MSK imaging primer for gross dissection

Olga Laur PGY4, MD, Alexander Christakis, PGY4 MD

Radiology Preceptor: ***Stacy E Smith, MD***

Pathology Preceptor: ***Leona Doyle, MD***

HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

MAGNET RECOGNIZED
AMERICAN NURSES CREDENTIALING CENTER

Primer for bone tumor imaging evaluation

Goals

- Understand radiologic language and develop a language for interpretation of the resection specimen radiograph and its importance in clinical management

- Develop ability to understand the radiologic report in greater detail

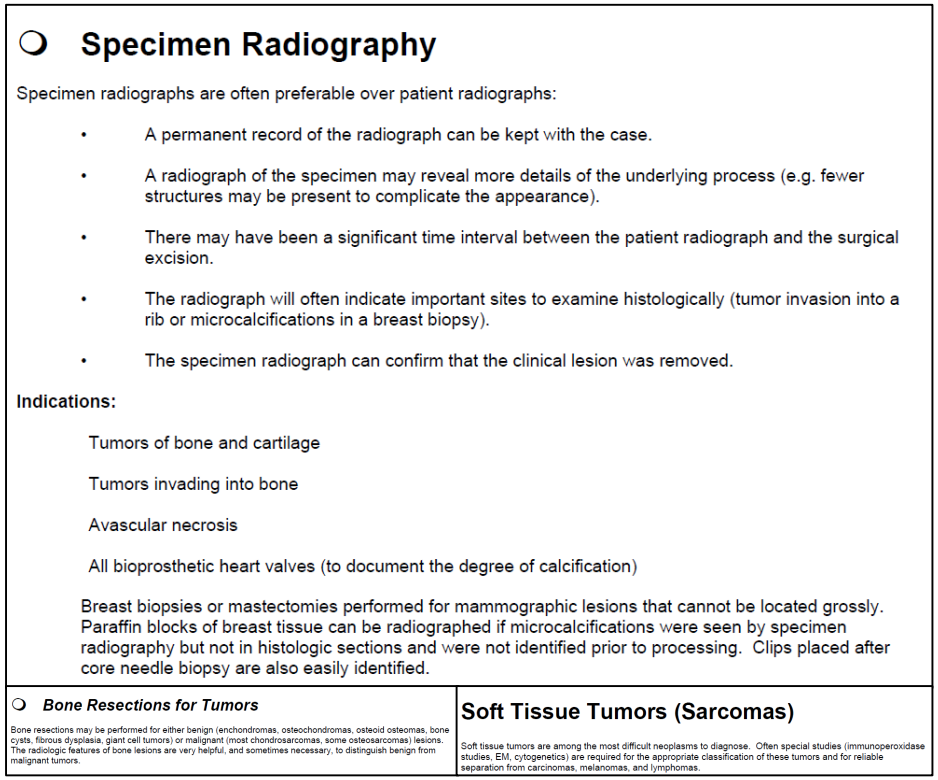
- Understand basic steps in pre-dissection evaluation of bone tumors using radiography and MRI for an optimized characterization of the tumor

Why is it important to look at preoperative imaging?

- Can determine optimal dissection plane (ie avoid necrotic/cystic parts of tumor as seen on imaging and focus on those with the highest pathologic yield)
- Estimate location and approximate size of the tumor for optimal dissection plan
- Determine high grade vs low grade features of the tumor for improved interpretation of tumor characteristics

What does the manual say…

- Use pre-op imaging to orient and understand lesion location/margins
- Any specimen containing bone should be radiographed in pathology
- Obtain specimen radiograph BEFORE cutting into specimen
- Important for records/documentation



Specimen Radiography

Specimen radiographs are often preferable over patient radiographs:

- A permanent record of the radiograph can be kept with the case.
- A radiograph of the specimen may reveal more details of the underlying process (e.g. fewer structures may be present to complicate the appearance).
- There may have been a significant time interval between the patient radiograph and the surgical excision.
- The radiograph will often indicate important sites to examine histologically (tumor invasion into a rib or microcalcifications in a breast biopsy).
- The specimen radiograph can confirm that the clinical lesion was removed.

Indications:

Tumors of bone and cartilage

Tumors invading into bone

Avascular necrosis

All bioprosthetic heart valves (to document the degree of calcification)

Breast biopsies or mastectomies performed for mammographic lesions that cannot be located grossly. Paraffin blocks of breast tissue can be radiographed if microcalcifications were seen by specimen radiography but not in histologic sections and were not identified prior to processing. Clips placed after core needle biopsy are also easily identified.

Bone Resections for Tumors

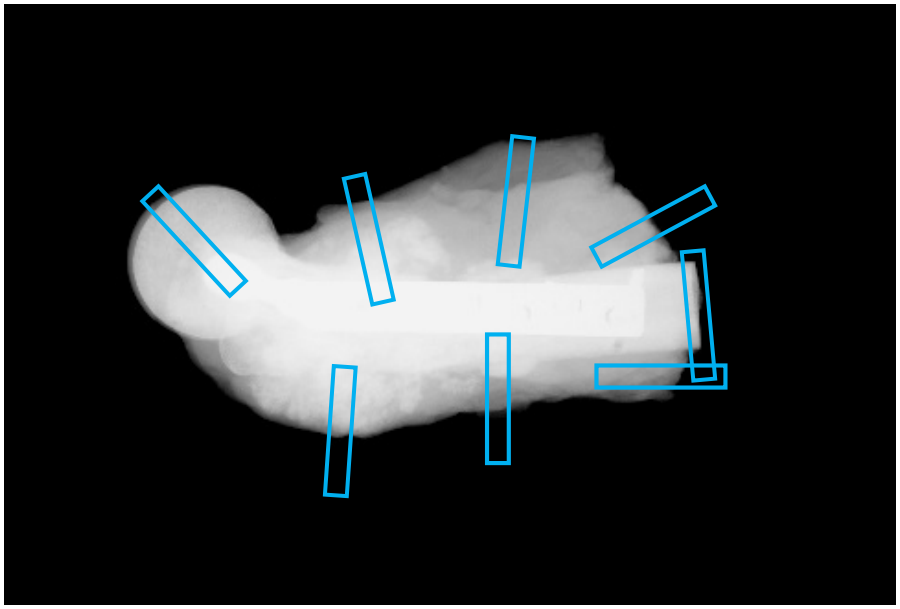
Bone resections may be performed for either benign (enchondromas, osteochondromas, osteoid osteomas, bone cysts, fibrous dysplasia, giant cell tumors) or malignant (most chondrosarcomas, some osteosarcomas) lesions. The radiologic features of bone lesions are very helpful, and sometimes necessary, to distinguish benign from malignant tumors.

Soft Tissue Tumors (Sarcomas)

Soft tissue tumors are among the most difficult neoplasms to diagnose. Often special studies (immunoperoxidase studies, EM, cytogenetics) are required for the appropriate classification of these tumors and for reliable separation from carcinomas, melanomas, and lymphomas.

Imaging guides sampling

- Target all margins accurately
- Identify surrounding structures that may be locally involved
- Identify solid vs cystic areas
- Ensure adequate sampling



Preoperative imaging options

- Radiograph – big picture of the tumor location/size/characteristics
- CT – more detailed appreciation of the fine osseous details and analysis of soft tissue
- MRI – virtually always obtained in tumor analysis for detailed evaluation of tumor characteristics , tumor/soft tissue interface as well as relationship with osseous structures

Radiograph - "Bird's eye view"

- Assess key characteristics of the tumor:
  1. Margin
  2. Matrix mineralization
  3. Cortical expansion
  4. Periosteal reaction
  5. Soft tissue extension, although limited on radiographs

*For radiologist, location of tumor and age of the patient in MSK is also extremely important as it allows to narrow differential diagnosis

