How to approach Bone Tumors

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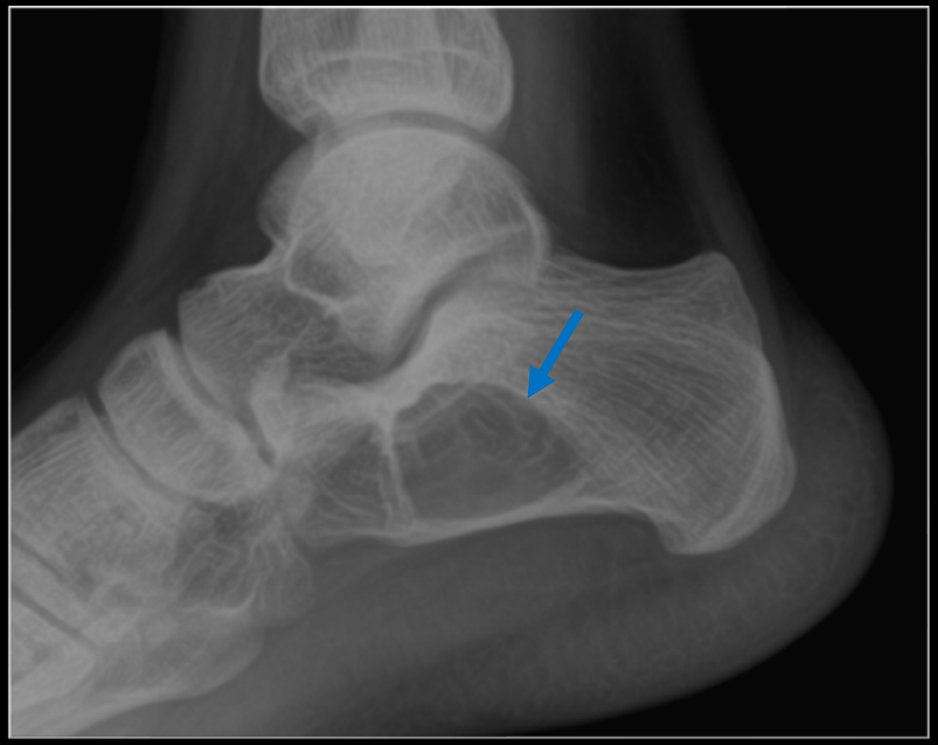
Evaluation of bone tumors- Radiographs

1. Margin/Zone of Transition
   - Geographic (Type 1a vs 1b vs 1c)
     - Focal discrete lesion
     - Narrow vs. broad zone of transition
     - Sclerotic vs. nonsclerotic margin
   - Moth Eaten (Type 2)- Multiple lytic areas with broad zone of transition
   - Permeative (Type 3)- Ill defined margins with broad zone of transition

Applies to lytic lesions

➢ Distinction between Type 2 and 3 is not significant, both indicate aggressive lesions

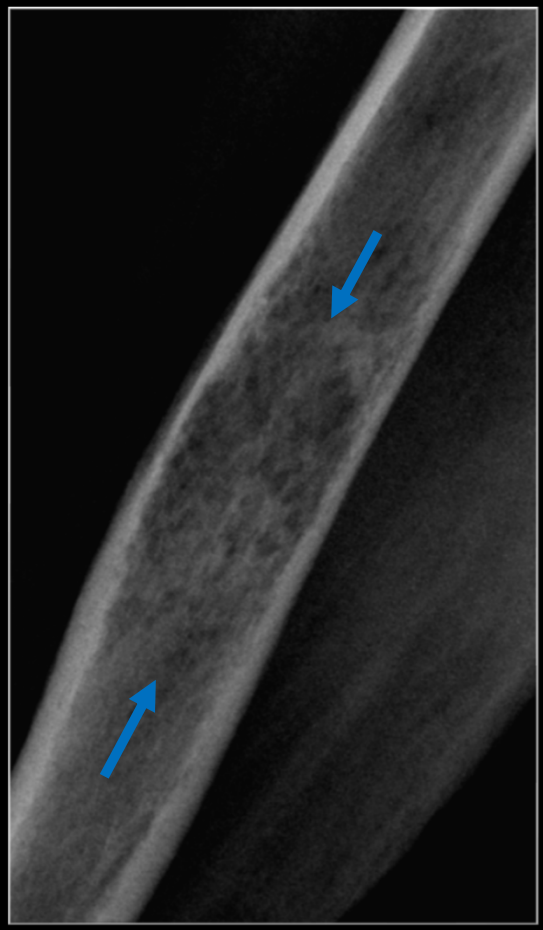
Type *IA* lesion- Focal, **sclerotic** margins, narrow transition zone
→ **nonaggressive**



Type *IB* lesion- Focal, **nonsclerotic** margins, narrow transition zone

Type *1c* lesion- Focal, non sclerotic margins, broad transition zone
→ **aggressive**

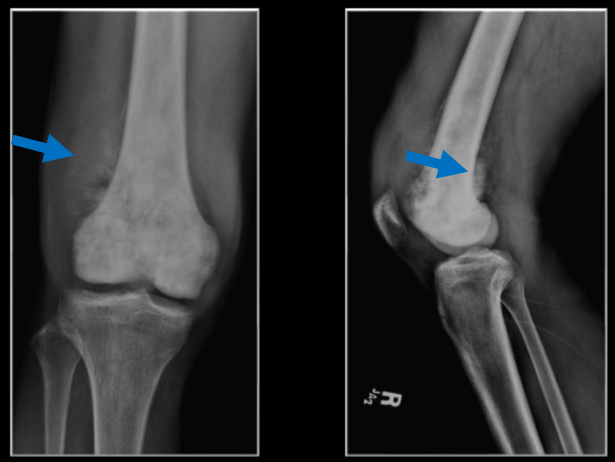
Moth-eaten (Type 2)- Multiple lytic areas with broad zone of transition → **aggressive**



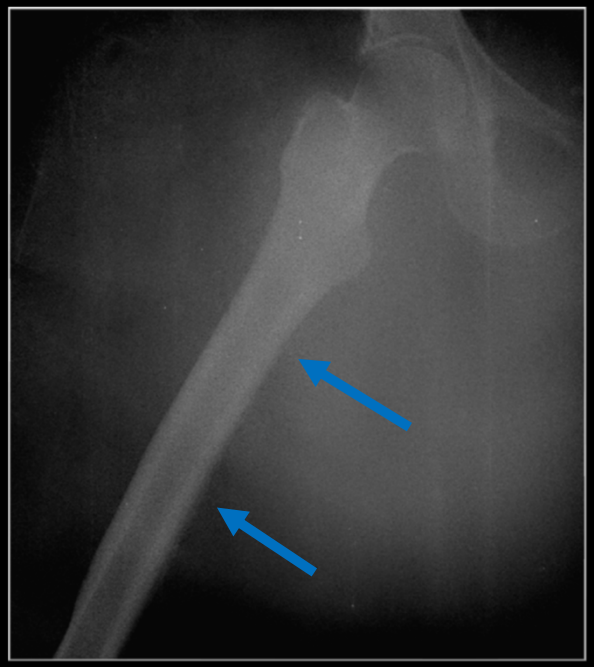
Permeative (Type 3)- Ill defined margins with broad zone of transition
→ **aggressive**

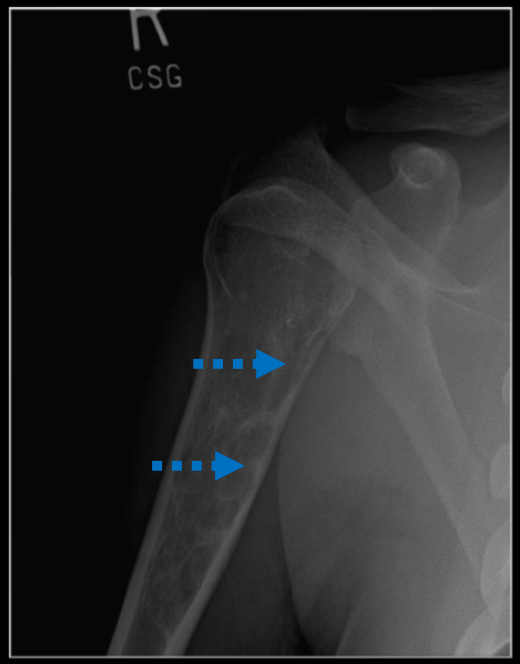
Evaluation of bone tumors- Radiographs

2. Periosteal reaction
   - Unilamellated- Single layer of reactive periosteum
   - Multilamellated- Multiple layers (onion skin) periosteal reaction
   - Codman Triangle- Elevated periosteum creating an angle with the cortex
   - Sunburst- Spiculated, hair-on-end periosteal reaction →



3. Cortical Involvement
    - Endosteal scalloping ⇢
    - Saucerization →





Evaluation of bone tumors- Radiographs

4. Lesion density/ tumor matrix
   - Chondroid
   - Osseous
   - Fibrous
   - Fat
   - Cystic

5. Location
   - Epiphysis / Apophysis
   - Diaphysis
   - Metaphysis

Evaluation of bone tumors- Radiographs

6. Patient Age

7. Size and Number of lesions

Evaluation of bone tumors- MRI
Protocol & Approach

- General recommendations:
  - Similar to 'Soft Tissue Mass' protocol
  - FOV determined by mass size/ location
  - Always image in three planes
    - T2 fat saturated sequences typically in two planes (better SNR than STIR)
    - However, inhomogeneous fat saturation is a possibility
    - Third plane usually STIR sequence

  - Evaluate T1 and T2 characteristics. If the the T1 signal is darker than that of the adjacent muscle, this is concerning for a marrow replacing process.
  - This can be confirmed on *in and out of phase* imaging. If the abnormal signal does not decrease by $\geq$ 20% on out of phase imaging, this is again concerning for a marrow replacing process

- Evaluate for aggressive features including cortical destruction, soft tissue mass, adjacent marrow edema, and periosteal reaction

- Evaluate the matrix by MRI if possible (i.e. chondroid, cystic)

- If gadolinium contrast is administered, evaluate for the presence or absence of enhancement and define enhancement patterns
  - Contrast is especially useful to evaluate a possible soft tissue component (‘dirty edema’ versus possible soft tissue component)

- Evaluate for additional lesions

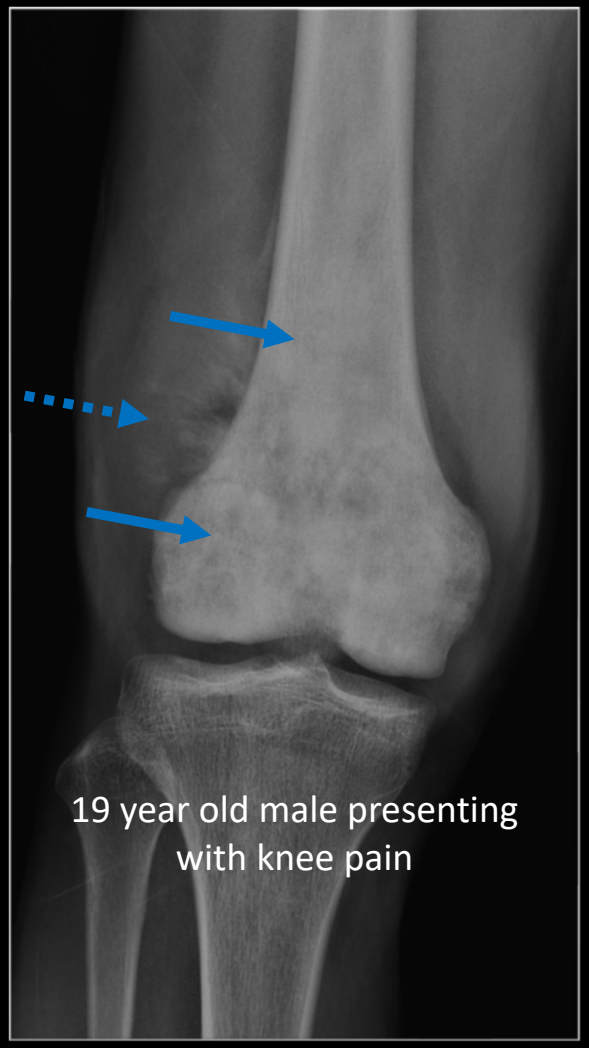
Seq.	FOV	Matrix/ Nex	Slice	TR	TE	TI	Flip	ETL	BW
Axial T1 SE Non FatSat		256 x 192	5/1	400-800	minimum				16
Axial T2 FSE FatSat		256 x 192	5/1	> 2000	40-60			8	16
Sag or Cor T1 SE NonFatSat		256 x 192	5/1	400-800	minimum	150			16
Sag or Cor STIR		256 x 192	5/1	> 2000	30-40			8	16
Axial T1 GRE or SE FatSat Pre/Post Gd		256 x 192	5/1	60 400-800	5 minimum	30-40 -		8	16
Sag or Cor T1 GRE or SE FatSat PRE/Post Gd		256 x 192	5/1	60 400-800	5 minimum	30-40 -		8	16

Common Cases

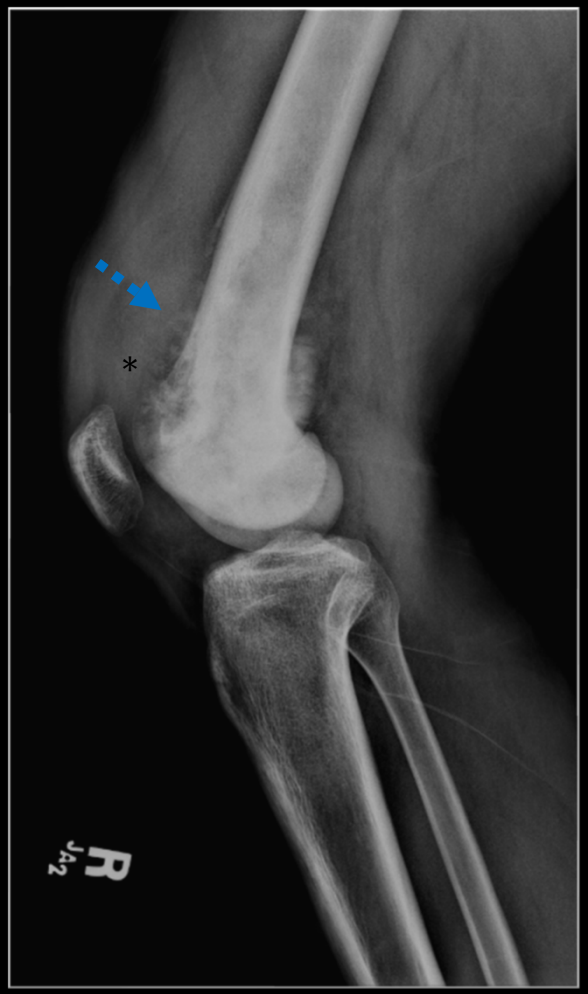
Osteosarcoma

- Multiple different types of Osteosarcomas (conventional, parosteal, periosteal etc.)
  - Conventional by far the most common and discussed in the following
- Malignant, highly aggressive bone tumor
- Most common malignant bone tumor in children/adolescents (most common age range 10-25 years)
  - Older patient often secondary Osteosarcoma (e.g. Paget's, history of radiation)
- Long bones most commonly affected (50% around the knee), typically arising from the metaphysis
- Density ranges from lytic to densely sclerotic
- Demonstrates typical aggressive features (Cortical destruction, wide zone of transition, associated soft tissue mass)
- On MRI: Heterogenous mass on fluid sensitive sequences with intense enhancement of marrow and associated soft tissue mass

- Large osteoblastic lesion in the distal femur
- Aggressive features include sunburst periosteal reaction wide transition zone and associated soft tissue mass
- Note also the large joint effusion

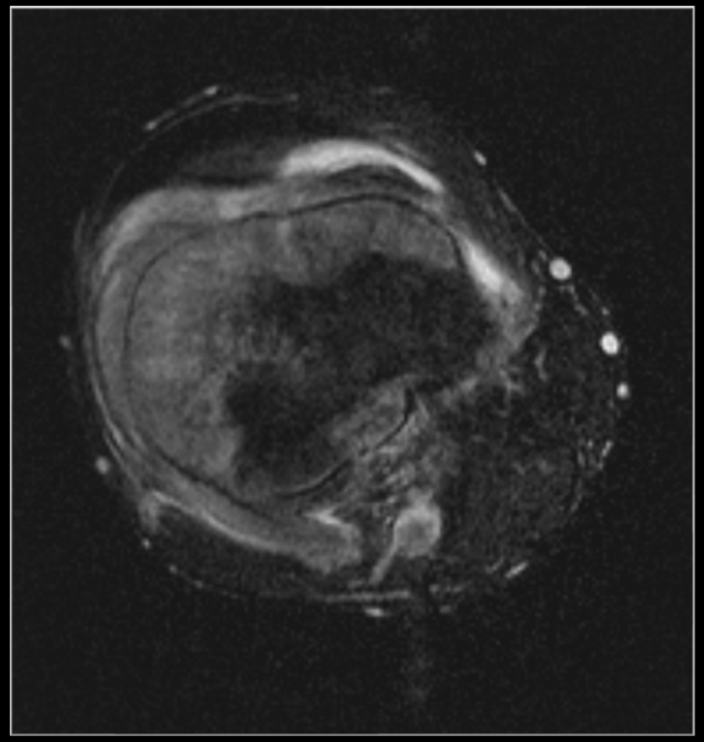


19 year old male presenting with knee pain

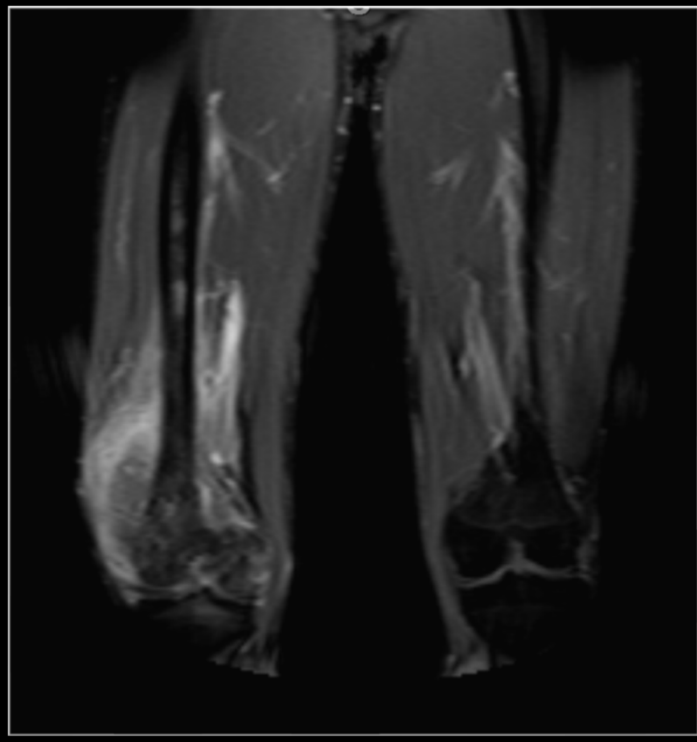


- MRI in the same patient demonstrates abnormal signal and enhancement, most pronounced in the metadiaphysis with cortical breakthrough and extension into the surrounding soft tissues/musculature

STIR



T2

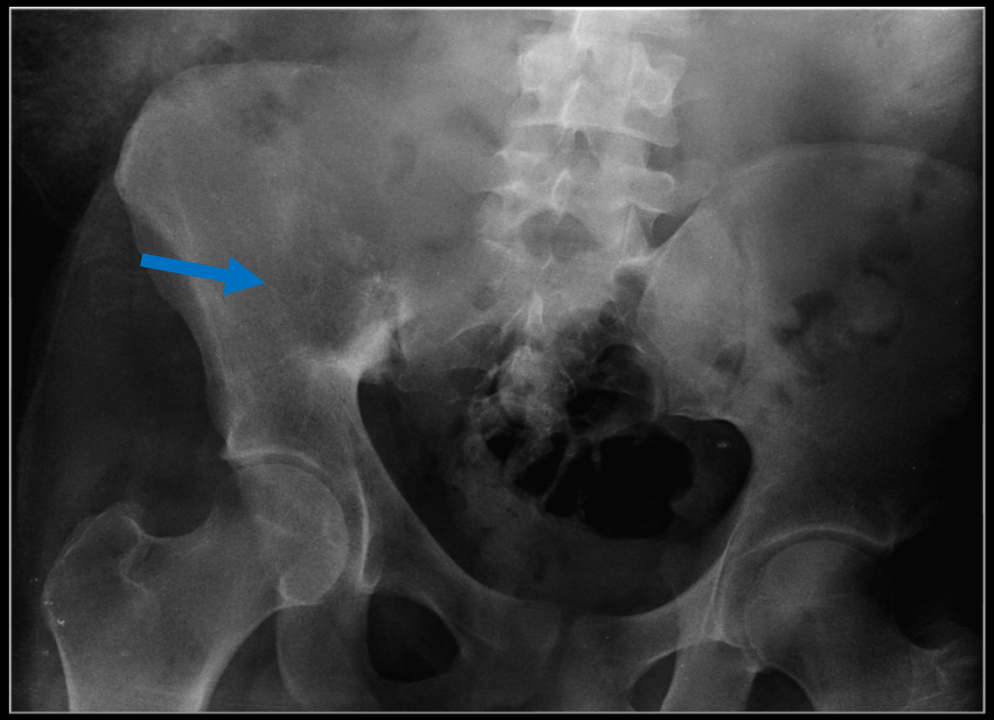


Post contrast

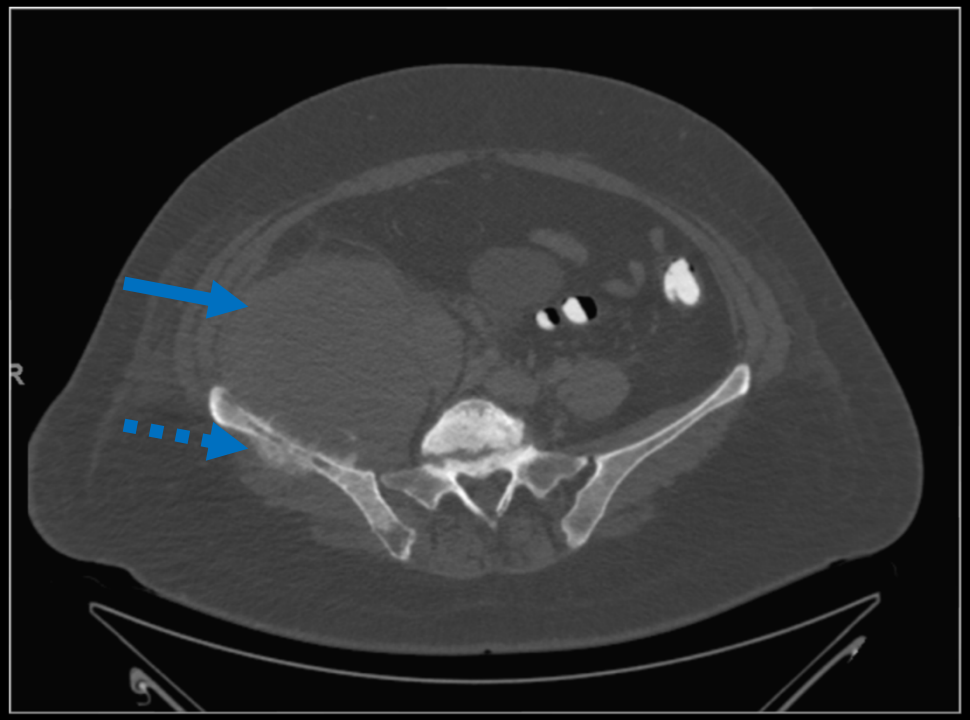
Ewing's Sarcoma

- 2nd most common sarcoma in children and adolescents
- Location: Diaphysis or metadiaphysis of long bones with up to 25 % of Ewing's sarcomas located in flat bones (e.g. ilium, scapula)
- Demonstrates typical aggressive imaging features (often associated with a large soft tissue mass)
  - Periosteal reaction often lamellated (Osteosarcoma shows sunburst pattern more often, however imaging features overlap)
- Bone and lung metastasis are common

Large lytic lesion → centered in the right hemipelvis seen on radiograph in a 16 yo patient who was worked up for RLQ pain to rule out appendicitis



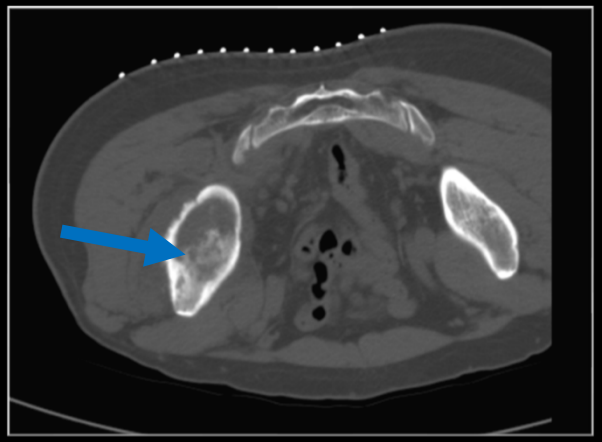
CT of the same patient demonstrates typical appearance of Ewing's Sarcoma: Large soft tissue mass → centered in the right iliac bone with associated bony destruction and extension into the surrounding musculature ⇢

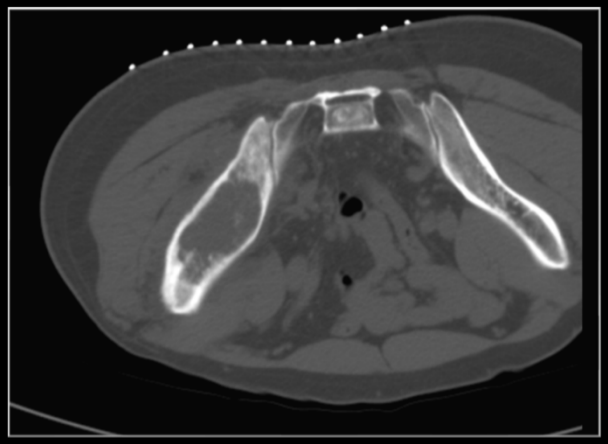


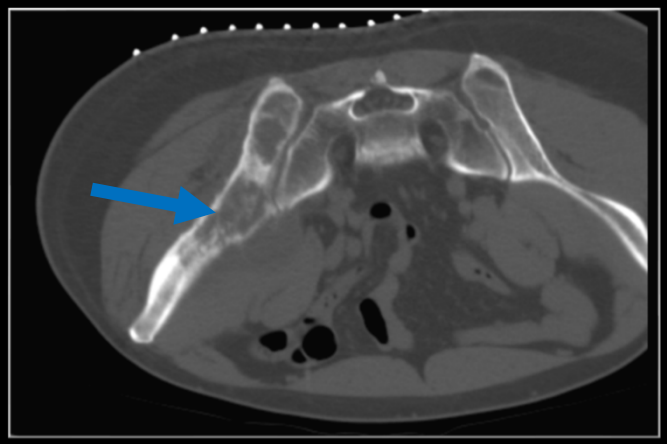
Chondrosarcoma

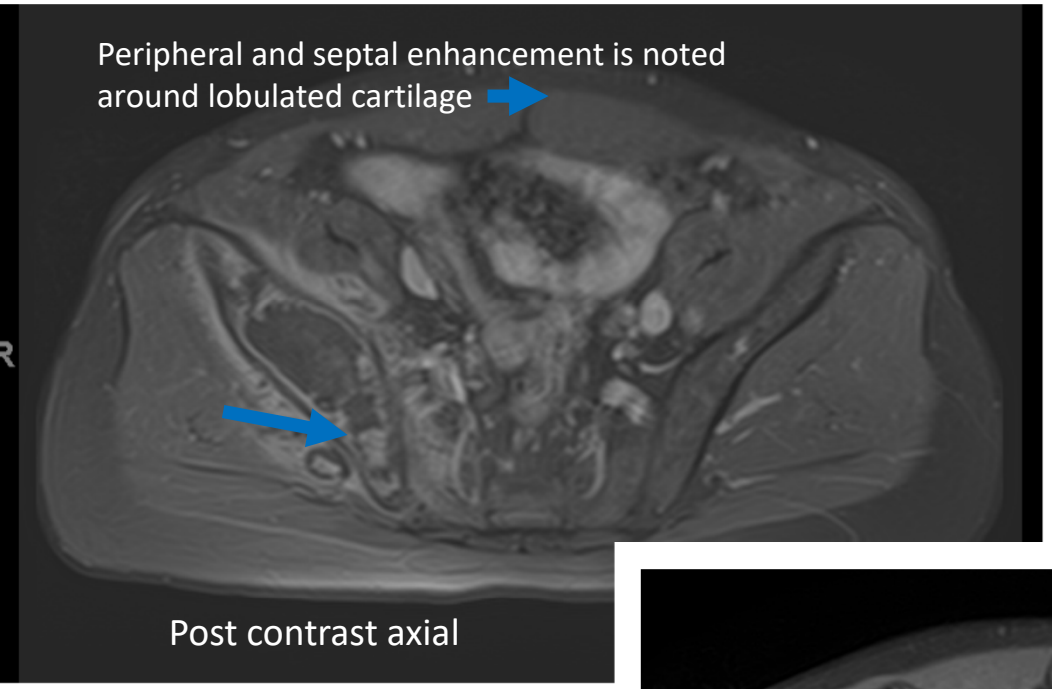
- 3rd most common primary malignant bone tumor
- Chondroid tumor matrix (variable expression, lesion might be almost entirely cystic)
- Central, metaphyseal, endosteal cortical thickening as well as scalloping can be seen
- Peak incidence 50-70 years of age (but wide age range, can be also seen in younger patients)
- Can have a nonaggressive appearance
  - Large lesions, lesion growth or increasing pain should raise suspicion for Chondrosarcoma

- Note the chondroid matrix of the large mass on CT obtained during biopsy
- MRI (next slide) shows a large mass involving almost the entirety of the right iliac bone with cortical destruction, areas of necrosis, and a enhancing soft tissue component

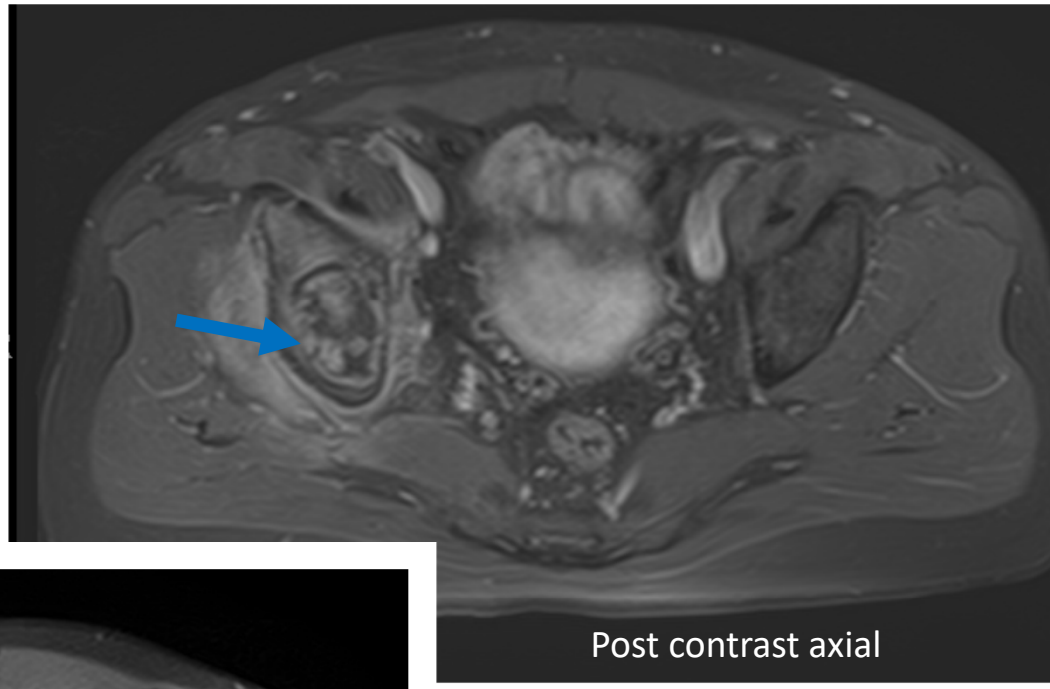




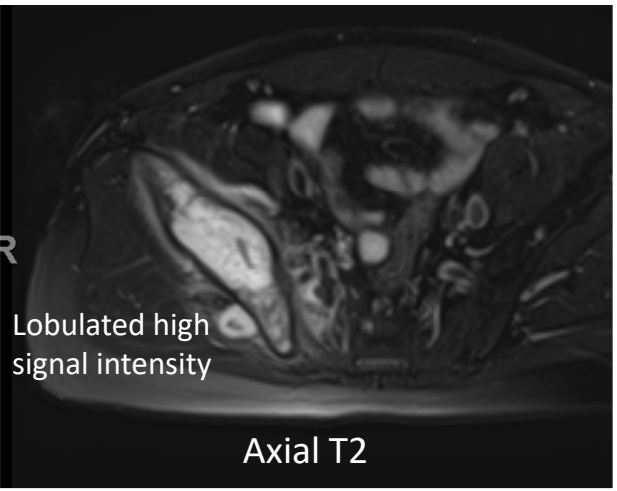




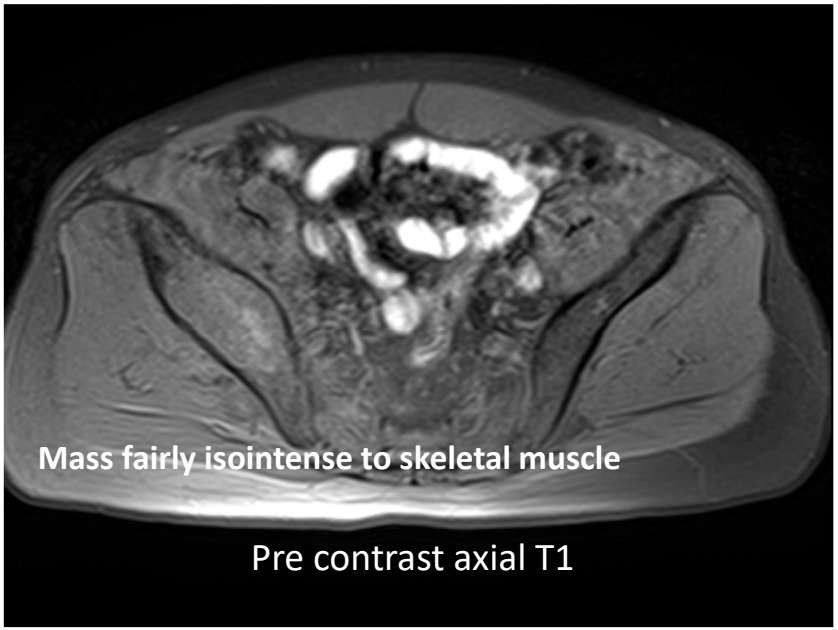
Post contrast axial



Post contrast axial



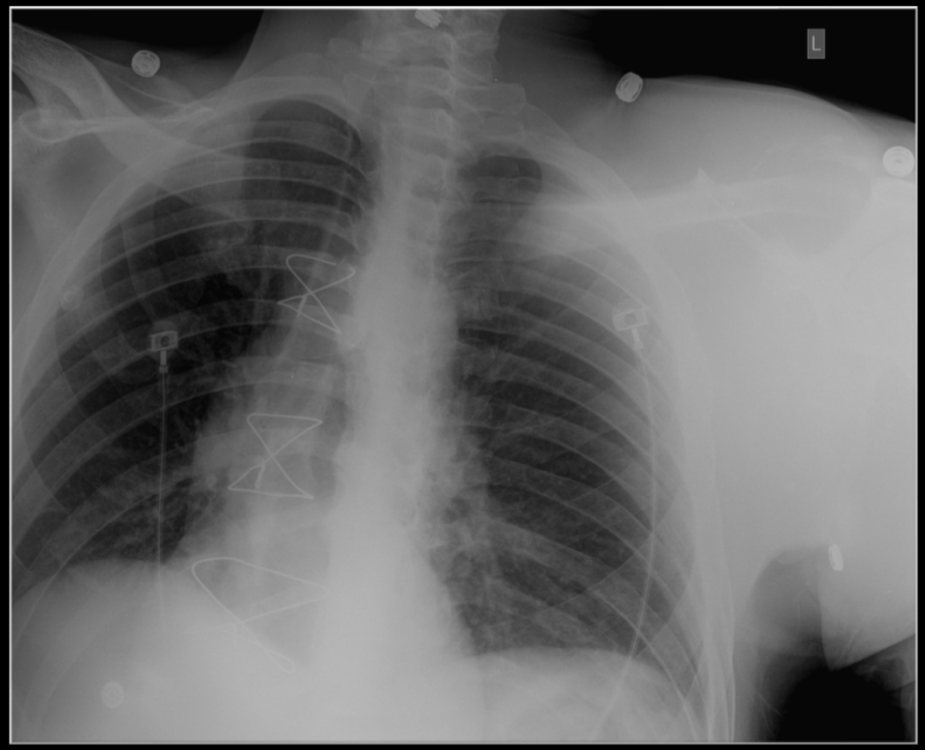
Axial T2

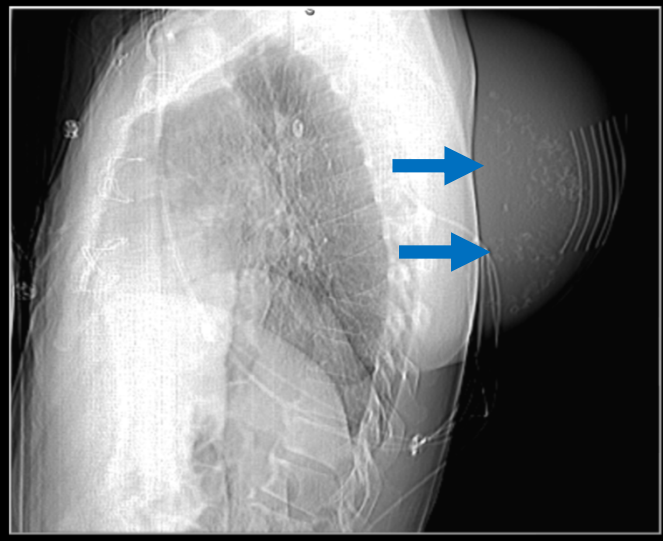


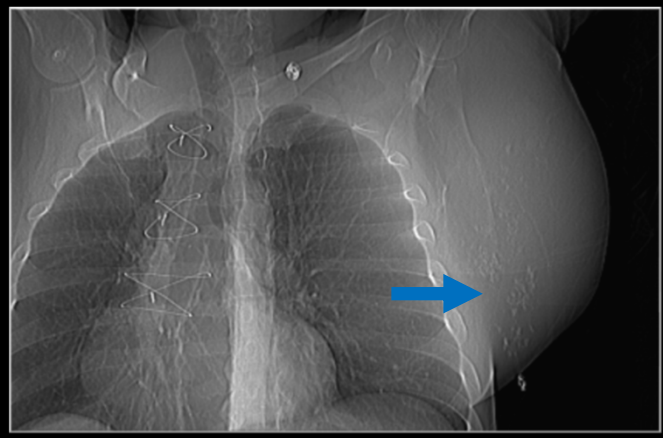
Pre contrast axial T1

Post contrast axial

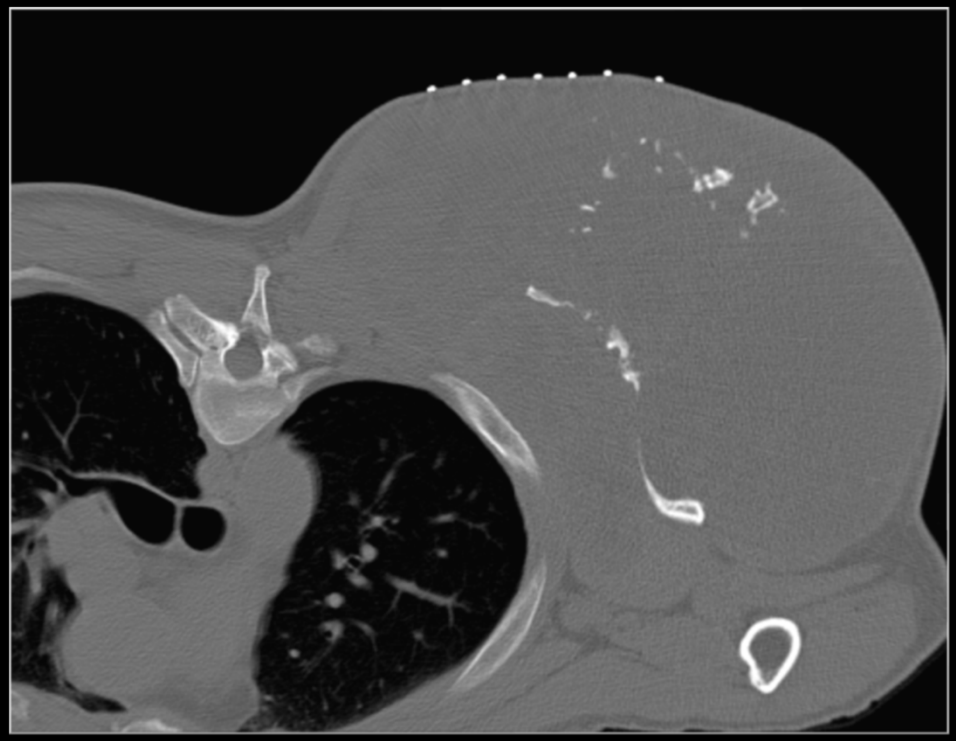
- Chest radiograph and scout images of a CT shoulder in a different patient demonstrate a large mass in the region of the left scapula containing multiple areas of calcifications

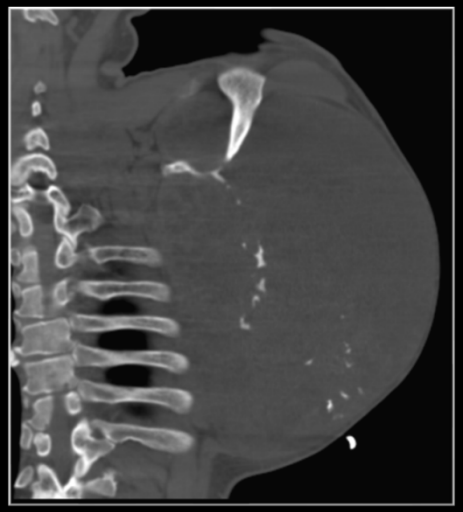


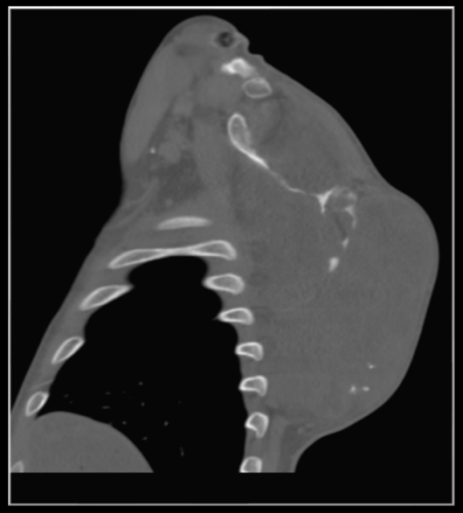




- CT shows a large mass arising from the body of the left scapula, with extensive soft tissue component, eroding and destroying the majority of the scapular body, and containing multiple coarse/lobular calcifications suggestive of chondroid matrix. Biopsy result revealed chondrosarcoma.



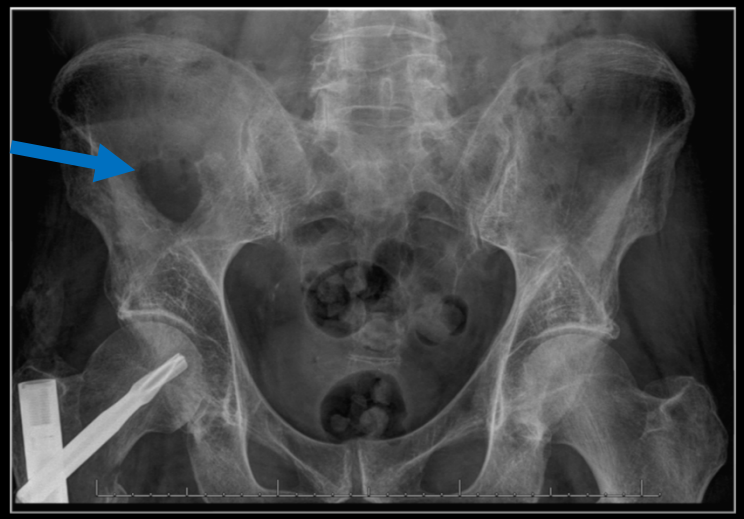


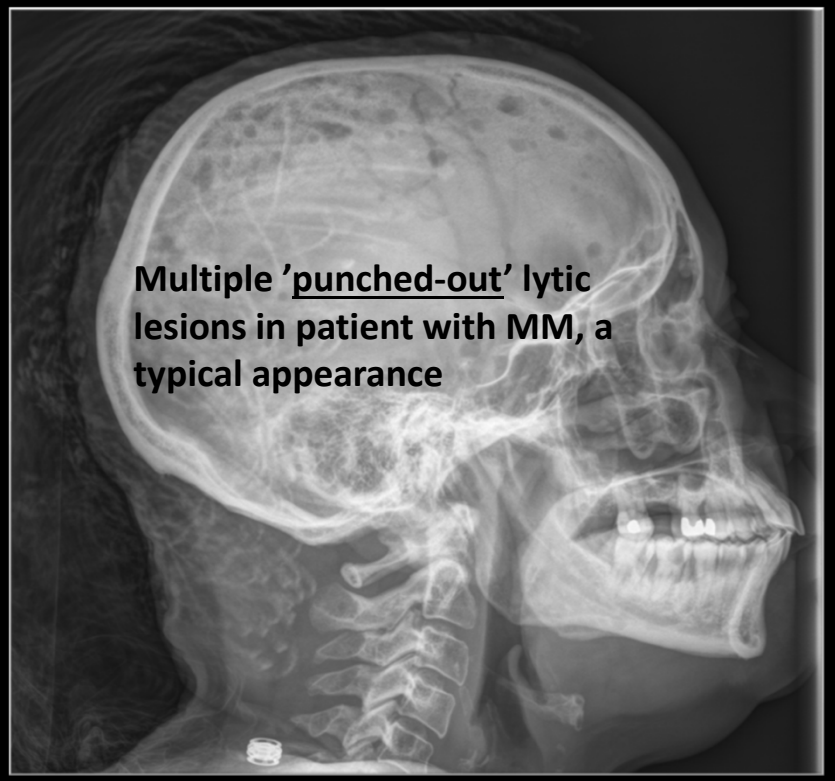


Metastasis / Multiple Myeloma (MM)

- Lytic metastasis → , and multiple myeloma are very similar in appearance
  - Should be in the differential in any patient with new lytic lesion(s) above the age of 40

- Tumors with purely lytic metastasis: Lung, Renal cell cancer Thyroid, Breast, GI, neuroblastoma (variable)

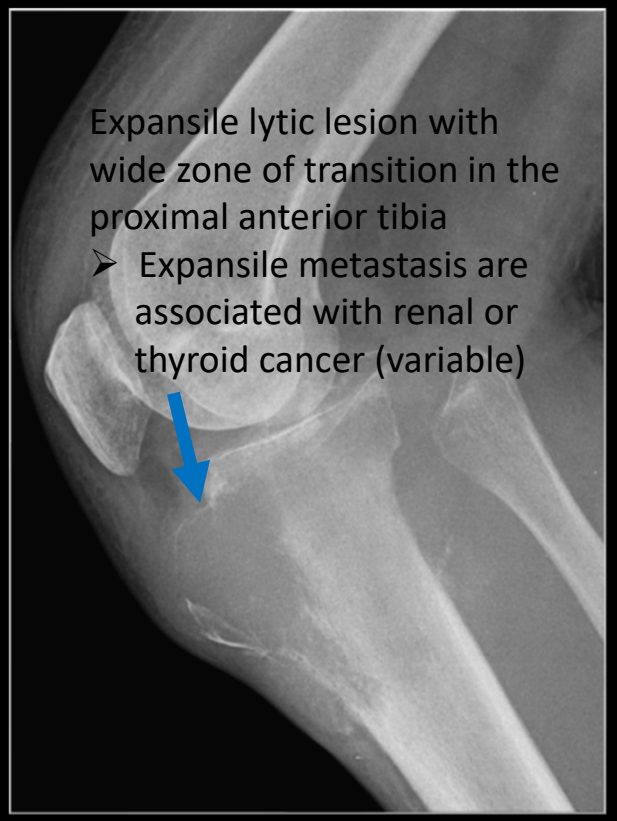




Multiple 'punched-out' lytic lesions in patient with MM, a typical appearance

Lytic Metastasis

Pathologic destruction of the greater tuberosity

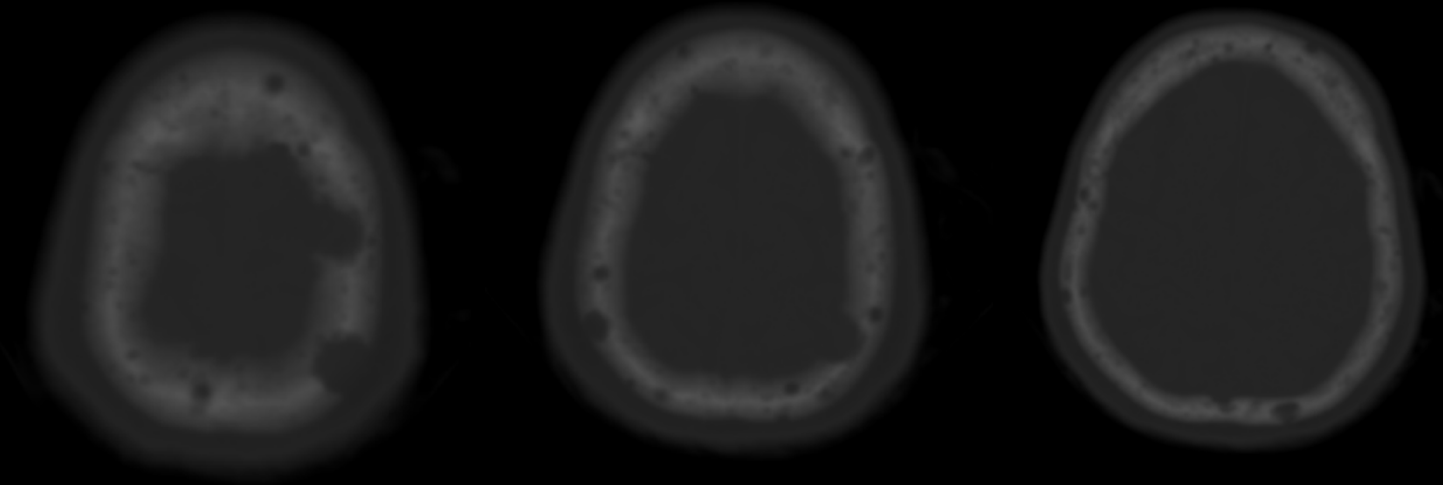


Expansile lytic lesion with wide zone of transition in the proximal anterior tibia

- Expansile metastasis are associated with renal or thyroid cancer (variable)

Multiple Myeloma (MM)

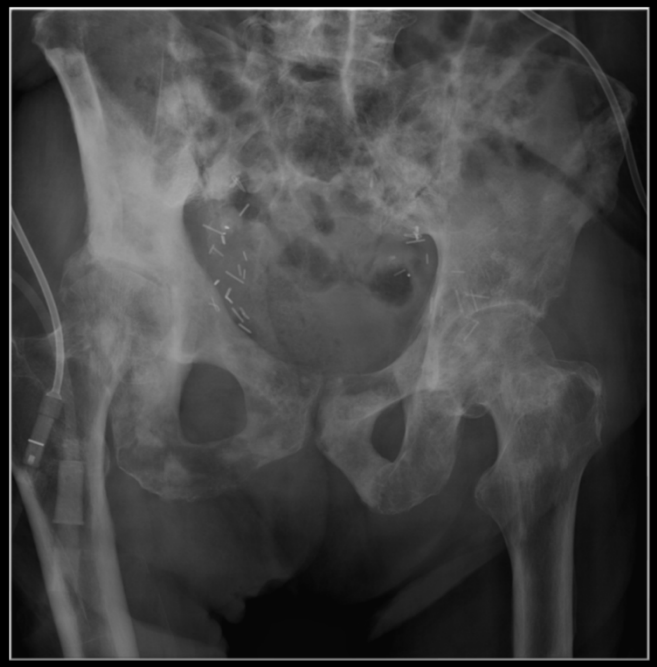
- Most common primary bone tumor
- Solitary lesion: plasmacytoma
- Monoclonal gammopathy of undetermined significance (MGUS):
  - Precursor to MM (1% per year)
- Sclerotic form of MM rare (5%)

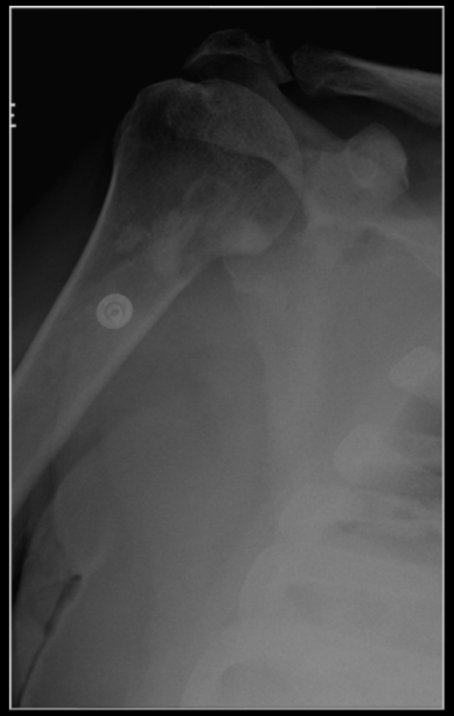


’Punched-out’ lytic lesions in patient with MM on head CT

Sclerotic Metastasis

- Tumors with purely sclerotic metastasis: Prostate, breast, bladder, GI (carcinoid), Lung (Small cell lung cancer), medulloblastoma

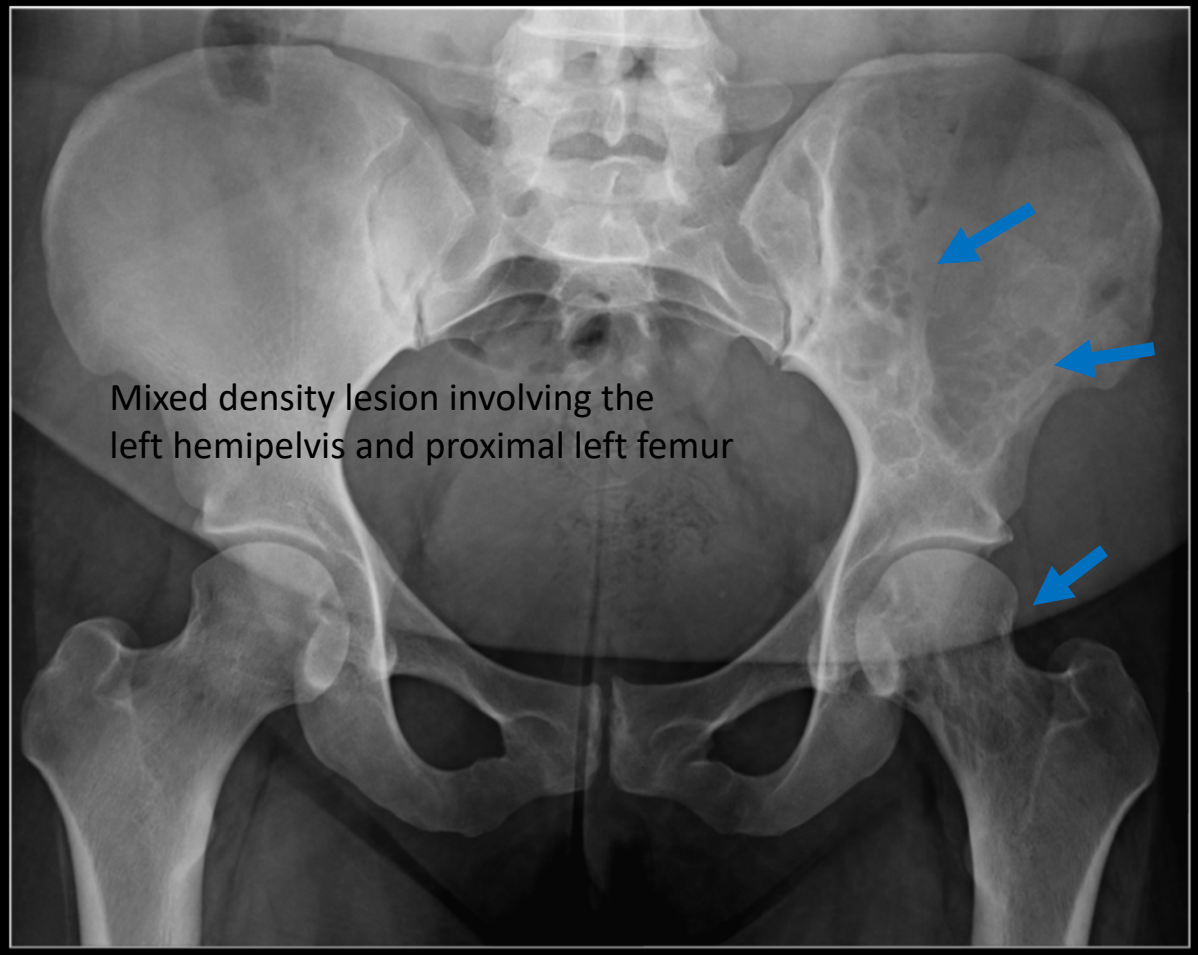


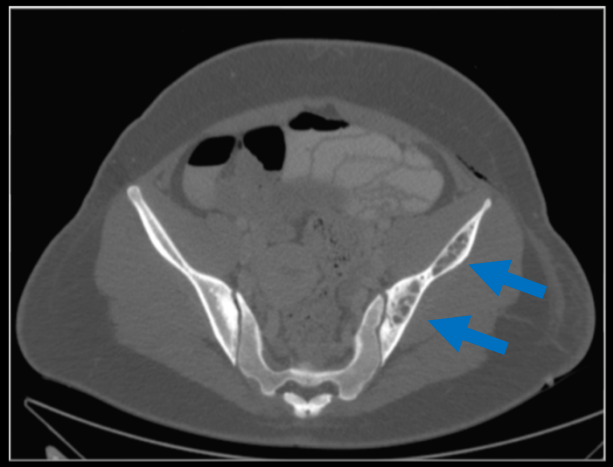


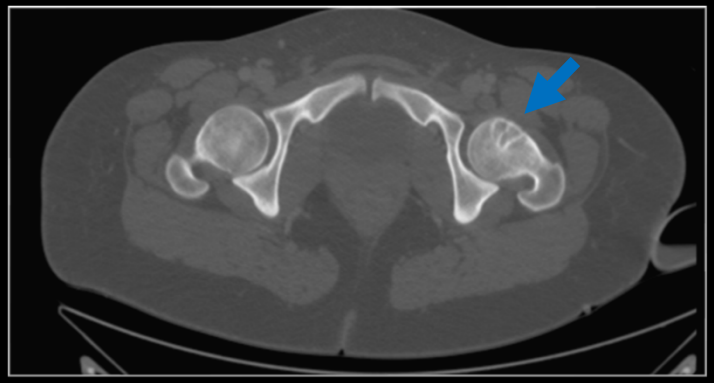
Fibrous Dysplasia

- Benign condition
- Can be seen in any bone, however certain locations are more common
  - Tubular bones, pelvis, ribs, skull and facial bones preferred
- Density varies from lytic to densely sclerotic
- Lesions can causing some degree of expansion/bowing of the bone
- No aggressive features seen (e.g. periosteal reaction, cortical breakthrough etc.)

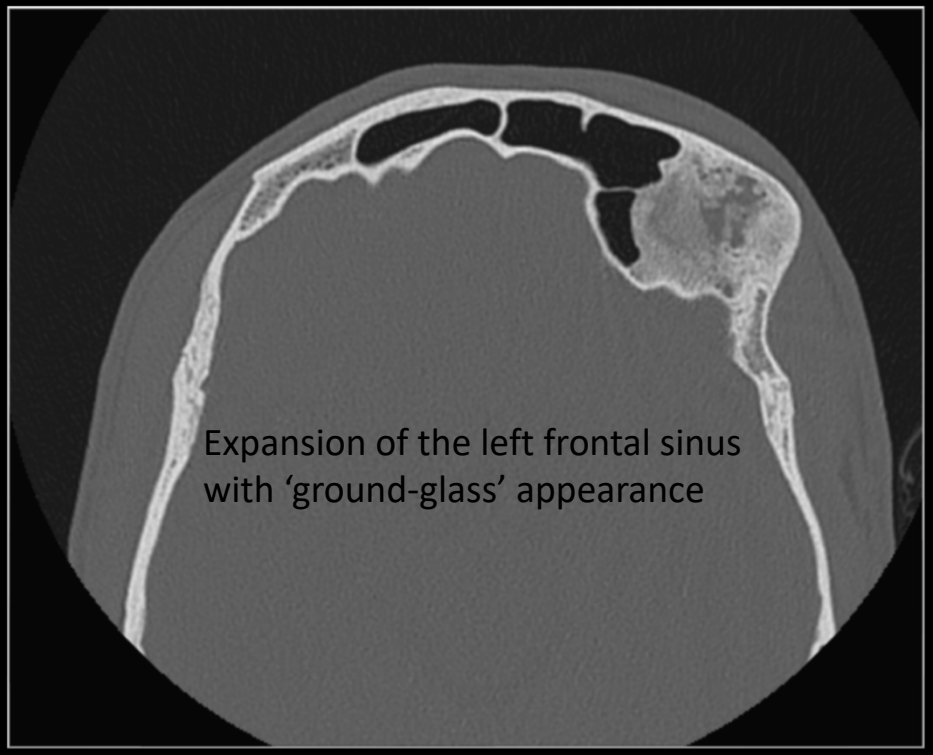
Fibrous Dysplasia



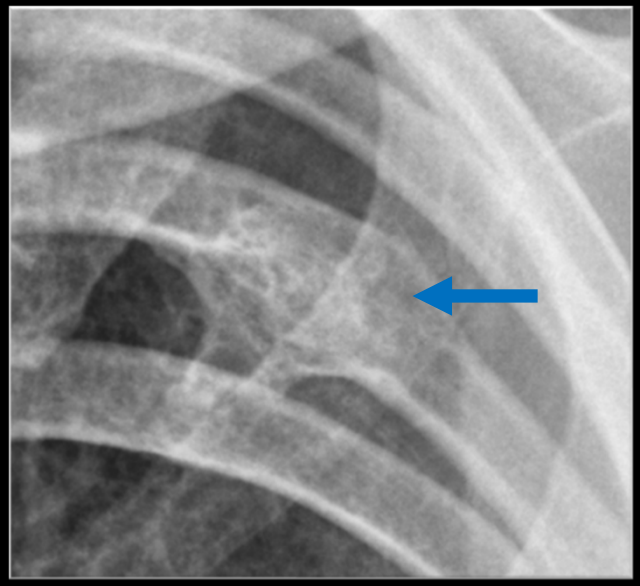




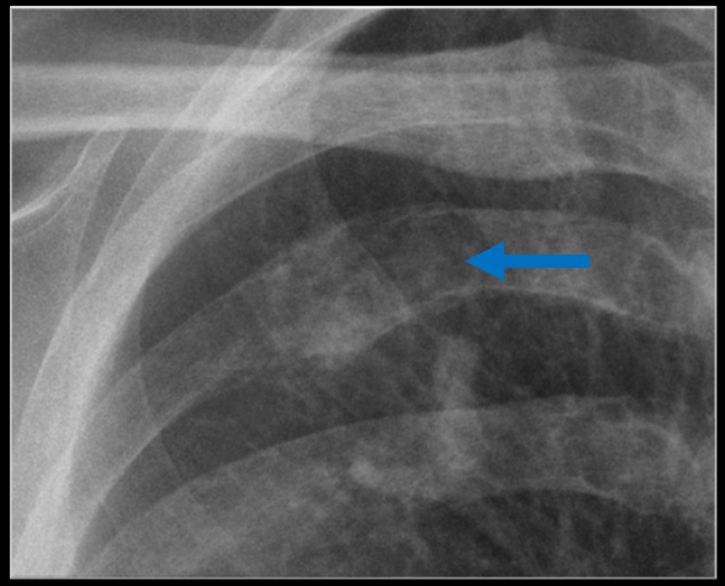
Fibrous Dysplasia



- Note the similarity of these rib lesions
- Further imaging and biopsy may be necessary to distinguish between lesions at times



Fibrous dysplasia



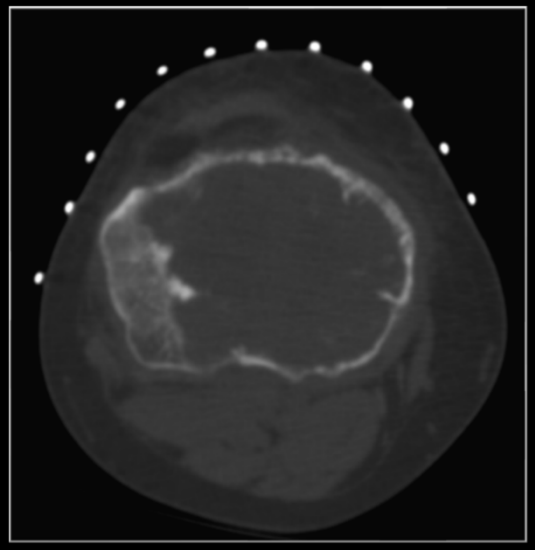
Lytic metastasis

Giant cell tumor (GCT)

- Usually benign lesion (5% are malignant)
- Originates in metaphysis and extends into epiphysis
  - Often extends to end of bone
- Narrow transition zone with non-sclerotic margins
  - Unique appearance
- Can have fluid levels on MRI
- High recurrence rate

Corresponding CT of the same patient (obtained during biopsy) shows large lytic lesion with areas of cortical thinning/destruction

- Biopsy result revealed GCT with atypical features

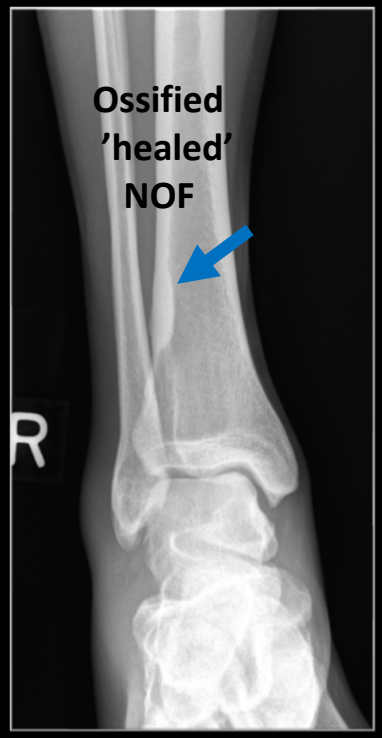


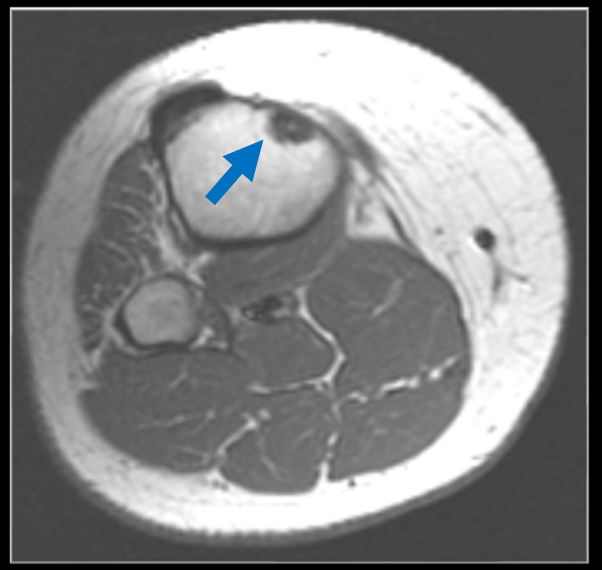
MIR in the same patient 6 month later status post neoadjuvant chemotherapy to assess for treatment response shows marked interval increase in size of the lesion

- T2 images demonstrate large heterogenous mass with nodular/whorled features

Nonossifying Fibroma (NOF)

- Benign lesion
- Cortical based, lytic lesion with sclerotic margin
- Often ‘heals’ with age

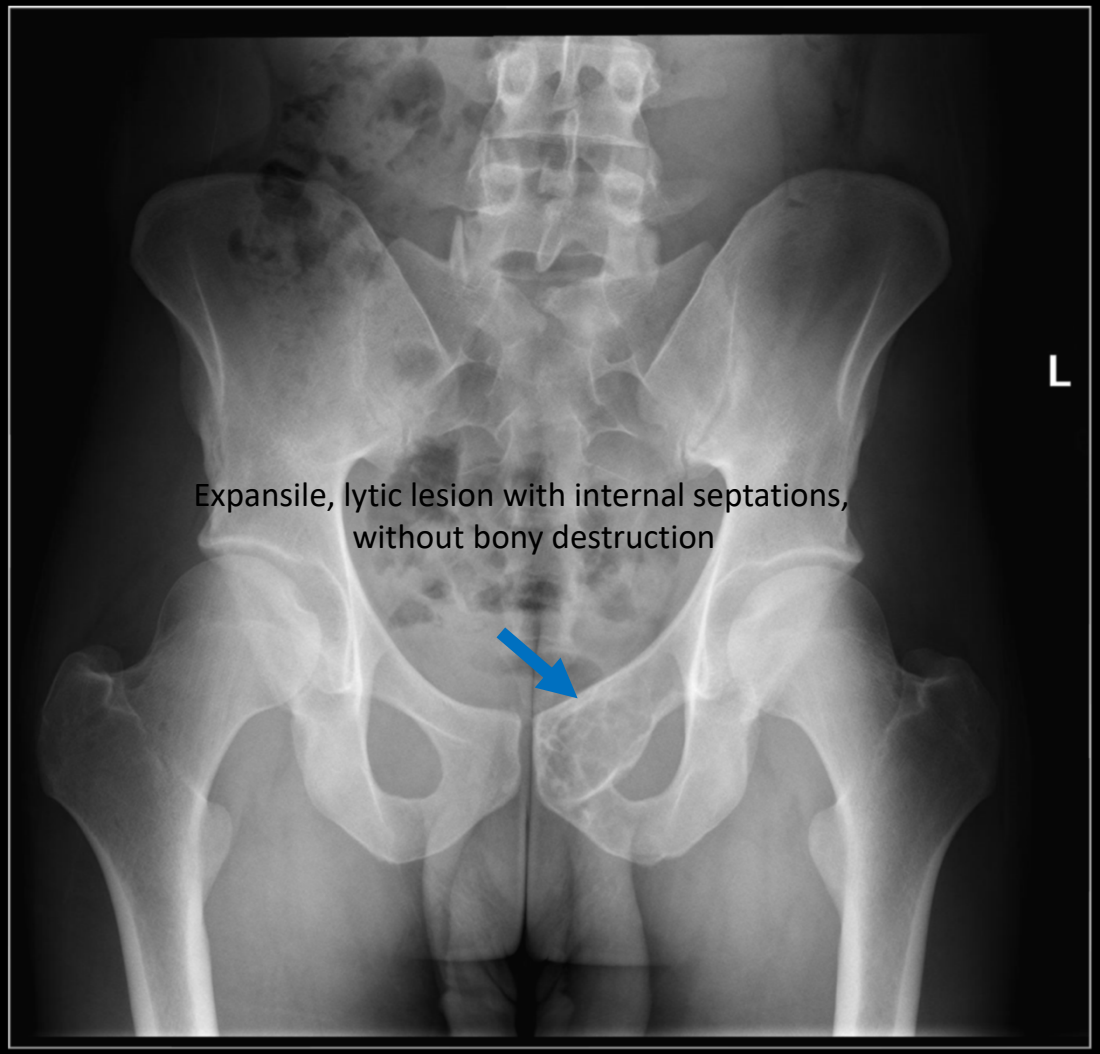




Axial T1

Aneurysmal Bone Cyst (ABC)

- Benign cystic lesion
  - Primary vs. secondary ABCs (secondary ABCs can arise in various other tumors)
- Usually seen in long bones
  - Also found in the posterior elements in the spine
- Patients are usually < 30 years old
- Lytic, expansile lesion, thin sclerotic margin, may contain septations
  - CT and MRI demonstrate fluid levels in most cases
- May demonstrate rapid growth → can simulate a more aggressive lesion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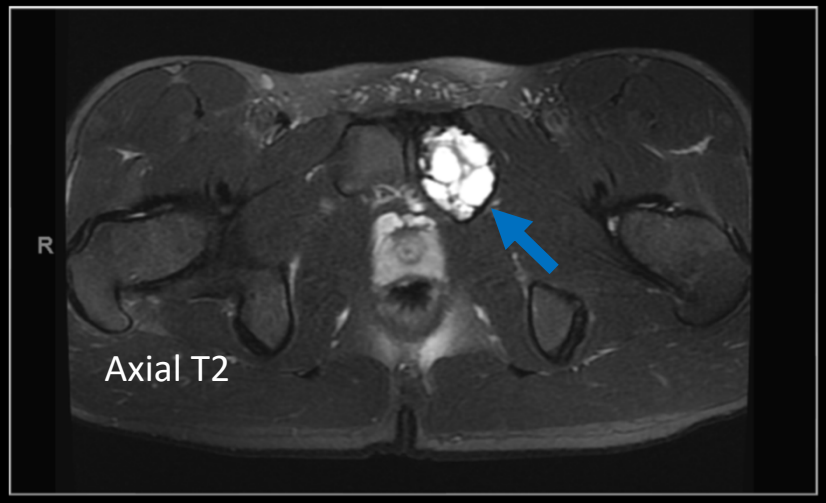
Expansile, lytic lesion with internal septations, without bony destruction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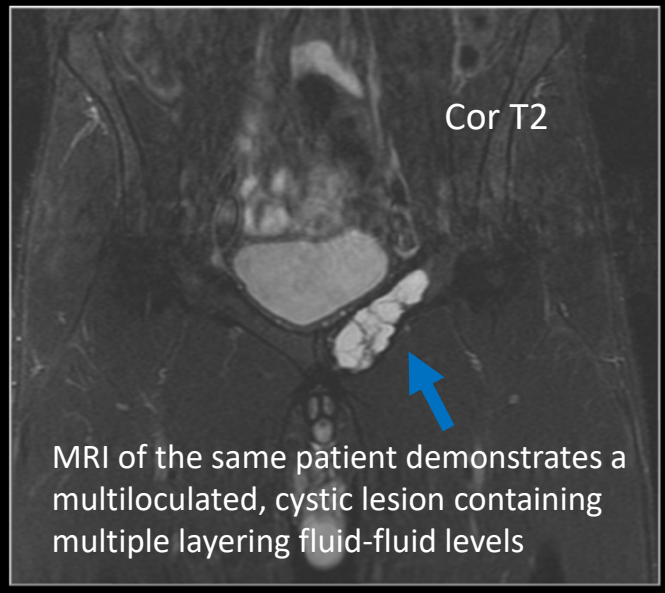
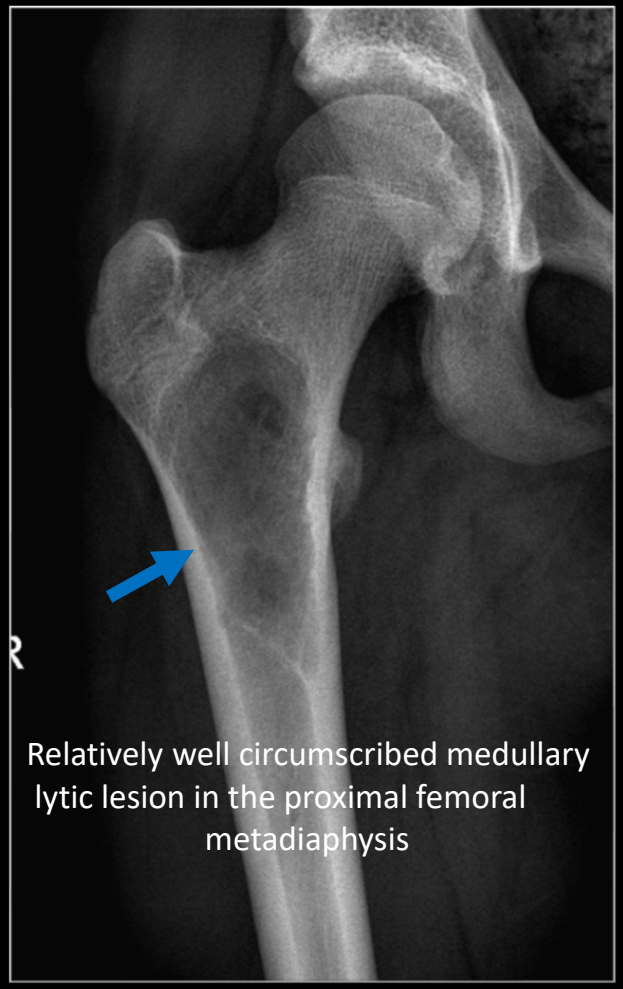
Axial T2

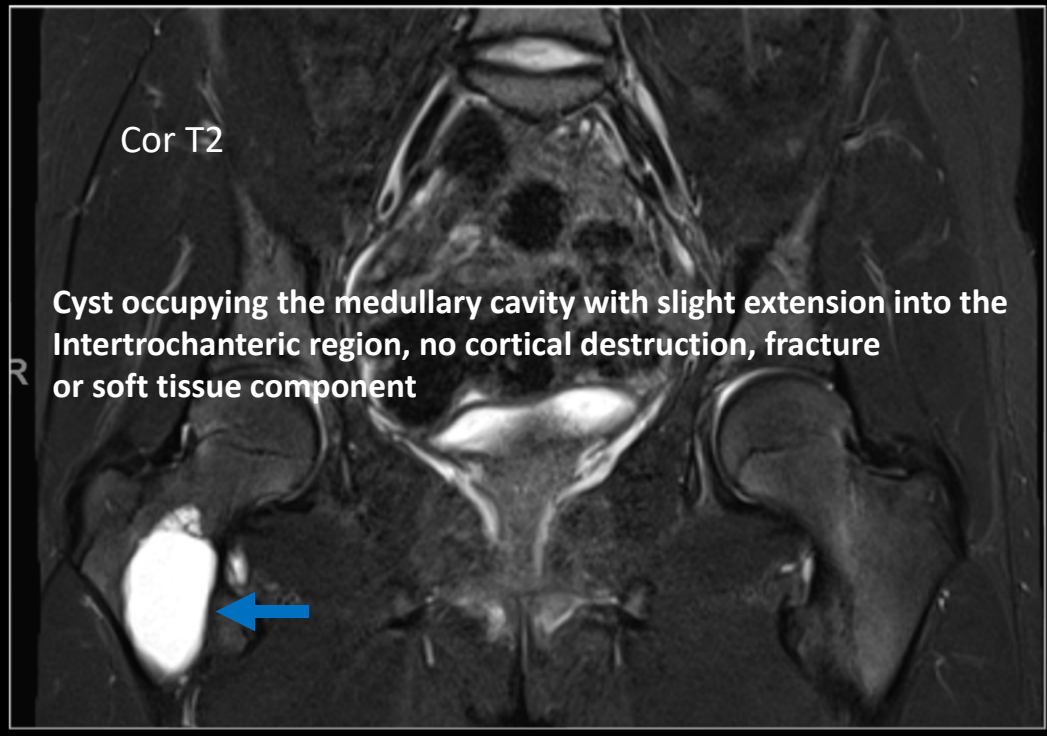

Cor T2
MRI of the same patient demonstrates a multiloculated, cystic lesion containing multiple layering fluid-fluid levels

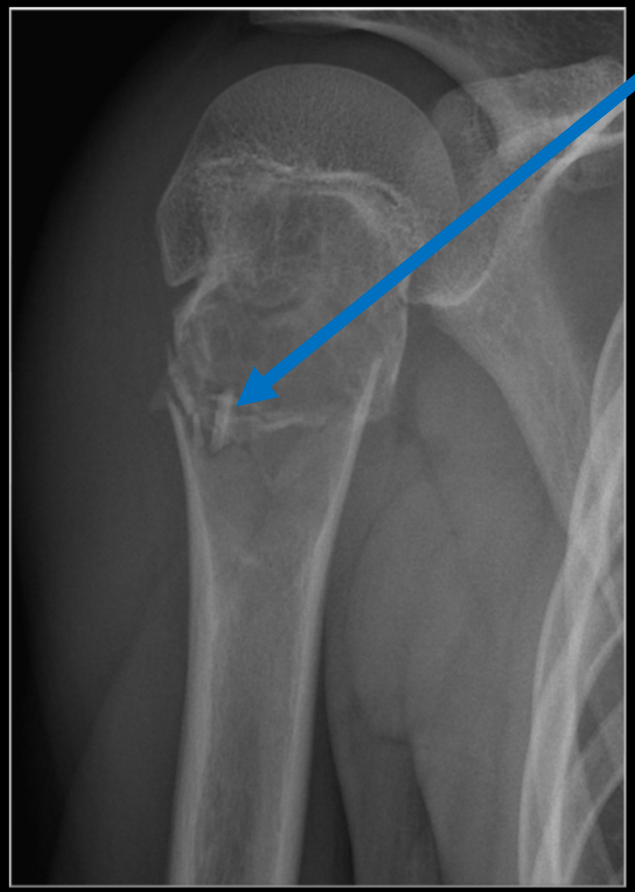
Simple (Unicameral) bone cyst

- Benign cystic lesion
- First and second decades of life
- Expansile, arising centrally in the medullary cavity, may contain septations and loculations
  - ABC usually more eccentric
- 'Fallen fragment' sign → represents fractured fragment of bone
- May spontaneously resolve
  - No consensus on best treatment option (Steroid injection, curettage etc.)



Relatively well circumscribed medullary lytic lesion in the proximal femoral metadiaphysis

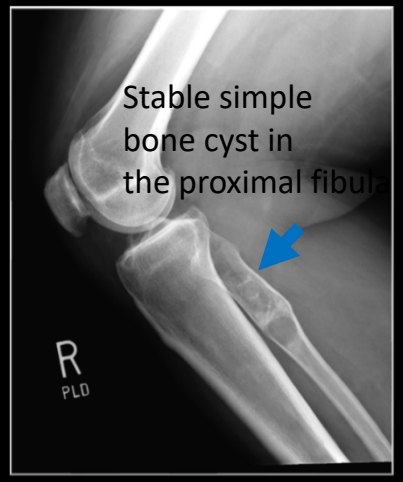




'Fallen Fragment' sign indicating a pathologic fracture

- Representing a fracture fragment resting dependently in the cystic bone lesion
- Pathognomonic for simple bone cyst

Differential Dx: Intraosseous Lipoma



2016

2009

Enchondroma

- Benign, cartilage forming tumor
- Chondroid matrix, usually central location
  - In small tubular bones may be expanded and bubbly appearing
- Differential Dx: Medullary bone infarct

Chondroblastoma

- Benign tumor in skeletally immature individuals
- Epiphyseal origin, proximal humerus most common location
- Geographic lytic lesion, up to 50% contain chondroid matrix
  - Main differentials include infection, Langerhans cell histiocytosis, Clear Cell Chondrosarcoma
- On MRI lesion can contain fluid levels (secondary aneurysmal bone cyst)
- Treatment usually consists of curettage and bone graft

- 16 year old male presenting with shoulder pain for 5 months. MR arthrogram demonstrates a mildly T2 hyperintense lesion in the proximal humeral epiphysis with extensive surrounding bone marrow edema . Biopsy confirmed a chondroblastoma.