Magnetic Resonance Imaging of Epiphyseal Lesions

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Learning objectives

1. Learn the MRI appearances of the wide spectrum of disorders that affect the epiphysis.

2. Learn the proposed imaging classification into three broad categories for their differentiation.

3. Learn the typical imaging features of these entities and a systematic approach to the diagnosis of these lesions.

Background

Introduction

A wide variety of pathological processes can affect the epiphysis including benign and malignant tumor as well as tumor-like lesions. Management strategies differ widely according to the specific diagnosis. Hence early, accurate diagnosis and appropriate management of epiphyseal lesions is critical as these conditions may lead to disabling complications such as limb length discrepancy, angular or joint surface deformities and secondary osteoarthritis. Most of these lesions are symptomatic and present with pain. The others may be incidental findings or may be found during work-up and staging of a known malignancy. Plain radiography is the initial imaging modality. Computed Tomography (CT) is helpful in special situations such as detection and characterization of the tumor matrix. MRI is considered the best non-invasive method for further characterization.

MRI technique

High-resolution MRI provides unparalleled multiplanar imaging with excellent soft tissue resolution resulting in clear depiction of the detailed anatomy as well as pathology in the epiphysis(1). One of the major advantage of MRI is lack of ionizing radiation. High field strength MRI (1.5 or 3 Tesla) systems should be used for evaluation of epiphyseal lesions. For the purpose of this review we have arbitrarily grouped the MRI techniques in two. The first group comprises of conventional (routine) sequences such as T1-weighted / Proton density; T2-weighted, fat suppressed T2-weighted / Proton density, Short Tau Inversion Recovery (STIR) and T1-weighted images after IV Gadolinium. Anatomical sequences such as T1-weighted images (spin echo sequence and the gradient echo pulse) show exquisite detail and allow accurate assessment of the extent of the lesion. Fluid sensitive sequences (T2 weighted with Fat Saturation and Short Tau Inversion
Recovery; STIR) usually demonstrate areas of hyperintensity due to edema and fluid signal within the majority of tumor and tumor-like conditions of the epiphysis. IV Gadolinium is helpful as enhancement patterns (intense, rim enhancement or lack of enhancement) help in narrowing the differential. IV Gadolinium also allows depiction of small areas of tumor involvement which may be missed otherwise. The second arbitrary group of MRI sequences comprises of in- and out of phase Chemical Shift Imaging (CSI) and Diffusion weighted imaging (DWI). CSI has shown high accuracy for distinguishing benign from malignant processes in the musculoskeletal system(2). A signal drop of more than 80% is generally considered as the cut-off for excluding a malignant neoplasm(3). Diffusion weighted imaging (DWI) with apparent diffusion coefficient (ADC) provides information regarding the microdiffusion of water within the intra-and extracellular compartments(4). These sequences serve as problem solving techniques for specific questions, as discussed in detail in later sections.

**Imaging findings OR Procedure details**

**Imaging appearance of the normal epiphysis**

The epiphysis is the rounded end of a long bone, beyond the physeal scar (Fig. 1). Normal epiphysis is mostly composed of yellow marrow, which is 80% fat, 15% water, and 5% protein.(5). Due to the predominant fat, normal epiphysis shows homogenous hyperintensity on T1- and T2- weighted images, roughly similar to that of subcutaneous fat. There is no fluid signal or edema seen on fat suppressed T2-weighted / Proton density or STIR images. No focal areas of enhancement are seen after intravenous Gadolinium.
**Fig. 1:** Fig. 1 MRI appearance of normal epiphysis on conventional techniques. (a) Illustration shows the physeal scar (red line and arrows) and epiphysis; the rounded end of a long bone, beyond the physeal scar (outlined between golden yellow line). (b) Coronal T1-weighted image shows a normal epiphysis contains mostly fatty marrow. (c) Coronal STIR image does not show any abnormal high signal. (d) Coronal T1-weighted image with fat saturation after IV Gadolinium does not show any focal enhancement.