1. Tumor Margin

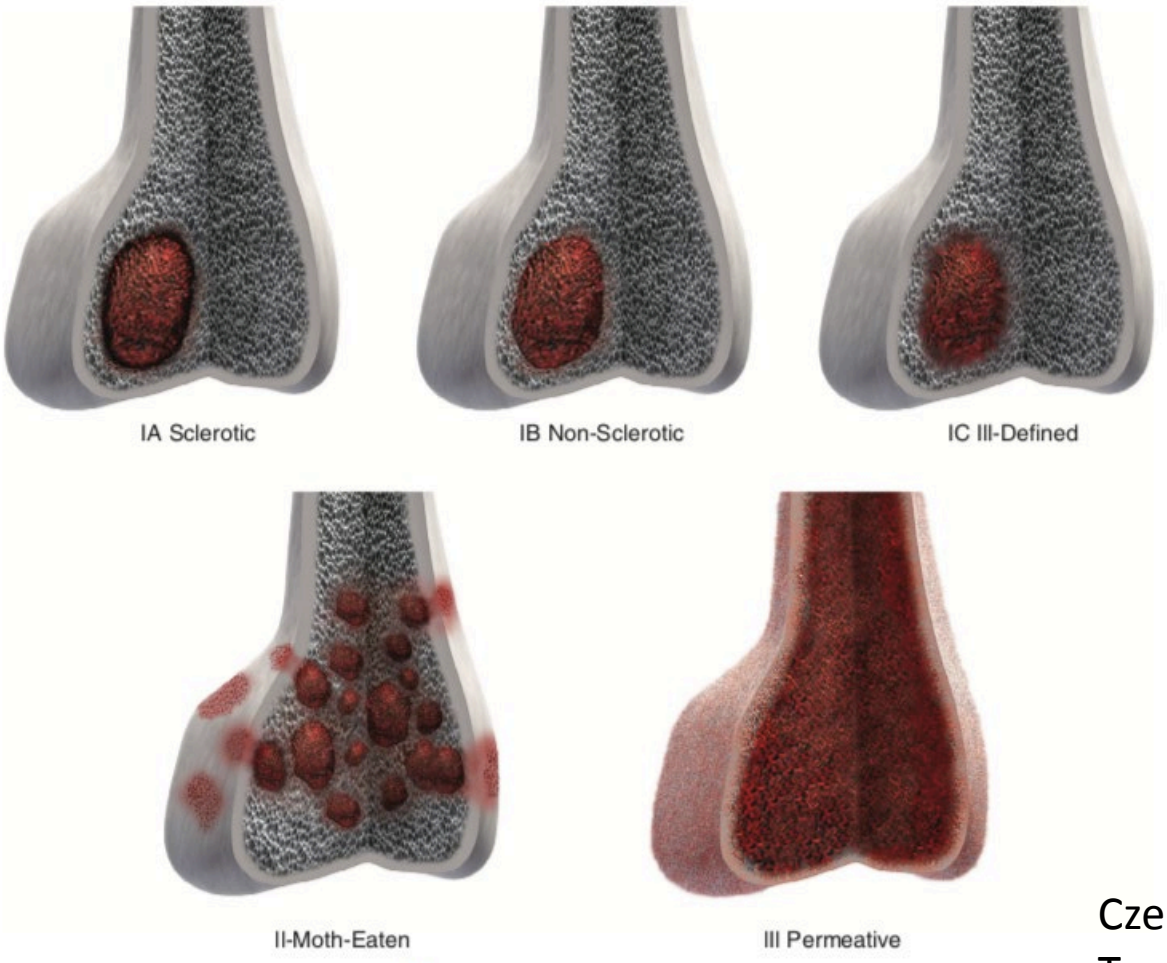


FIGURE 2-5 ■ Classification of bone tumor margins.

Czerniak et al, Bone Tumors

2. Matrix mineralization

Source: https://radiologykey.com/bone-tumors-and-related-condition/
Radiologyassistant.com
https://orthoinfo.aaos.org/en/diseases--conditions/enchondroma
http://learningradiology.com/archives05/COW%20142-Osteoblastic%20mets/blasticmetscorrect.htm

3. Cortical expansion

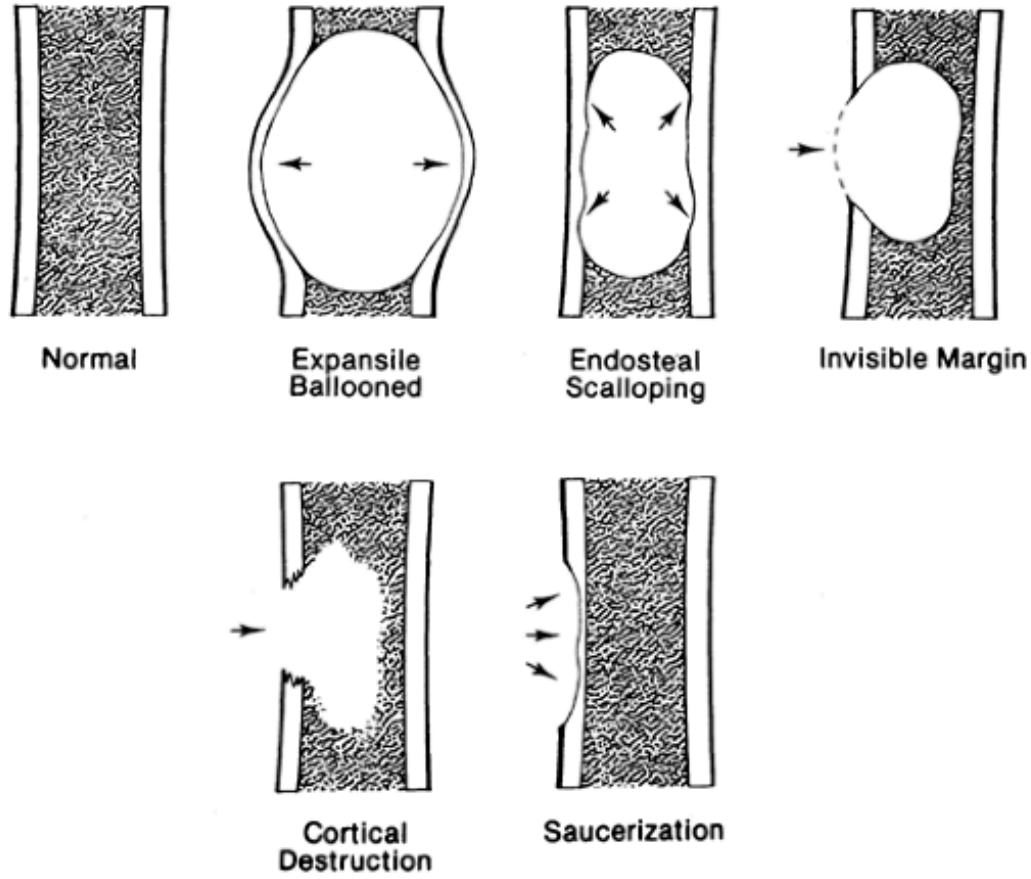


FIG. 4-3. Patterns of cortical disturbance.

