within the PCL is abnormal and indicative of a partial tear. Rupture, when it occurs, is most common in its midportion (76%)

B) Correct. Bucket handle tears usually involve the medial meniscus in young athletes and present with locking of the knee. A bucket handle tear is a vertical tear with longitudinal extension from the posterior to the anterior horn. The inner fragment is unstable. Sagittal images show an abnormality in size of the anterior or posterior horns. An image through the intercondylar notch shows the displaced inner fragment of the tear paralleling the posterior cruciate ligament (the double cruciate sign). Coronal images reveal the peripheral the displaced fragment beneath the posterior cruciate ligament.

C) Incorrect. Bone contusions are common in knee injuries. Osteochondral impaction with “kissing” contusions involving the distal medial femoral condyle and lateral proximal tibial plateau are indicative of the forced valgus stress in external rotation which is typically the mechanism of injury in ACL tears. Bone contusions are felt to represent microfractures of bone trabeculae. T1 weighted MRI shows ill-defined areas of decreased signal, usually with no discrete fracture line. T2 weighted images, especially those with fat suppression, show diffuse increased T2 signal indicating edema.

D) Incorrect. Patellar tendinitis, or “jumper’s knee”, is a chronic condition associated with repetitive trauma resulting in microtears in the substance of the tendon. MRI shows thickening of the patellar tendon with increased T2 signal. It is most commonly seen in athletes participating in sports such as volleyball where jumping and abrupt quadriceps contraction are frequent. The proximal portion of the tendon is most often involved, and patients have pain and tenderness at the patellar insertion of the tendon. The normal appearance of the highly ordered patellar tendon on MRI is decreased signal intensity on all sequences. The patellar tendon seen in this examination is entirely normal, with no evidence for either chronic or acute injury.

E) Incorrect. Osteochondritis dissecans (OCD) describes idiopathic osteonecrosis involving subchondral bone in characteristic locations, including the lateral and medial femoral condyles at the knee. The underlying process is avascular necrosis. The focus of osteonecrosis is typically small, but may become displaced in the joint leading to crepitus and pain. MRI is a sensitive examination for evaluation OCD. Early in the process, marrow edema may be the prominent finding. Later on, MRI can predict instability of the in situ fragment, and is well suited to locating loose fragments which may be radiographically difficult to see. The typical location at the knee is within the lateral aspect of the medial femoral condyle, but other locations, including the patella, may be seen. The disease commonly presents in childhood or adolescence and is more common in boys. The age and MR appearance in the test case are inconsistent with the diagnosis of OCD.

Citations:
8. You are shown a lateral radiograph (Figure 3) of the left ankle of an 85-year-old woman with heel pain. Which one of the following is the MOST likely diagnosis?

A. Paget’s disease
B. Reiter’s syndrome
C. Insufficiency fracture
D. Osteomyelitis
E. Pathologic fracture
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Question # 8

Findings: Lateral radiograph of the ankle demonstrates markedly decreased bone density. The cortices are distinct. There is a curvilinear band of sclerosis in the posterior calcaneus.

Rationales:
A) Incorrect. Paget's disease is an idiopathic disease of bone consisting of a process of osteolysis with marked reparative changes. It is seen in elderly individuals and is more common in the northern United States and Great Britain. There are three distinct radiographic phases of the disease: lytic, mixed and sclerotic. In the lytic phase, the most common appearance is of a long, lytic lesion with a leading edge within a long bone, the so-called “blade of grass” appearance. The mixed phase shows lytic and sclerotic changes and the sclerotic phase shows the classic trabecular and cortical thickening. Common locations include the skull, pelvis, and spine. Complications of Paget's disease include deformity, pseudo fractures, congestive heart failure due to hypervascularity and rarely, sarcomatous degeneration. Paget's disease may involve the calcaneus and the age of this patient is appropriate, but the appearance of the test case is not consistent with Paget's disease.

B) Incorrect. Reiter's syndrome is characterized by a classic triad of arthritis, urethritis, and conjunctivitis. There is a male predominance. Peak age at diagnosis is 15 to 35 years. Common sites of involvement are the small articulations of the foot, the calcaneus, and the ankle, knee, and sacroiliac joints. Calcaneal inflammation occurs along the plantar aspects and causes ill-defined erosions, often at the attachment of the plantar fascia. Hyperostosis and spur formation are later findings. The sex and age of the test patient and the location of the abnormality in the test images are not consistent with the diagnosis of Reiter's syndrome.

C) Correct. Stress fractures result from repetitive muscular activity rather than direct trauma. Two basic types of stress fractures have been described: fatigue and insufficiency. Fatigue fractures occur in normal bone subjected to excessive stress. Insufficiency fractures result from normal or physiologic stress placed on bone that has less than normal elastic resistance, such as that seen in osteomalacia or osteoporosis. Senile osteoporosis is the loss of bone related to aging. The age of onset is the sixth or seventh decade for men and after menopause in women. Women are much more commonly affected until the ninth decade when the gender ratio equalizes. Trabecular bone is lost at twice the rate of cortical bone. Changes are generalized in the skeleton. Bone density may be measured by dual or single photon absorptiometry, quantitative computed tomography or by measuring the cortices of the second and third metacarpal cortices radiographically. Radiographs show markedly diminished bone density and also demonstrate the complications of osteoporosis, namely, insufficiency fractures. These are commonly located in the spine, ribs, hips and pelvis. Weightbearing bones such as the posterior calcaneus are also commonly affected, with the test case showing the classic features of an insufficiency fracture of the calcaneus.