**References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

Normal epiphysis may also contain islands or rests of hematopoietic red marrow which is 40% water, 40% fat, and 20% protein (5). This may result in focal areas of low signal intensity on T1- and T2- weighted images. Red marrow does not demonstrate edema.
signal on STIR and no focal areas of enhancement are seen. In doubtful cases, problem solving techniques, will usually provide the confirmation. CSI shows significant drop out of signal on out-of phase imaging (6) and there is no evidence of restricted diffusion on DWI and Apparent Diffusion Coefficient (ADC) map (7), within normal red marrow (Fig. 2).

**Fig. 2:** Fig. 2 MRI appearance of normal epiphysis on problem solving techniques; An area of low signal intensity was noted on T1-weighted images (image not shown). Axial in and out of phase images (a) and (b) respectively show the problem solving role of chemical shift imaging. The significant signal drop in the out of phase image (arrows) confirm benign finding. Axial in and out of phase images (c) and (d) confirm
the signal drop quantitatively using a region of interest (ellipse). The average in phase measurement is 361 while the average out of phase measurement is 197 resulting in a signal drop of about 45%. (Case continues on next set of images...)

**References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

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**Fig. 19:** Fig. 2 (Continued) MRI appearance of normal epiphysis on problem solving techniques; An area of low signal intensity was noted on T1-weighted images (image not shown). Axial Diffusion weighted image (e) shows no restricted diffusion in the area of T1 signal abnormality. Axial ADC map (f) shows no abnormality. Findings are consistent with a normal focus of red marrow in femoral epiphysis.

**References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

Based on bone marrow edema (BME) pattern, contrast enhancement and characteristics on problem solving techniques, we present an MRI based approach to classification of the various epiphyseal lesions into three categories (Table 1). In the following sections of this review, we will discuss the clinical features and imaging findings of various epiphyseal lesions grouped into three categories (Table 2).

**Table 1**
### Table 1. Imaging based classification

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**Table 2**: Table 1. Imaging based classification of epiphyseal lesions.

**References**: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA
Category I Lesions:

Lesions in category I demonstrate BME signal (hyperintensity on fluid sensitive sequences) that is nearly equal to hypointensity on T1-weighted sequence. Intense enhancement is seen after IV gadolinium. Restricted diffusion may be seen with malignancy and organized pus. Malignant lesions also show less than 20% loss of signal on out of phase imaging. Infectious and infiltrative processes comprise the first category; infection is discussed first.

Infectious processes

Hematogenous seeding (most common), contiguous spread of infection from adjacent soft tissues and joints, or direct inoculation of infection into the bone may all result in osteomyelitis (8). The most common site of osteomyelitis in a tubular long bone is the metaphysis (9). The blood vessels in metaphysis lack a basement membrane and the blood flow in this area is slow, which predisposes to hematogenous seeding. Infection then usually spreads to the adjacent epiphysis. Osteomyelitis is usually seen in children
and elderly, and is rare in adolescents as the physeal scar is a barrier to microbial spread (10). MRI is an excellent modality for imaging of suspected infection, with sensitivity similar to radionuclide studies (11). BME pattern is seen with hyperintensity on fluid sensitive sequences nearly equal to hypointensity on T1-weighted sequence with contrast enhancement along the edge due to presence of granulation tissue. If necrosis is present, no central enhancement is seen. Extensive periosteal edema is common and infection may spread from the epiphysis to the adjacent joint causing effusion and septic arthritis (Fig. 3). Occasionally, intra-osseous abscesses may develop (Fig.4). In addition MRI demonstrates the extent of bony (cortical and medullary) destruction as well as soft tissue involvement. Treatment of osteomyelitis involves surgical debridement of the necrotic bone as well as antimicrobial therapy. Based on available literature, the best antibiotic agent, route and duration of therapy remain unclear; six weeks is the most common duration of therapy in the reported literature (12).

Fig. 3: Fig. 3 46 year-old-male with right hip pain, fever and leukocytosis. Coronal STIR image (a) and axial T2-weighted image with fat saturation (b) shows bone marrow edema in the femoral epiphysis and proximal shaft (white arrows). Also note the periosteal edema (curved arrows) and small joint effusion (arrowhead). Axial T1-weighted image (c) shows low signal intensity in same area (white arrow). The hyperintensity on fluid sensitive sequences is nearly equal to the hypointensity on T1W sequence. Findings are consistent with osteomyelitis and septic arthritis.