Source: https://radiologykey.com/bone-tumors-and-related-condition/

4. Periosteal reaction

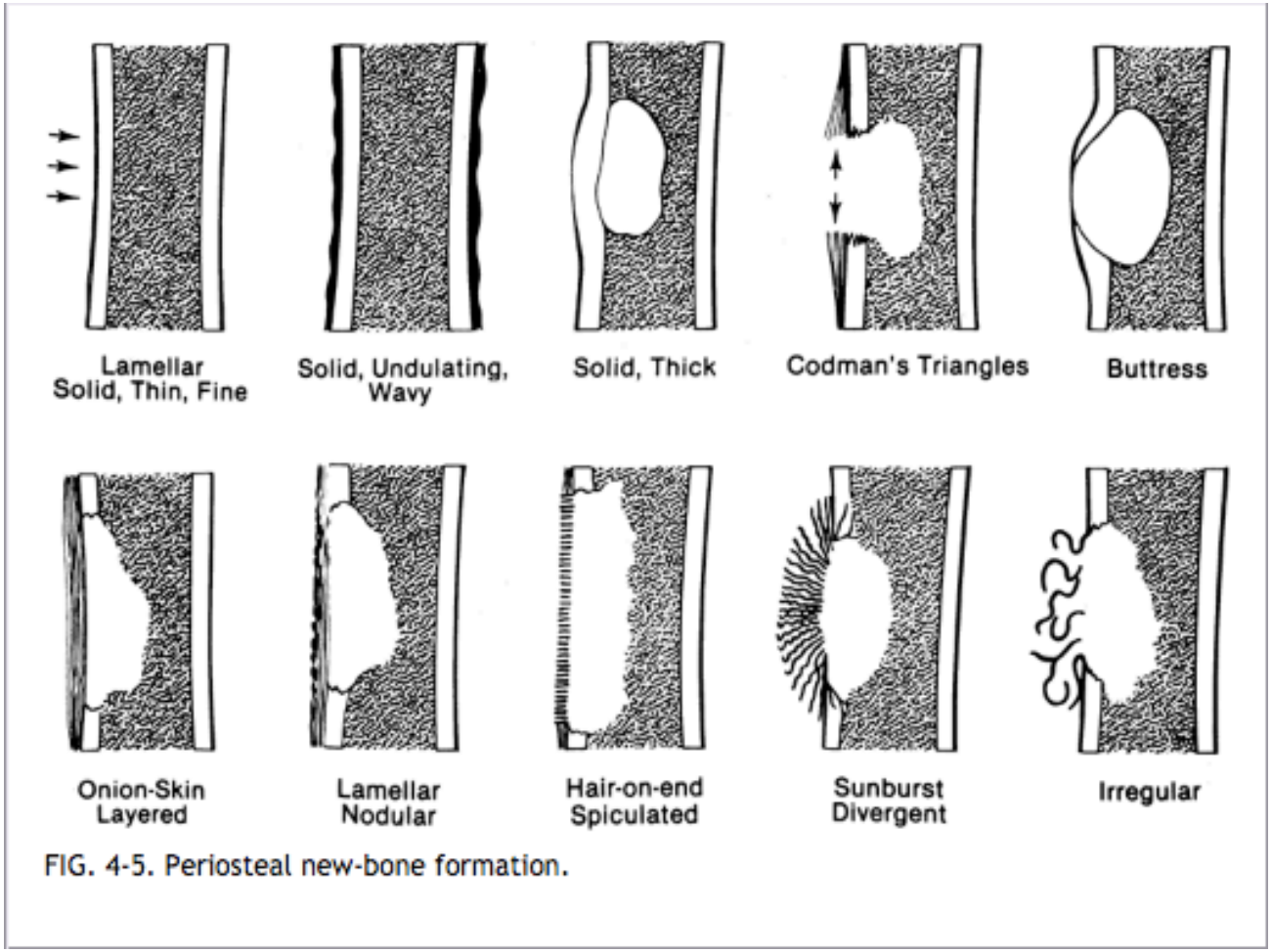


FIG. 4-5. Periosteal new-bone formation.

Source: https://radiologykey.com/bone-tumors-and-related-condition/

5. Soft tissue extension

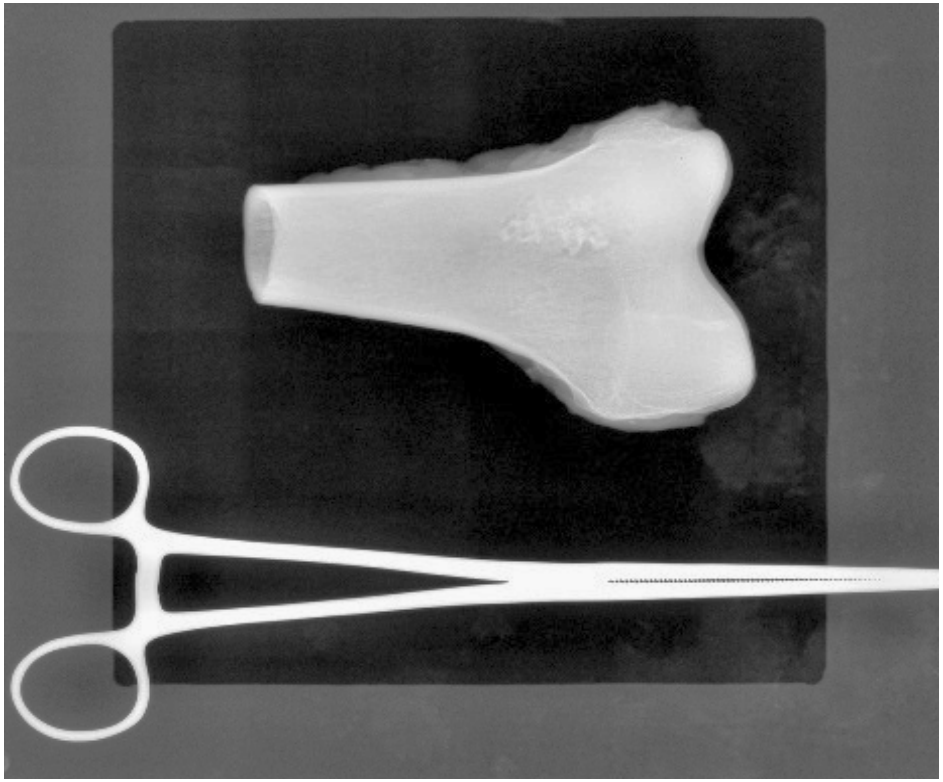
- Best evaluated with MRI, but can see on radiograph if significant extension/abnormal mineralization of soft tissue

MSK specimen radiograph assessment

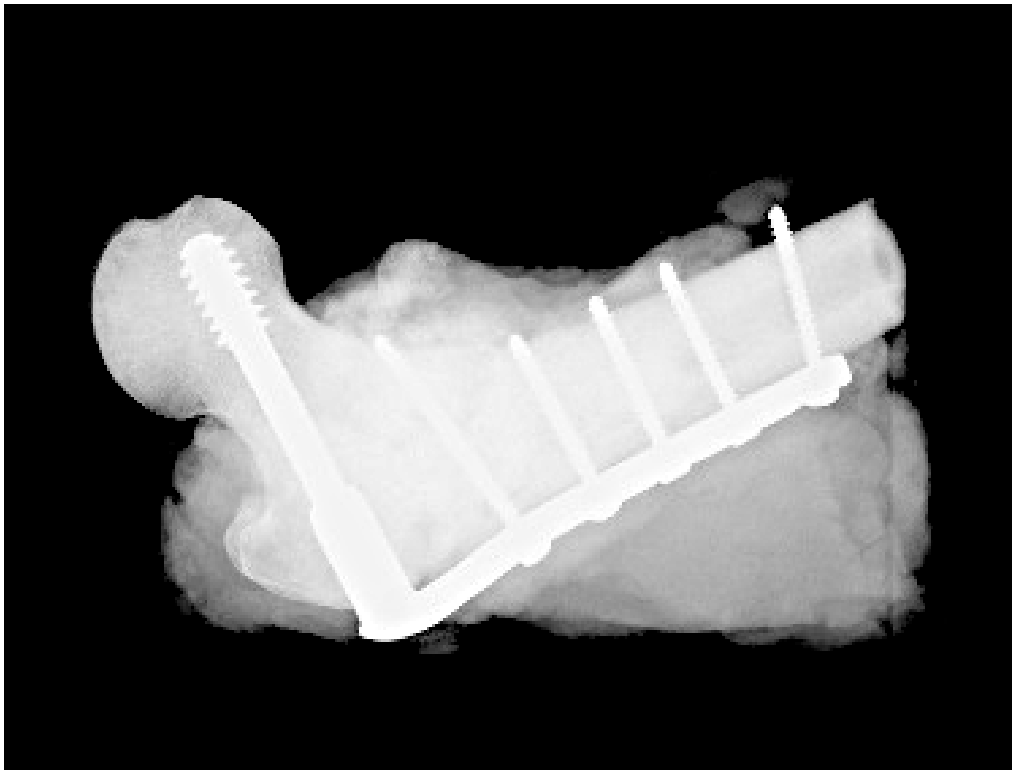
- Limited in interpretation:
  - One projection
  - Deformed resected specimen
  - Unclear specimen radiograph parameters

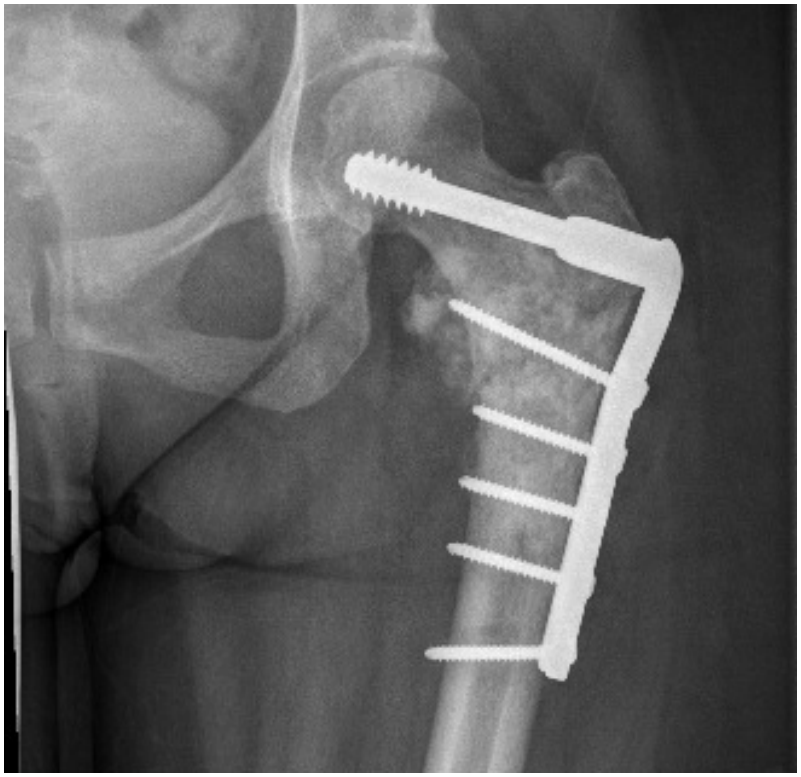
However, a comment can be made regarding :