D) Incorrect. Osteomyelitis may occur via hematogenous spread of a bacterial infection, spread from an adjacent source of infection, secondary to direct implantation or due to surgical manipulation or procedures. In adults and infants, the epiphysis of long bones may be involved due to vascular communication across the physis. In childhood, the physis acts as an effective barrier and most hematogenously spread infections occur in the metaphysis. Radiographs are insensitive in the early phases of infection. MRI and bone scan are both significantly more sensitive, and MRI also has increased specificity. Very early on, only soft tissue swelling and perhaps periostitis can be seen. As the disease progresses, radiographic changes including cortical destruction and erosions become more prominent. Advanced changes, including the formation of sequestra, involucra and sinus tracts may be seen. Soft tissue and intrasosseous abscesses are best demonstrated on MRI. Chronic osteomyelitis may lead to squamous metaplasia, and even squamous cell carcinomas. The calcaneus could be involved with osteomyelitis, either from direct penetration or extension from a heel ulcer. The test case, though, shows no periostitis or destructive changes to suggest osteomyelitis.

Incorrect. Metastatic disease is the most common tumor of bone in patients over the age of 40. About 80% of metastatic disease to bone is from breast, prostate, kidney or lung primaries. Hematogenously spread, most metastatic lesions involve the marrow-rich axial and proximal appendicular skeleton. Metastases distal to the elbows and knees are very uncommon, and most are from breast or lung carcinoma. Rarely metastases to the
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Phalanges are seen with bronchogenic carcinoma. Pathologic fractures are common in the case of lytic metastases in weightbearing bones such as the proximal femur. A metastasis to the calcaneus would be extremely rare, and there is no underlying lesion on the radiograph to suggest that this is a pathologic fracture.

Citations:
9. You are shown an AP radiograph (Figure 4A), T1- (Figure 4B) and T2- (Figure 4C) weighted images of the knee of a 35-year-old woman with pain and a chronic knee effusion. There is no history of prior trauma. No other joints are involved. Which one of the following is the MOST likely diagnosis?

A. Osteoarthritis
B. Gout
C. Synovial chondromatosis
D. Rheumatoid arthritis
E. Pigmented villonodular synovitis
Question # 9

Findings: All of the presented images show large, well marginated erosions in the distal femur and proximal tibia. There is a prominent synovial proliferation with decreased signal on both T1 and T2 weighting extending throughout the spaces around the knee, including into the popliteus tendon sheath. T2 weighed image shows a moderately large joint effusion.

Rationales:

A) Incorrect. Osteoarthritis is common in older patients, with the knee very commonly affected. Osteoarthritis has a mixed radiographic appearance, with hypertrophic changes including osteophyte formation and subchondral sclerosis, as well as subchondral cysts and even some erosive changes. The primary process in the development of osteoarthritis is cartilage degeneration, rather than a process involving the synovium as in the test case. Large joint effusions may be present, but they do not typically have any associated hemorrhage or hemosiderin deposition. Osteoarthritis is commonly a polyarticular disease. When a single joint is involved, it is usually due to antecedent trauma with damage to the joint surface and articular cartilage. This patient has not history of trauma, involvement of only a single joint and a relatively young age, making osteoarthritis unlikely.

B) Incorrect. The arthritis seen with gout is induced by intra-articular deposition of sodium monourate crystals. Aggregates of these crystals may form in the soft tissues adjacent to joints (tophi). Gout is twenty times more common in men than women, with age of onset usually after 40 years. Gout may be primary (related to enzymatic deficiency) or secondary. Radiographic findings include well defined, periarticular erosions with sclerotic margins and overhanging edges. Chondrocalcinosis is a common feature, especially at the radiocarpal joint and the knee. The first metatarsophalangeal joint is most often affected (podagra). The radiographic findings are diagnostic, but uncommon in this era of early treatment of hyperuricemia.

C) Incorrect. Synovial chondromatosis is a metaplastic process of the articular cartilage resulting in nodules of cartilage which detach within the joint, forming loose bodies. They may or may not calcify. If calcified, the radiographic appearance is diagnostic showing multiple small, calcified loose bodies about a joint. The most commonly affected joints are the shoulder, elbow, hip and ankle. MRI shows the increased T2 and decreased T1 signal within the bodies that is indicative of their cartilaginous origin. MRI also shows best the associated large joint effusions. CT will demonstrate the small erosions on the joint surfaces which are commonly present. Synovial chondromatosis is usually monoarticular and is much more common in males. There is no association with hemorrhage or hemosiderin deposition such as is seen in the test case.