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA
Fig. 4: Fig 4 39 year-old-male with right thigh and hip pain, fever and leucocytosis. Coronal T2-weighted image with fat saturation (a) shows extensive and diffuse bone marrow edema involving the right femur (arrow). Note the intra-osseous abscess (arrowheads). Coronal T1-weighted image (b) shows low signal intensity in same area (arrow). The hyperintensity on fluid sensitive sequences is nearly equal to the hypointensity on T1W sequence. (Case continues on next set of images...)

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA
Fig. 5: 39 year-old-male with right thigh and hip pain, fever and leucocytosis. Coronal T1-weighted image after IV Gadolinium (c) shows extensive enhancement (arrowheads). Coronal out of phase image (d) shows signal loss (white arrow). Findings are consistent with osteomyelitis and intra-osseous abscess.

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

Infiltrative processes (malignancy and metastases)

The second subgroup in category I comprises of infiltrative processes such as lymphomas and diffuse metastases. Hodgkin and non-Hodgkin lymphomas, comprise approximately 5.0% of all cancers in the United States (13). Detection or exclusion of bone marrow involvement is of particular importance. If present, by definition, it indicates the highest stage (stage IV) according to the Ann Arbor system (14). Bone marrow biopsy has a high specificity, however, focal bone marrow involvement can be missed as only a very small portion of the entire marrow is sampled potentially leading to false negatives (15). MRI is a very sensitive technique for the detection of lymphomatous involvement of bone marrow. With continued improvement in coils, parallel imaging and fusion techniques, whole body MRI can be used as an initial staging modality. A systematic review showed the sensitivity of MRI for bone marrow involvement in lymphoma as 50% to 100%, with a median of 100% (16).

MRI is also being increasingly utilized for detection of skeletal metastatic disease. For systematic screening of skeletal metastases, $^{99m}$Tc-phosphonate-based scintigraphy is
a widely established method. However, it has certain limitations such as non-visualization of lesions in the absence of an osteoblastic response and false-positive findings due to healing fractures or degenerative disease. A higher specificity and sensitivity in the early detection of skeletal metastases has been reported with MRI when compared to bone-scintigraphy (17,18). Similar findings on MRI are seen with infiltration of bone marrow with lymphoma or metastatic involvement. A known underlying lymphoproliferative disorder or an abnormal peripheral smear may suggest lymphoma. A known primary malignancy with other findings of malignant spread such as soft tissue lesions and multicentricity will suggest metastatic involvement of the bone marrow. BME pattern is seen with hyperintensity on fluid sensitive sequences nearly equal to hypointensity on T1-weighted sequence with intense contrast enhancement. On problem solving techniques (Figs. 5 and 6), restricted diffusion is seen with less than 20% loss of signal or signal increase on out of phase imaging. Metastatic lesions may have a bright rim on T2-weighted images (19). Finding seen with infection such as periosteal edema, effusion and fluid collections are usually absent or minimal in cases of lymphoma or metastatic involvement.

Fig. 18: Fig. 5 44 year-old-female with history of breast cancer and right hip pain. Coronal STIR image (a) shows high signal intensity in the right femoral epiphysis
Coronal T1-weighted image (b) shows low signal intensity in same area (arrow). Axial T1-weighted image after IV Gadolinium (c) shows enhancement (arrow). (Case continues on next set of images...)

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

Fig. 6: Fig. 5 (Continued...) 44 year-old-female with history of breast cancer and right hip pain. Axial in and out of phase images (d and e) show significant signal drop in the out of phase image, >20% (ellipse). The findings of bone marrow edema, enhancement and signal drop on CSI are confusing. Another problem solving technique helps in this
Axial Diffusion weighted image (f) shows restricted diffusion (arrow) confirmed by axial ADC map (g) (arrow). Findings are consistent with metastatic disease.

**References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

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Fig. 7: Fig. 6 70 year-old-female with history of breast cancer and right hip pain. Coronal STIR image (a) shows several areas of BMEP in osseous structures including right femoral epiphysis (arrows). Coronal T1-weighted image (b) shows corresponding low SI areas (arrows). Coronal T1-weighted image (c) after IV Gadolinium shows extensive enhancement (arrows). Coronal out of phase image (d) shows no corresponding signal loss. Findings are consistent with multiple metastases. **References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

**Category II Lesions:**

Lesions within category II demonstrate BME (hyperintensity on fluid sensitive sequences) signal that is significantly greater than the hypointensity seen on T1W sequence. In
contrast to category I lesions, lesions in category II show only minimal enhancement after IV gadolinium. Usually there is no restricted diffusion and a significant drop out on out of phase imaging is seen. These benign lesions are discussed below.

**Transient osteoporosis of the hip**

This uncommon clinical condition that mostly affects adult men and pregnant women in third trimester (20). The clinical and radiographic changes follow a typical time course. Slow or rapid onset dull and aching pain is usually the presenting feature and the condition may affect bilateral hip joints. After a variable period following onset, marked osteoporosis of the femoral head is seen on radiographs(21). MRI shows hyperintensity on fluid sensitive sequences. Associated findings such as periosteal edema and joint effusion are uncommon. The diagnosis is presumptive based on complete resolution of clinical and radiographic features, usually over the course of several weeks (Fig. 7). Occasionally on follow up, this condition migrates to another subchondral area, and is termed migratory transient osteoporosis (21). Treatment is supportive and consists of rest, restricted weight bearing to prevent micro-fractures, nonsteroidal anti-inflammatory drugs, oral and intraarticular corticosteroids and physiotherapy (20).

![Fig. 7](image)

**Fig. 7**: 56 year-old-male with one week history of bilateral hip pain. Radiograph (a) shows subtle lucency at both femoral metaphyses (arrows). Coronal T2-weighted image with fat saturation shows very abnormal high signal intensity involving the bilateral femoral epiphyses(arrows). Note the absence of periosteal or fascial edema. Also no fracture line was noted on any image. Clinical symptoms resolved after four weeks. Findings are consistent with transient osteoporosis of the hip.

**References**: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA
Subchondral insufficiency fracture

Subchondral insufficiency fracture of the femoral head is most commonly seen in osteoporotic elderly women, organ transplant recipients (22) and in young military recruits (23). Diffuse extensive bone marrow edema pattern is seen. Linear ill-defined, irregular fracture line is seen in the weight-bearing portion of the bone and may be convex to the articular surface (Fig. 8). Associated findings include underlying meniscus tear or labral tear. On follow up imaging this condition may resolve or progress to subchondral collapse and rapid cartilage loss.
**Fig. 10**: Fig. 8 44 year-old-male with left hip pain. Coronal STIR image (a) shows high signal intensity in the left femoral epiphysis (arrow). Coronal T1-weighted image (b) shows low signal intensity in same area (arrow). Note that the hyperintensity on fluid sensitive sequence is greater than hypointensity on T1-weighted sequence. Axial out of phase image (c) shows signal drop (arrow). Sagittal Proton density image (d) with fat saturation shows the subtle subchondral fracture line. A small superolateral labral tear was also seen (images not shown). Findings are consistent with subchondral insufficiency fracture.

**References**: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

**Avascular necrosis (AVN)**

AVN may be acute or subacute. Several combined mechanisms such as effects of metabolic factors, vascular damage, increased intraosseous pressure, and mechanical stresses are postulated to cause avascular necrosis; the exact pathogenesis is still unclear (24). Underlying systemic disease and steroids have been implicated, however the strength of association with steroids seems low and higher incidence is seen with higher doses such as >40mg/day (25). Detection of the double-line sign; high signal intensity inside a low intensity rim on T2-weighted images (Fig. 9) has been studied in detail (26,27). Based on its morphology, the low signal intensity line seen in AVN may be differentiated from the subchondral fracture line in subchondral insufficiency fracture. In AVN, histopathologically the low-intensity band represents repair tissue. This results in visualization of smooth low intensity line on MRI, which is seen in non weight bearing portions and circumscribes all of the necrotic segments (22,28). In contrast the low-intensity band in subchondral insufficiency fracture histopathologically represents the fracture line and is hence irregular, serpiginous, and convex to the articular surface and often discontinuous (22,28). Mild or focal bone marrow edema may be centered around a half-moon shaped or serpiginous subchondral lesion and an effusion may be present. Associated findings such as edema and synovitis indicate active disease. Follow up imaging may show progression to subchondral collapse especially with large lesions that involve more than a third or half of the size of the epiphysis. Treatment may be conservative (29), or surgical with joint preserving techniques (30) or joint replacement (31).
**Fig. 11:** Fig. 9 68 year-old-male with chronic left hip pain. Coronal Proton density image with fat saturation (a) shows the crescent sign of subchondral fracture (arrow). Note the large infarct (black and white arrowheads) with the double line sign, black arrowhead showing the low intensity inner dark line with white arrowheads demonstrating the outer bright line. Coronal Proton Density-weighted image (b) shows the large infarct (arrowheads). Note that the hyperintensity on fluid sensitive sequence is greater than hypointensity on T1- sequence. (Case continues on next set of images...)

**References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

**Fig. 9:** Fig. 9 (Continued...)68 year-old-male with chronic left hip pain. Sagittal Proton density image with (c) and without (d) fat saturation shows the crescent sign of subchondral fracture (arrow). Note the large infarct (arrowheads). Coronal Out of phase image (e) shows loss of signal (arrow). Findings are consistent with avascular necrosis.
Osteochondral fracture

Osteochondral fracture (acute or subacute) develops when a segment of articular cartilage, with its underlying subchondral bone, separates from the surrounding osteocartilaginous tissue (32). Several mechanisms have been suggested; repeated injury or microinjuries, vascular or synovial injury, with or without a microtraumatic context and localized hyperpressure (33,34). This condition is usually seen in young and athletically active individuals. In the knee, association with impaction injuries, such as transient patellar dislocation and with ligament injuries such as anterior or posterior cruciate ligament is seen while twisting injuries are implicated in ankle. Extensive edema centered around a fracture line is seen (Fig. 10). Both conservative and surgical management are therapeutic options and no specific treatment is superior to other (32).

Fig. 17: Fig. 10 25 year-old-male with a recent twisting injury. Sagittal STIR image (a) shows the edema in the talar dome (arrow). Coronal T1-weighted image (b) shows the fracture line (arrow). Note that the hyperintensity on fluid sensitive sequence is significantly greater then hypointensity on T1-weighted sequence. (Case continues on next set of images...)

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA
Fig. 12: Fig. 10 (Continued...) 25 year-old-male with a recent twisting injury. Coronal Out of phase image (c) shows loss of signal (arrow). Coronal CT reconstruction in bone window (d) shows the fracture line (arrow). Findings are consistent with osteochondral fracture.

**References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

**Osteochondritis Dissecans (OCD)**
The most common etiology for OCD is considered to be trauma. However, other proposed causes include mechanical stress, familial dysplasia and avascular necrosis (35). This condition is a common articular lesion in adolescents and young adults. Classically the articular lesion shows surrounding edema with cystic change at the base of the lesion (36). As in other lesions in category II, the hyperintensity on fluid sensitive sequence is greater than the hypointensity on T1-weighted sequence. Out of phase images show signal drop as it is not a malignant process (Fig. 11). OCD usually affects the medial condyle of the knee, but it can also occur in the ankle (dome of talus), patella, and elbow (anterior capetellum) (37,38). MRI helps with the decision to operate as it shows the displaced fragments that may need to be debrided or surgically fixed.
Fig. 13: Fig. 11 13 year-old-male with bilateral knee pain. Images of the right knee are shown. Coronal Proton density image with fat saturation (a) shows osteochondral defect involving the lateral femoral condyle (arrowheads). Underlying bone edema is also seen (arrows). Coronal Proton Density image (b) shows the large osteochondral defect (arrow). Note that the hyperintensity on fluid sensitive sequence is greater than the hypointensity on T1-weighted image. Coronal out of phase image (c) shows signal drop (arrow). Radiograph (d) shows the osteochondral lesion with flattening of articular surface (arrow). Findings are consistent with Osteochondritis Dessicans.

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA
Category III Lesions:

Category III comprises of focal lesions with generally typical appearances as discussed below. Enhancement after IV gadolinium is variable. Malignant lesions in this category show diffusion restriction. On CSI, significant signal drop out in surrounding bone marrow edema pattern is seen in chronic osteochondral lesion, geode and eosinophilic granuloma while <20% SI loss or signal increase on out of phase imaging is seen in other malignant focal lesions.

Eosinophilic Granuloma (EG)

EG is the bony manifestation of Langerhans cell histiocytosis, which is a rare and not well understood disease without any definite proven etiology (39). This condition is usually seen in young males (< 20 years), presents with pain with or without swelling and generally has a benign clinical course (40). EG may present with single or multiple focal lesions with minimal or no sclerosis, however sclerosis may be seen after iatrogenic intervention (41). In EG, BME signal on MRI, seen as hyperintensity on fluid sensitive sequence is greater than hypointensity on T1W sequence. As it is a benign lesion, significant signal drop out in surrounding bone marrow edema pattern is seen in CSI(Fig. 12). MRI features of EG are not specific(42) and biopsy may be needed for definitive diagnosis. Treatment is simple excision or curettage with or without lose dose radiotherapy (40).
**Fig. 14:** Fig. 12 7 year-old-male with left hip pain. Coronal STIR image (a) shows edema in the left iliac bone (arrow). Underlying bone edema is also seen. Coronal T1-weighted image (b) shows low signal intensity (arrow). Note that the hyperintensity on fluid sensitive sequence is greater than hypointensity on T1W sequence. Coronal Diffusion weighted image (c) shows restricted diffusion (arrow). Coronal out of phase image (d) shows signal drop (arrow). Radiograph (e) shows the radiolucent lesion (arrow). Biopsy showed Eosinophilic Granuloma.

**References:** S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

**Chondroblastoma and clear cell chondrosarcoma**

Chondroblastoma is a rare benign chondroid bone tumor, which typically arises from the epiphysis of a long tubular bone (43). It is treated with curettage and has a low morbidity. The most common presentation is in second decade with a male to female ratio of 2:1 (44). In contrast, clear cell chondrosarcoma which behaves as a low grade malignant bone tumor presents about a decade later in life (45). The mortality of clear cell chondrosarcoma (15%) is significantly lower than conventional chondrosarcoma (46). Heterogeneous signal intensity on MRI is seen with both chondroblastoma and clear cell chondrosarcoma. Enhancement after IV gadolinium is more intense with clear cell chondrosarcoma, while bone marrow edema, periosteal reaction and soft tissue component may be more associated with chondroblastomas (44). In general, differentiation between the above two entities is not possible with MRI alone.

**Osteoid Osteoma**

Osteoid Osteoma is a benign bone-forming tumor that commonly occurs in adolescents and young adults. The diagnostic imaging hallmark is a small radiolucent nidus (47). While an initial report suggested that CT was more accurate than MRI in detection of the osteoid osteoma nidus (48), a newer study shows that MRI reliably demonstrates the nidus of an osteoid osteoma (49). MRI is also more superior in demonstrating the intramedullary and soft-tissue extent (48). MRI features such as signal intensity of the nidus and the bone marrow edema around it are variable. For the best accuracy in detection of the nidus, the radiologist should interpret MRI with CT or radiograph, whenever available.

**Giant cell tumor (GCT)**

GCT is a rare benign tumor that arises in the metaphysis. Once the physis is closed, GCT may extend to involve the epiphysis and subchondral bone (50). GCT is rare before age of 20, and the peak incidence is in the second and third decade with a slight female predominance (51). Peripheral low signal on T1-weighted and hypointensity on T2-weighted images is seen (50). The low signal intensity on T2-weighted is believed to be due to either tumor cellularity, or from recurrent hemorrhage within the lesion.
Enhancement after IV gadolinium is seen in the solid components while cystic components may show septal and peripheral enhancement (52).

Geode

Geode or subchondral cysts are spherical radiolucencies that are seen adjacent to the articular surfaces of joints and may occur in a subarticular, subchondral or synovial location (53). Degenerative osteoarthritis is the most common cause, however, other forms of arthritides such as rheumatoid arthritis, haemophilia, calcium pyrophosphate deposition disease or gout may also result in this condition (54). The mechanism is believed to be raised intra-articular pressure within the joint exceeding that of adjacent intraosseous pressure which in combination with concurrent loss of articular cartilage results in the development of defects resulting in migration of synovial fluid into the underlying subchondral bone (55). A geode is usually of no clinical significance, however, it may mimic malignancy on imaging. Problem solving techniques; CSI and DWI are helpful do differentiate from malignancy (Fig. 13).

Fig. 16: Fig. 13 54 year-old-female with right hip pain. Coronal STIR image (a) shows cystic lesion in acetabulum (arrow). Underlying bone edema is also seen (arrowheads). Coronal T1-weighted image (b) shows low signal intensity (arrow). Chemical shift imaging helps as a problem solving tool. Coronal in and out of phase images (c and d) shows signal drop on out of phase image(arrow). (Case continues on next set of images...)

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA
Fig. 15: Fig. 13 (Continued...) 54 year-old-female with right hip pain. Radiograph (e) shows the radiolucent lesion (arrow). Note the degenerative changes. Findings are consistent with subchondral cyst / geode.

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

Lipoma

Lipoma is a very rare primary bone tumor composed of mature fat cells with small quantities of fibrous and vascular tissue (56). A lesion that is entirely composed of fat is easy to diagnose on MRI. Areas of fat necrosis, cyst formation and dystrophic calcification are seen commonly due to involution and complicate the imaging appearance (57). The fatty components follow fat signal intensity on all MRI sequences. High signal intensity on both T1-weighted and T2-weighted images is seen with loss of signal intensity on
fat suppression sequences (58). Cystic component show intermediate signal intensity on T1-weighted sequences and high signal intensity on T2-weighted and fat-suppressed images while areas of calcification show low signal intensity on MRI (59).

**Chronic osteochondral lesion**

Chronic osteochondral lesion is most commonly found in ankle (talus) and the knee (60). The etiology is believed deprivation of the blood supply of an osteochondral fragment either due to spontaneous osteonecrosis or traumatic subchondral fracture. A single traumatic event or repeated microtrauma leads to microfractures of the subchondral bone, which in turn causes altered biomechanical forces and eventually leads to a subchondral cyst (61). MRI findings may be non specific and show areas of low signal intensity on T1-weighted images, with a T2 hyperintense rim that represents instability of the osteochondral fragment. Using arthroscopy as the standard, MRI has been shown to accurately evaluate and grade the articular cartilage overlying osteochondral lesions of the talus (62). MRI has been shown to have high accuracy for evaluating repair tissue in full-thickness traumatic defects treated by microfracture in the knee (63). Also, in the ankle, the degree of edema on MRI correlated with inferior clinical outcomes following microfracture of the osteochondral lesions of the talus (64).

**Conclusion**

To summarize, a myriad of tumor and tumor like lesions may occur in the epiphysis. Using a systematic approach, the radiologist may be able to provide the accurate diagnosis. First, the radiologist should access the characteristics of BME pattern and compare it to hypointensity on T-1 weighted images and make an attempt to compartmentalize the pathology in one of three categories that we proposed in this review. Following this, problem solving techniques (DWI and CSI), are very helpful to differentiate between different entities. Clinical history and other imaging studies, if available should be used to further narrow down the differential diagnosis. However, it should be remembered that many of these tumor and tumor like lesions have overlapping MRI appearance and biopsy may be considered for definitive diagnosis.

**Conclusion**

A wide range of tumor and tumor like conditions effect the epiphysis. Using conventional and problem solving techniques on high-resolution MRI, the radiologist may be able to identify the specific pathology and thus positively affect patient management. In this review we outlined the differentiating MRI features of the spectrum of diseases in this domain and provided the reader with a systematic imaging approach which may help in making an accurate diagnosis.
Fig. 20: Contact Information

References: S. K. Thawait; Bridgeport, UNITED STATES OF AMERICA

References