1. **Margins of the lesion entirely resected versus margins are inconclusive; surgeon may need to go back in to resect entire lesion**
2. The osseous part affected – ie distal femur, proximal humerus etc
3. Matrix mineralization of the lesion
4. Bone and soft tissue components
5. Comparison to prior imaging – if key features on prior imaging are not identified on resection radiograph, lesion may need to be further resected



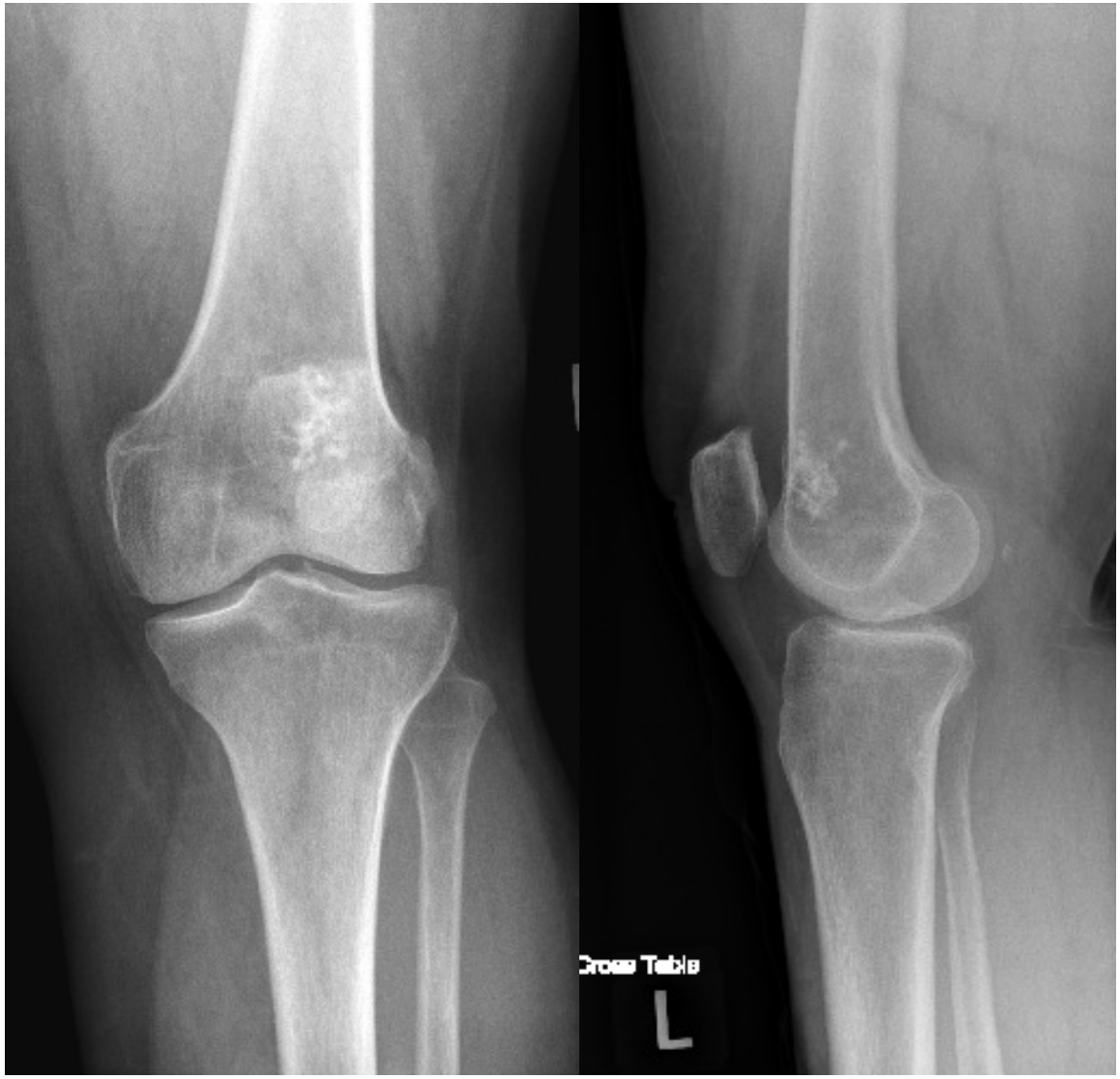
"Single radiograph of the resected left distal femur with the known tumor with chondroid matrix seen within the lateral distal femoral metadiaphysis is better visualized on prior imaging but appears to be included in the resection"





"Single radiograph of the resected left proximal femur with hardware and known tumor with osteoid matrix at the intertrochanteric region is better visualized on prior imaging but appears to be included in the resection"

"Single radiograph of the resected left proximal femur with total knee replacement with the known tumor recurrence at the level of lateral proximal tibia is better visualized on prior imaging and appears to be included in the resection"



Case 1 – pt with longstanding lesion in her left femur with worsening weakness

1. **Margin:** ill defined
2. **Matrix:** chondroid
3. **Bone expansion:** NO
4. **Periosteal reaction:** NO
5. **Extraosseous soft tissue extension:** No definite extension

IMPRESSION: Overall benign appearing tumor with chondroid matrix, likely enchondroma but given worsening symptoms MRI and bx were performed

Next step – MRI

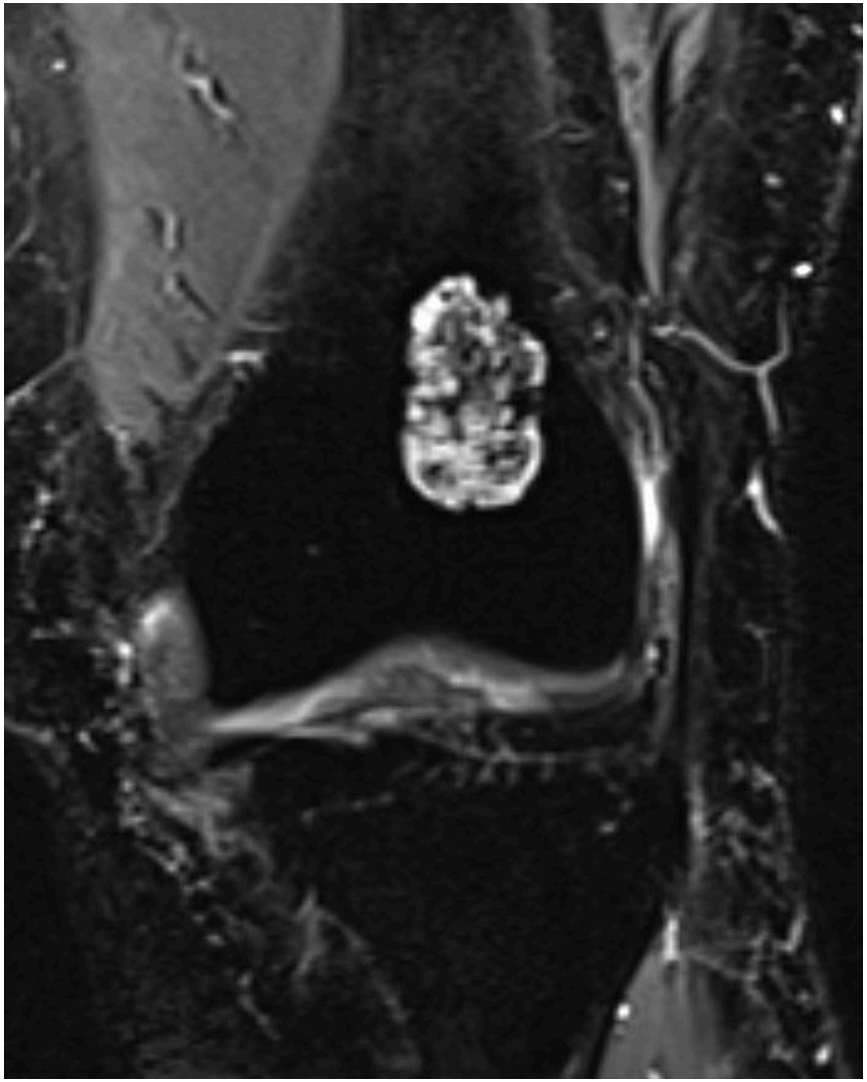
Basic assessment:

- STEP 1: Look at STIR sequence
- STEP 2: Look at T1 sequence
- STEP 3: Look at T1 post contrast (T1C+) sequence

Step 1 – STIR (fluid sensitive sequence)

- Most tumors are T2/STIR hyperintense
  - Lesion to bone contrast is usually best on this sequence – hyperintense tumor on the background of hypointense bone marrow (the fat is nulled on STIR i.e. appears black)
- T2 hyperintense signal is seen in the setting of
  - Pure tumor (secondary to inflammation and edema)
  - Edema around the tumor
  - Hemorrhage/cystic space
- Thus, tumor margin is often overestimated on STIR but it will usually stand out against the background of normal bone

Coronal STIR



Signal: heterogenous T2 signal

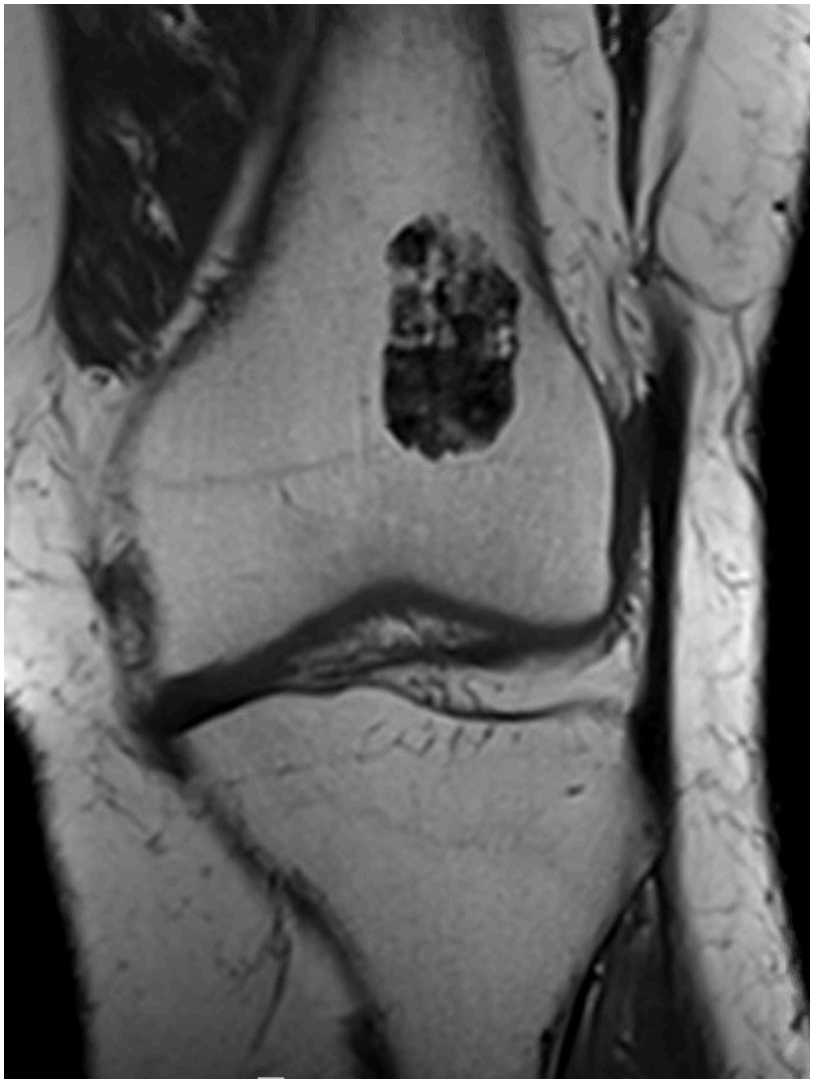
T2 is often used for tumor characterization with T2 signal in this case reflecting high water content of chondral lesion with T2 hypointensity representing mineralized foci as seen on the radiograph

STEP 2 – T1WI or PD sequence

- Anatomic sequence
  - Best sequence to assess tumor size
  - Tumor location and shape, fascia planes
  - Extraosseous extension
  - Tumor characterization – most tumors are T1 intermediate to hypointense and thus stand out compared to the fatty bone marrow

    IF see T1 hyperintense signal: fat, proteinaceous fluid and subacute hemorrhage

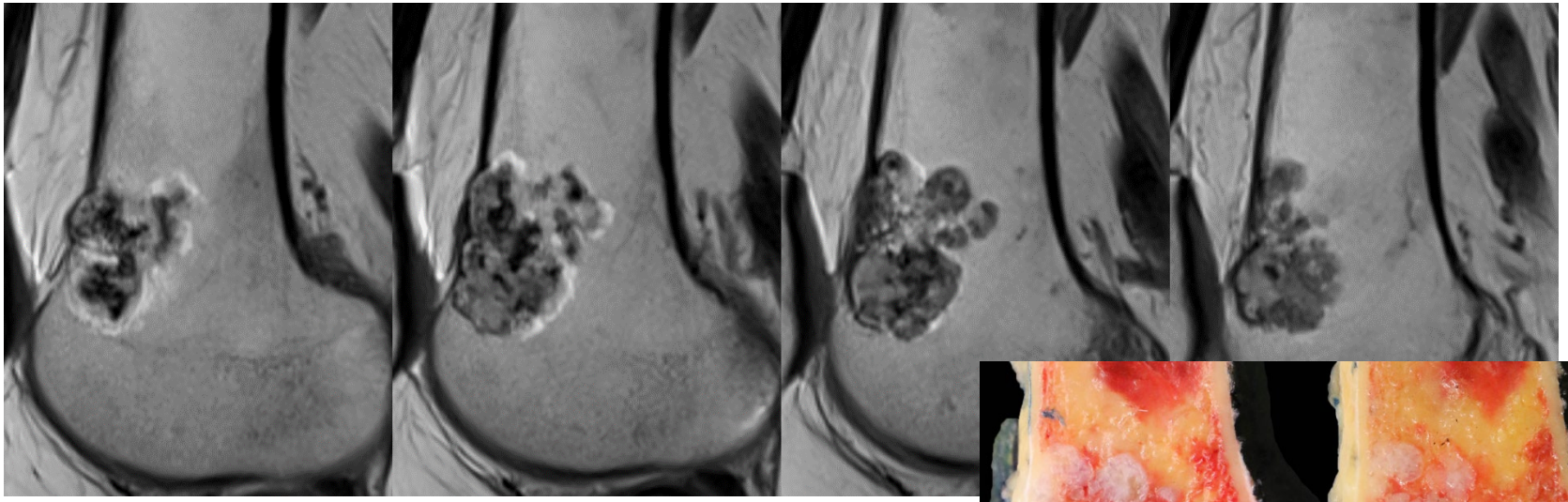
Coronal T1

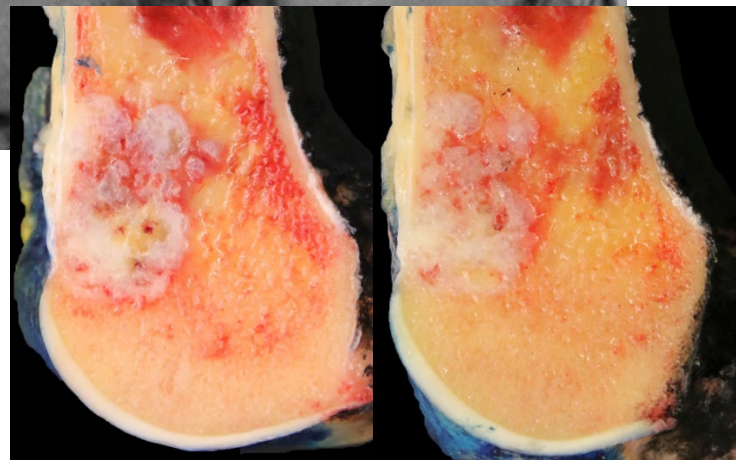


Step 2: T1WI

Signal: T1 hypointense (few speckles of T1 hyperintensity here represent entrapped areas of preexisting bone marrow)
Tumor location : lateral aspect of distal metadiaphysis of the femur
Tumor margin: Lobulated
Tumor size: BEST SEQUENCE (2.1 x 1.6 x 2.8 cm)
Extraosseous extension? – as you scroll pay attention to relationship of tumor to cortex and involve other sequences, such as sagittal and axial views

Look at other anatomic sequences in different plane – Sagittal PD





- ✓ There is cortical involvement of the anterior femur with no breakthrough
- ✓ No periosteal reaction
- ✓ High correlation of this sequence with gross specimen

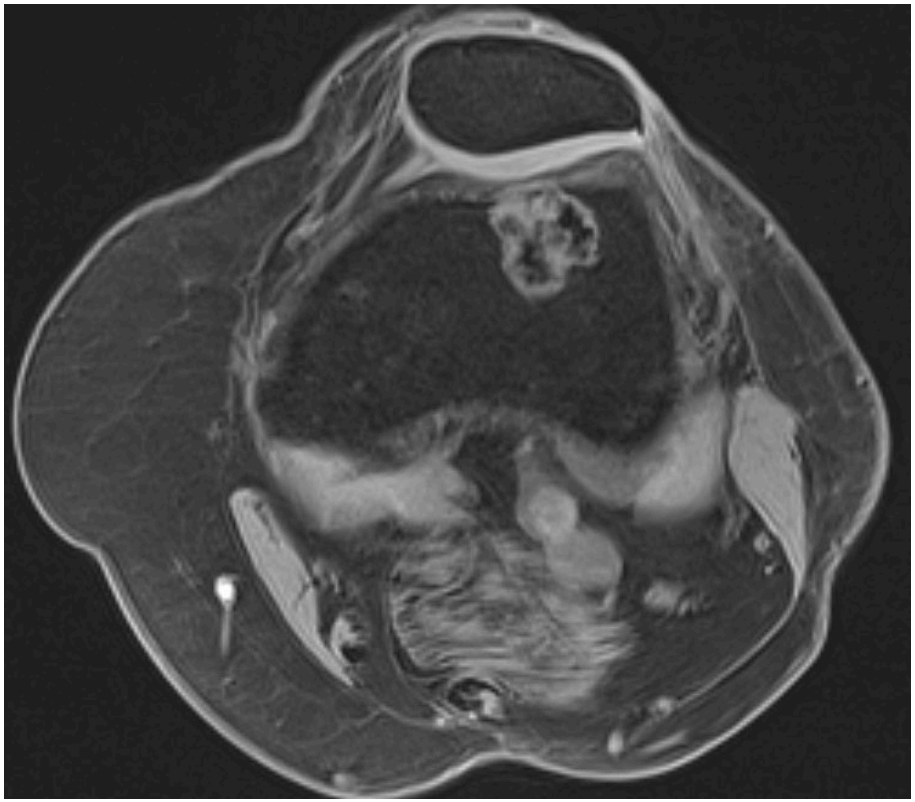
BS-17-46475, courtesy of Brian Quattrochi.

STEP 3 – T1 with contrast (T1C+) with fat saturation

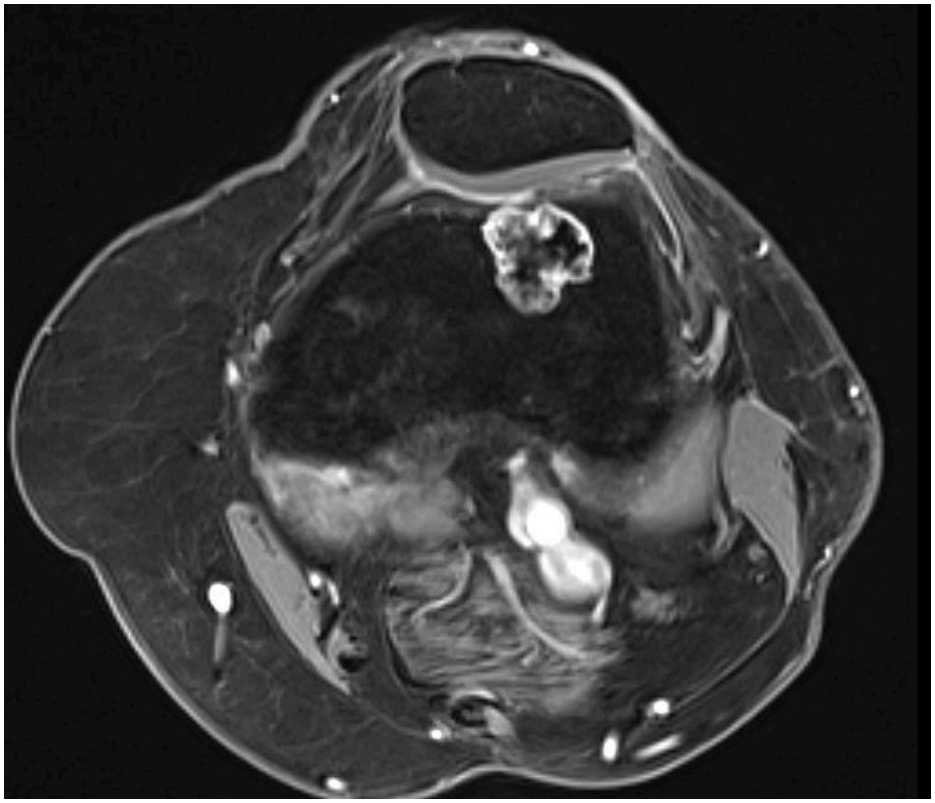
- Gadolinium is hyperintense on T1 - nonspecific vascular agent with tumor enhancement showing degree of vascularity, as well as inflammatory change, soft tissue involvement, neurovascular involvement
  - ✓Helps to differentiate myxomatous tumors from purely cystic
  - ✓Look for areas of NON enhancement – can assess the necrotic/cystic component – important for estimation of degree of necrosis
  - ✓Can overestimate tumor margin due to the enhancement of the peritumoral reactive marrow

Evaluation for extramedullary lesion

T1 C- FS



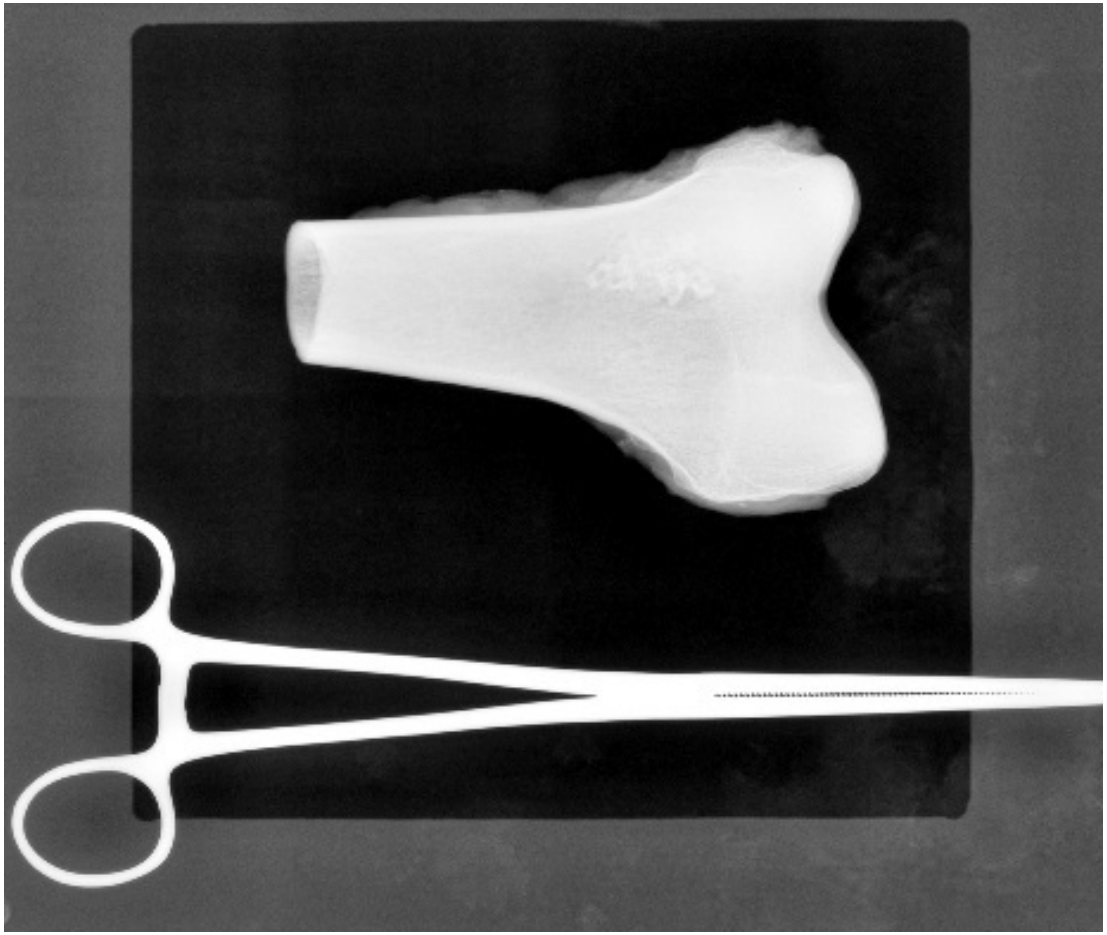
T1 C+ FS



Impression: enhancing mass with cortical involvement of the anterior femur - suspicious for malignancy

Peripheral, curvilinear enhancement

Radiograph of pathology specimen



"Single radiograph of the resected left distal femur with the known tumor with chondroid matrix seen within the lateral distal femoral metadiaphysis is better visualized on prior imaging but appears to be included in the resection"

Gross and histologic review

Gross description:

- White, lobulated, well circumscribed lesion in the anterior metaphysis (2.6 cm in craniocaudal dimension), 6.0 cm from the diaphyseal margin, 2.1 cm to the medial margin, 1.0 cm to the lateral margin, and 0.2 cm to the articular surface.
- The lesion extends grossly into the anterior cortical bone and produces a slight nodularity in the overlying periosteum.

Final diagnosis:

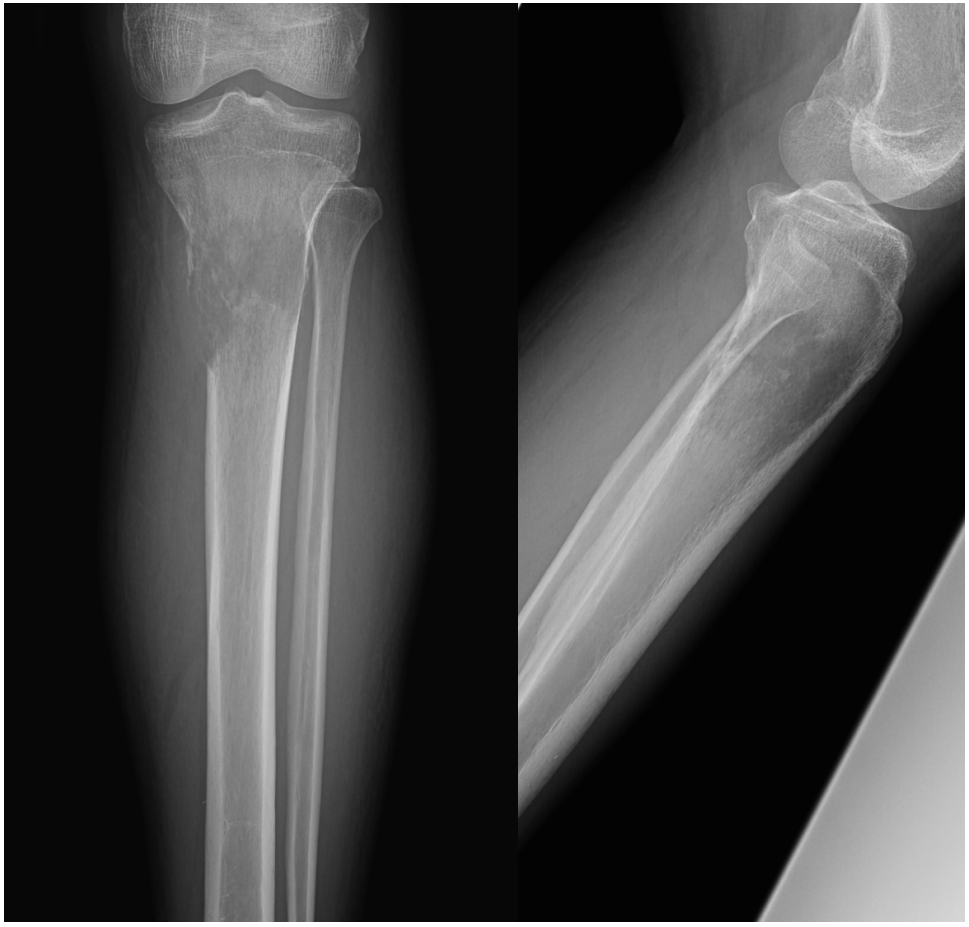
CHONDROSARCOMA, GRADE 1-2 (OF 3).

Tumor erodes but does not invade through cortical bone.

Resection margins are negative for tumor.

Tumor is 6.0 cm from the proximal diaphyseal bone margin.

Case 2 – 56 year old women with right knee pain



1. **Margin:** ill defined
2. **Matrix:** osteoid
3. **Cortical expansion:** significant cortical erosion with medial cortical discontinuity concerning for impending fracture
4. **Periosteal reaction:** Not clear
5. **Extraosseous soft tissue extension:** Lateral soft tissue extension

IMPRESSION: Overall aggressive looking lesion with osteoid matrix, likely representing osteosarcoma. MRI and biopsy were performed next

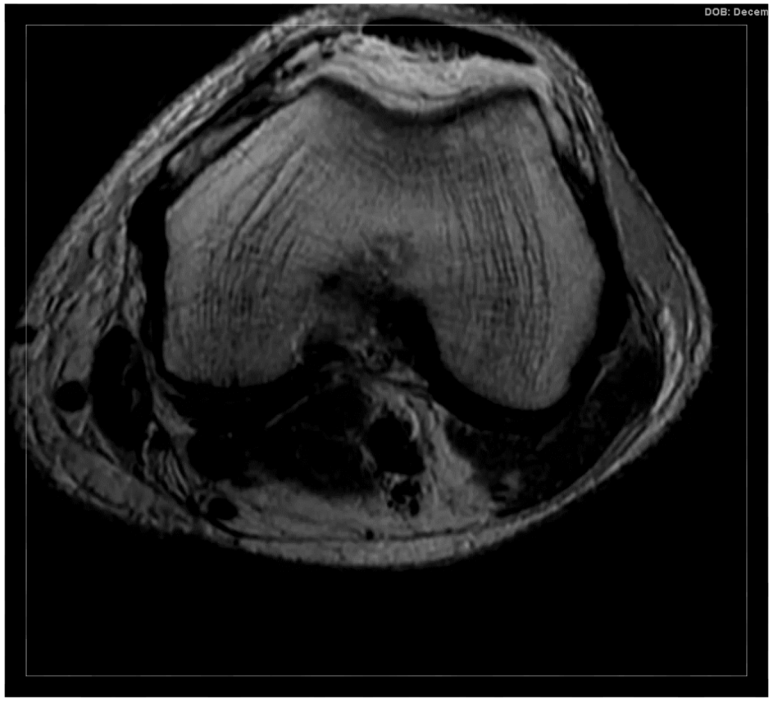
Step 1 – STIR (fluid sensitive sequence)

Signal: heterogenous T2 signal with T2 hyperintense and hypointense components

Again, this sequence usually shows best contrast of tumor compared to normal bone

STEP 2 – T1WI

Signal: T1 hypointense and somewhat heterogeneous
Tumor location : metadiaphysis of the proximal tibia
Tumor margin: lobular
Tumor size: BEST SEQUENCE (9.6 x 5.8 x4.9 cm)
Extraosseous extension? – cortical break medially and laterally with periosseous soft tissue extension



STEP 3 – T1C+ FS

Avid enhancement with areas on nonenhancement corresponding to necrosis/cystic change seen on T2

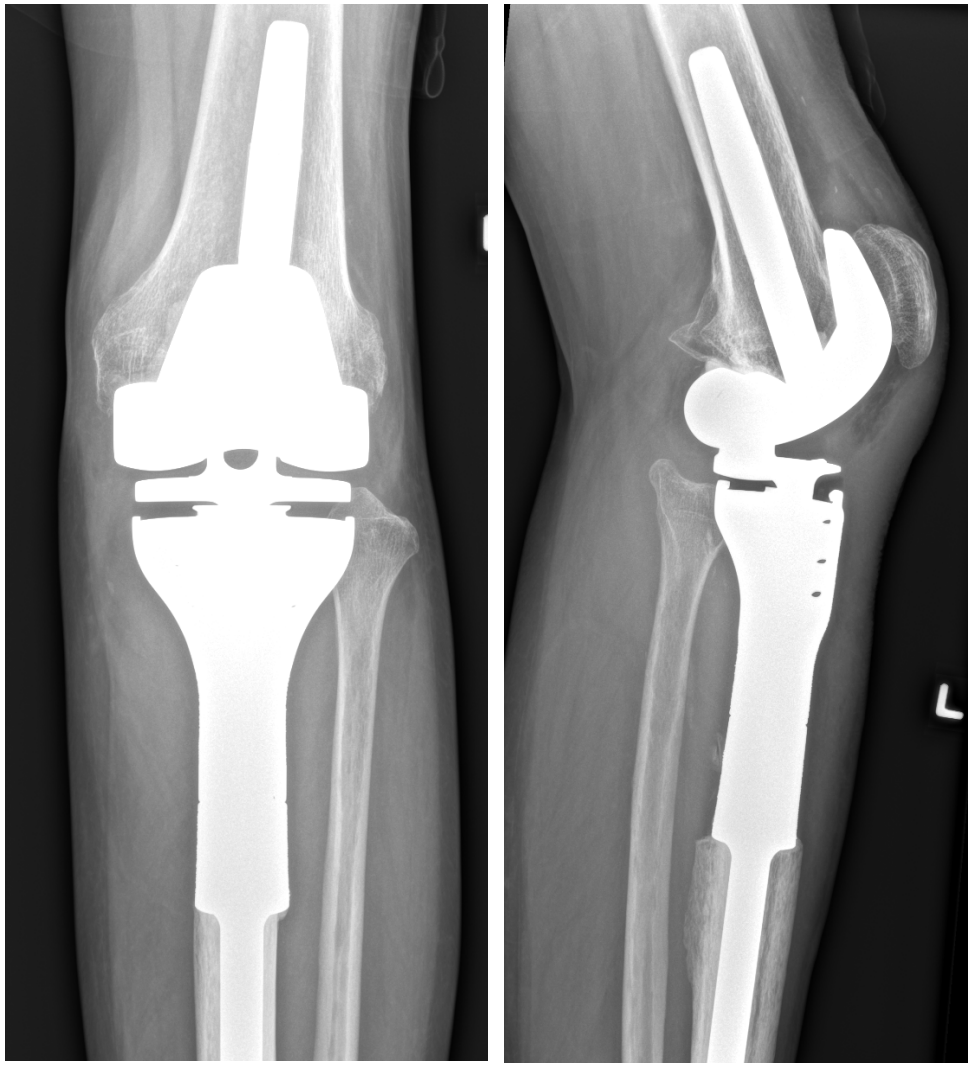
T1 C-

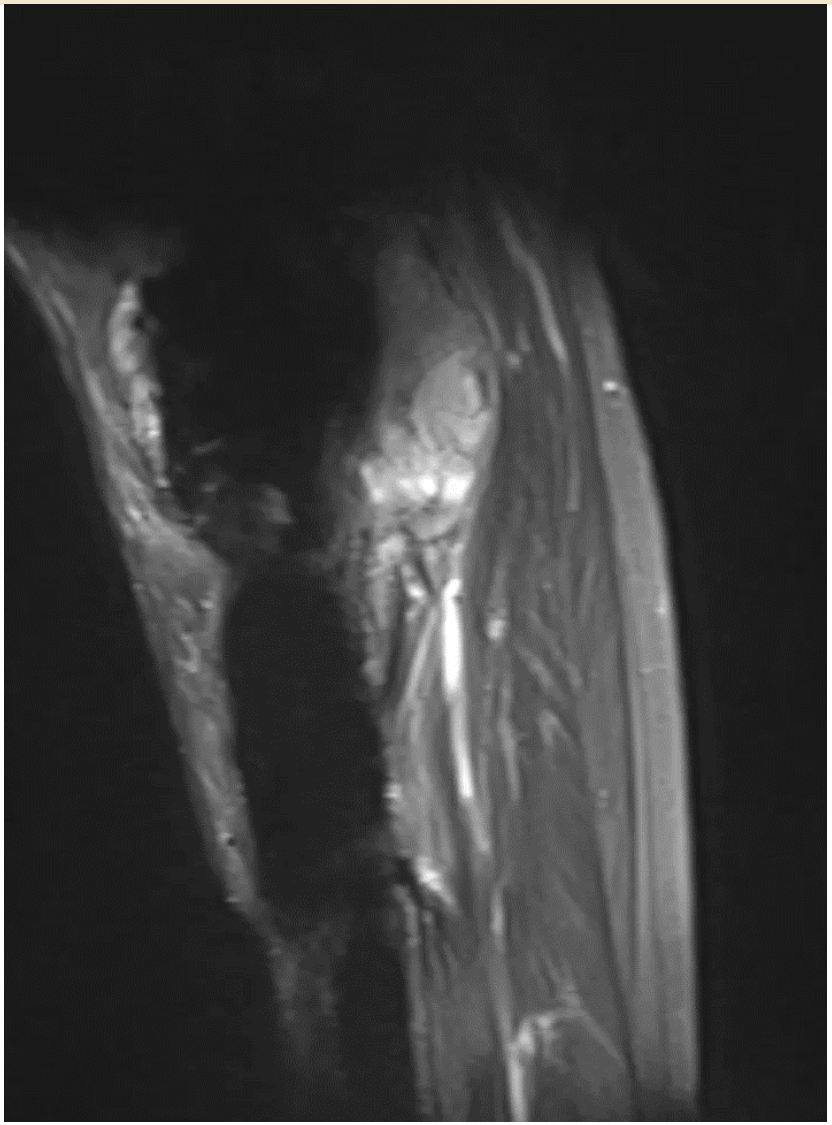
T1 C+ FS

STIR

To estimate NECROSIS - Look at T1C- and compare to T1C+ - non enhancing components (which are usually hyperintense on STIR) represent cystic change/necrosis

Case continued – status post resection of the original left tibial osteosarcoma and megaprosthesis placement

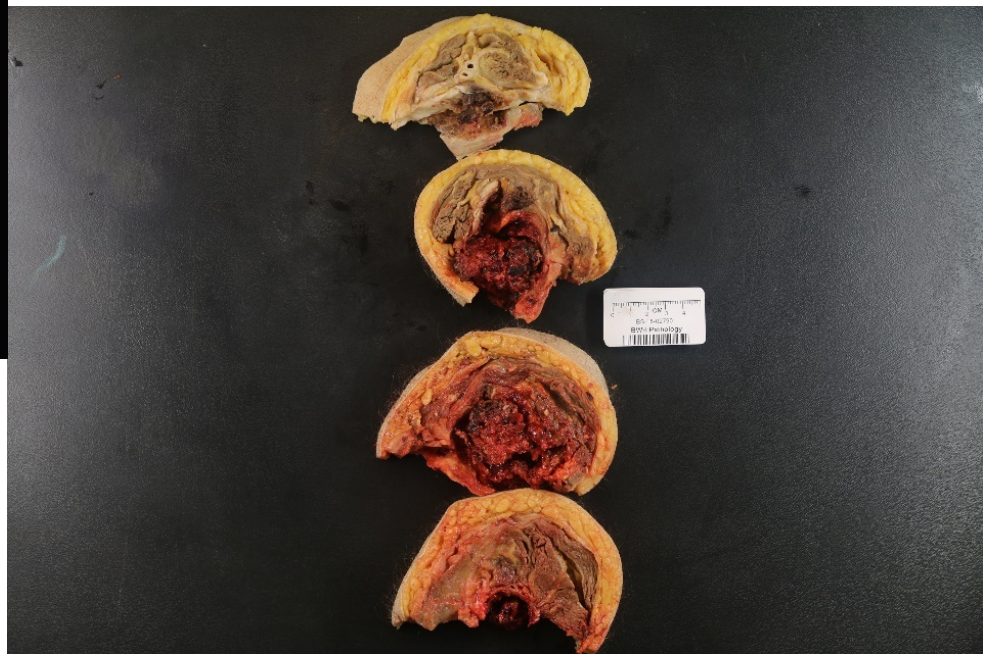




Coronal STIR metal reduction
Abnormality best seen

Coronal T1 – lots of hardware artifact

"Single radiograph of the resected left proximal femur with total knee replacement with the known tumor recurrence at the level of lateral proximal tibia is better visualized on prior imaging and appears to be included in the resection"



Gross and histologic review

Gross description:

- Cross sections of the leg shows a tumor mass 13.5 x 9 x 6.3 cm that is 14 cm from the soft tissue resection margins and 22 cm from bone resection margin.
- The tumor is partially encased by a thick fibrous membrane that lies posteriorly on top of metallic tibial prosthesis and anteriorly by fascial plans and skeletal muscle.
- The tumor is infiltrative into skeletal muscles at anterior, lateral, medial aspects of the leg and abuts the head and metaphysis of the fibula with apparent periosteal reaction. The tumor is lobulated and friable, pink-red-cream, with areas of necrosis and hemorrhage.

Final diagnosis:

RECURRENT HIGH GRADE OSTEOBLASTIC OSTEOSARCOMA (13.5cm).

Tumor involves fascia and skeletal muscle at the posterior aspect of the knee and calf surrounding the tibial prosthesis, and is adherent to periosteum of the fibula.

Necrosis is present in approximately 60% of tumor mass.

Resection margins (vascular, nerve, skin, and soft tissue and femoral bone) are negative for tumor.