D) Incorrect. Rheumatoid arthritis frequently involves the knee. Soft tissue swelling is a common feature, and large popliteal cysts are a common complication. Uniform joint space loss is the most frequent finding, but marginal erosions may be seen peripherally, most prominent at the tibial aspect of the joint. Large erosions, such as seen in this case, are uncommon. Fibroinuous loose bodies may form in the joint, so called “rice bodies” and large joint effusions and irregular synovium are commonly seen when these patients are examined with MRI. The signal characteristics of the synovium in rheumatoid arthritis—high T2 and low T1 signal intensity—are different from those seen in the test case.

E) Correct. Pigmented villonodular synovitis is a benign proliferative lesion of synovium that typically arises around the knee, and less frequently around other large joints. Pathologically, the lesion is characterized by the presence of hemosiderin-laden tissues. Plain radiographic findings include large well-defined periaricular erosions. MRI findings include: an intraarticular mass with a predominantly low signal intensity on T1-weighted and T2-weighted images, well-defined bone erosions on both sides of the joint, and a joint effusion. The deposition of hemosiderin produces marked signal loss on gradient echo images.

Citations:


10. You are shown lateral views of the cervical spine in neutral (Figure 5A), flexion (Figure 5B) and extension (Figure 5C) in a 45-year-old woman with neck pain and headache. Which one of the following is the MOST likely diagnosis?
   A. Jacoud’s arthropathy
   B. Rheumatoid arthritis
   C. Sarcoidosis
   D. Osteoarthritis
   E. Ochronosis
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Question # 10

Findings: Lateral views of the cervical spine in neutral, flexion and extension show widening of the atlanto-axial interval in neutral and flexion with reduction in extension, consistent with atlanto-axial subluxation.

Rationales:

A) Incorrect. Jacoudf’s arthropathy is an infrequent sequela of rheumatic fever. Acute rheumatic fever is often associated with migratory myalgias and arthralgias, but Jacoudf’s arthropathy is the more permanent deformity resulting from multiple episodes of recurrent rheumatic fever with joint involvement. The hands are invariably involved. Radiographic findings include easily reducible subluxations and dislocations, as well as ulnar deviation and swan’s neck and boutonniere deformities. Patients may be misdiagnosed with rheumatoid arthritis, but erosions are rarely present and the joint spaces are maintained. Jacoudf’s arthropathy radiographically resembles systemic lupus erythematosus. Both are characterized by deformity without destruction. Changes in the feet are less commonly present, but similar to those in the hand. Jacoudf’s arthropathy is not associated with atlanto-axial subluxation.

B) Correct. The most common disease associated with atlanto-axial subluxation is rheumatoid arthritis. Rheumatoid arthritis is a destructive arthritis with extensive erosive changes due to inflammatory changes in the synovium. All synovial joints can be affected, but the disease most commonly involves the small joint of the hands and feet. The cervical spine is also almost invariably affected. Atlanto-axial subluxation is common. The atlanto-axial interval is a true synovial joint, with synovium located at anterior tubercle of C1 and the anterior portion of the odontoid, as well as lining the transverse ligament. The transverse ligament normally acts as a check to posterior translation of the odontoid. With erosion or even destruction of the transverse ligament, as well as erosion of the tip of the odontoid, the odontoid is free to move posteriorly which results in the radiographically observable movement and in possible impingement on the cervical spinal cord. The normal atlanto-axial interval should be no greater than 2.2 mm in adults with no change between neutral, flexion and extension.

C) Incorrect. Sarcoidosis is a disease of unknown etiology characterized by the formation of non-caseating granulomas which may involve many organ systems simultaneously. The lung is the most common site of involvement, but there are skeletal manifestations in up to 15% of patients. The skeletal involvement is usually peripheral, with the hands, wrists and feet being the most common sites. Radiographically, there are large, well-circumscribed lesions commonly involving the phalanges which have been described as “lacelike”. The distribution is usually bilateral but asymmetric. The spine is almost never involved and there is no association with atlanto-axial subluxation.

D) Incorrect. Osteoarthritis (OA) is common in elderly patients, and the spine is a common site of involvement. The facet joints are the target site for OA in the cervical spine, resulting in the radiographic appearance of spurring and sclerosis. The uncovertebral joints are also commonly involved. The combined hypertrophic changes of the facets and the uncovertebral joints may result in encroachment on the neural foramina leading to radiculopathy. The degeneration of the facet joints may result in low grade subluxations in the mid and lower cervical spine, but the atlanto-axial joint is not generally involved.

E) Incorrect. Ochronosis is a rare metabolic disease resulting from a deficiency of homogentisic acid oxidase, which leads to an accumulation of homogentisic acid in cartilage and soft tissue. This process degrades cartilage, leading to joint degeneration. Gross examination shows brown pigmentation of tissues. Radiographically, chondrocalcinosis is common as is calcification of the intervertebral discs. Ligamentous calcification may also be seen. The spine findings begin in the lumbar spine, ascending to the mid and upper thoracic spine. The cervical spine is not generally involved. Atlanto-axial subluxation is not a feature of ochronosis.

Citations: