Malignant Cartilage Tumors
Chondrosarcoma

James C. Wittig, MD
Orthopedic Oncologist
Sarcoma Surgeon
www.TumorSurgery.org

Classification
Chondrosarcoma

Primary (90%)
Arising de novo in normal bone

Central Intramedullary (99%)
Conventional (85-90%)
- Grade 1 (30%)
- Grade 2 (40%)
- Grade 3 (30%)

Dedifferentiated (8%)
Clear Cell (4%)
Mesenchymal (1%)

Peripheral (1%)
Periosteal C.S

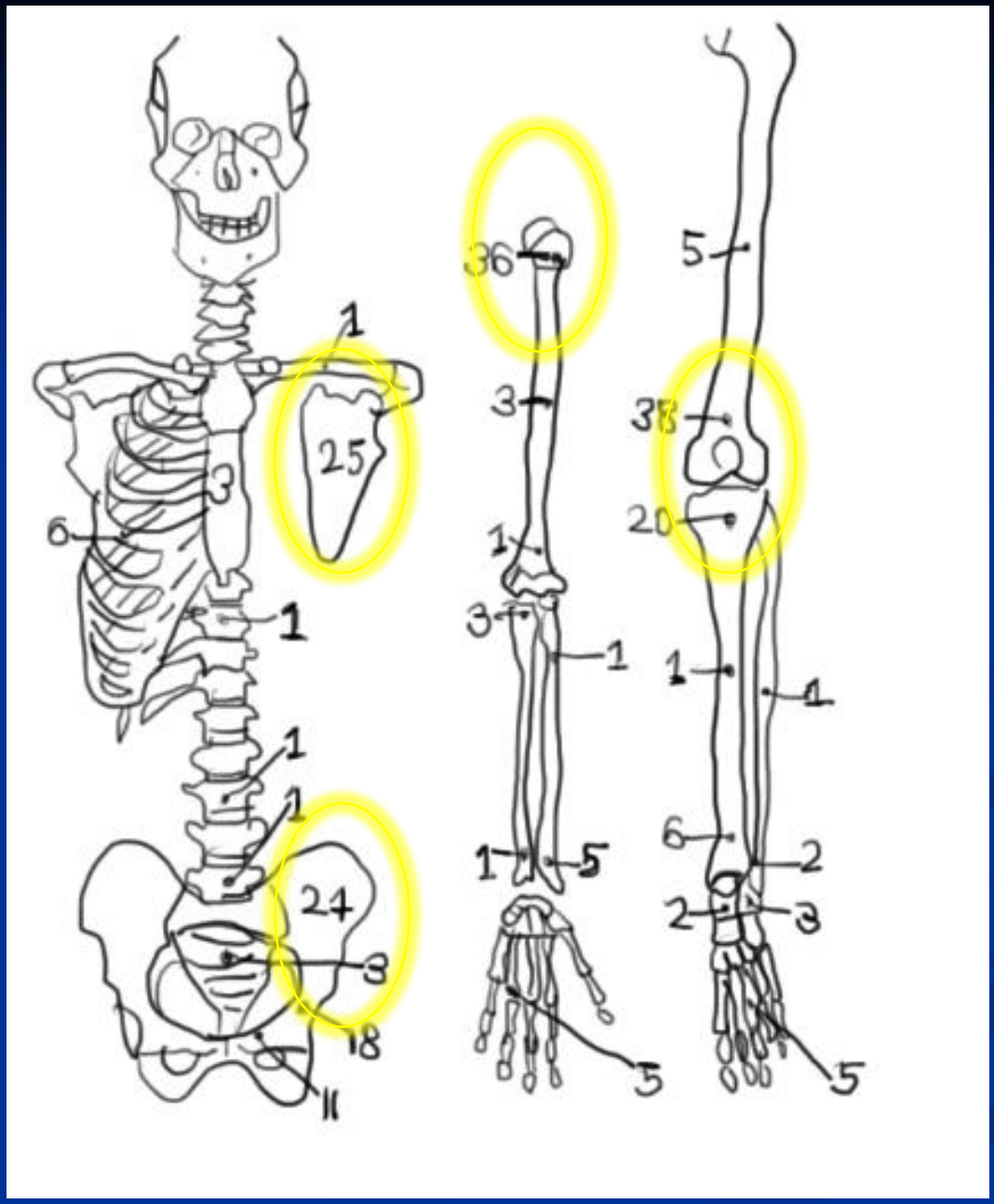
Secondary (10%)
Arising from pre existing conditions of bone

Enchondroma
Osteochondroma
Ollier's, Maffucci's
Fibrous Dysplasia
Paget's
Chondroblastoma
Radiation induced

Conventional Chondrosarcoma

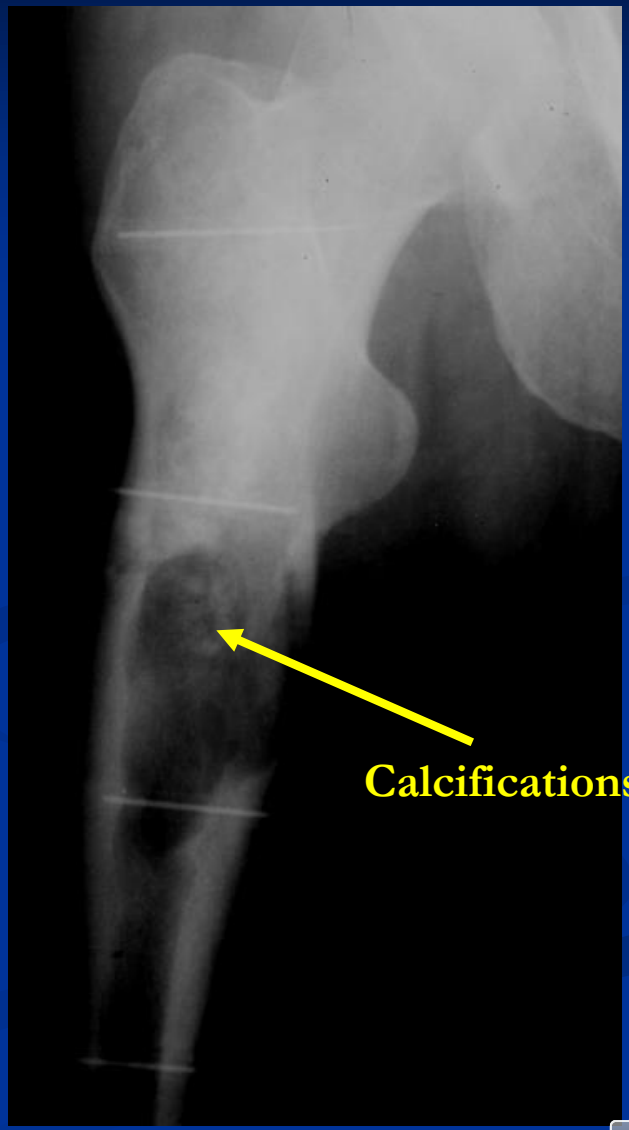
Conventional Chondrosarcoma Clinical Presentation

- **Signs/Symptoms:**
  - Pain, with or without mass
  - Pathological fracture is rare
- **Prevalence:**
  - 2 to 1 male predilection
  - Most common bone sarcoma in adult population
  - Second most common primary sarcoma of bone
  - 20% of all primary malignant bone sarcomas
- **Age:**
  - Peak incidence between 50-70 years of age
  - Uncommon before the age of 40
- **Sites:**
  - Most common sites: Proximal femur, Distal femur, Proximal Humerus, Pelvis, Scapula, Ribs
  - Spine and craniofacial bones are rare sites



Radiographic Presentation

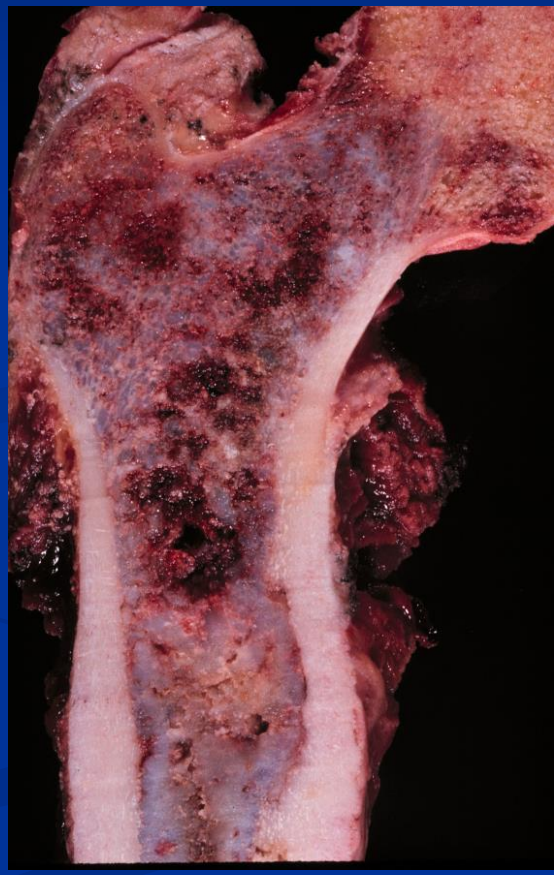
- Metaphysis or diaphysis
  - Rarely, they arise in the epiphysis
- Calcifications have a distinctive "Ring and Arc"-like pattern
- Low-grade chondrosarcomas
  - Uniformly calcified
  - Well-defined margins
- High-grade chondrosarcomas
  - Large non-calcified areas
  - Irregular, ill-defined margins
  - Often extend into soft tissues



Conventional Intramedullary Chondrosarcoma

Radiological Features of Malignancy

- Bone contour in the affected area may be expanded
- Cortical thickening
- Endosteal scalloping
- New areas of lysis adjacent to calcified areas
- Cortical destruction and soft tissue extension in higher grade lesions; extension into soft tissues is definitive

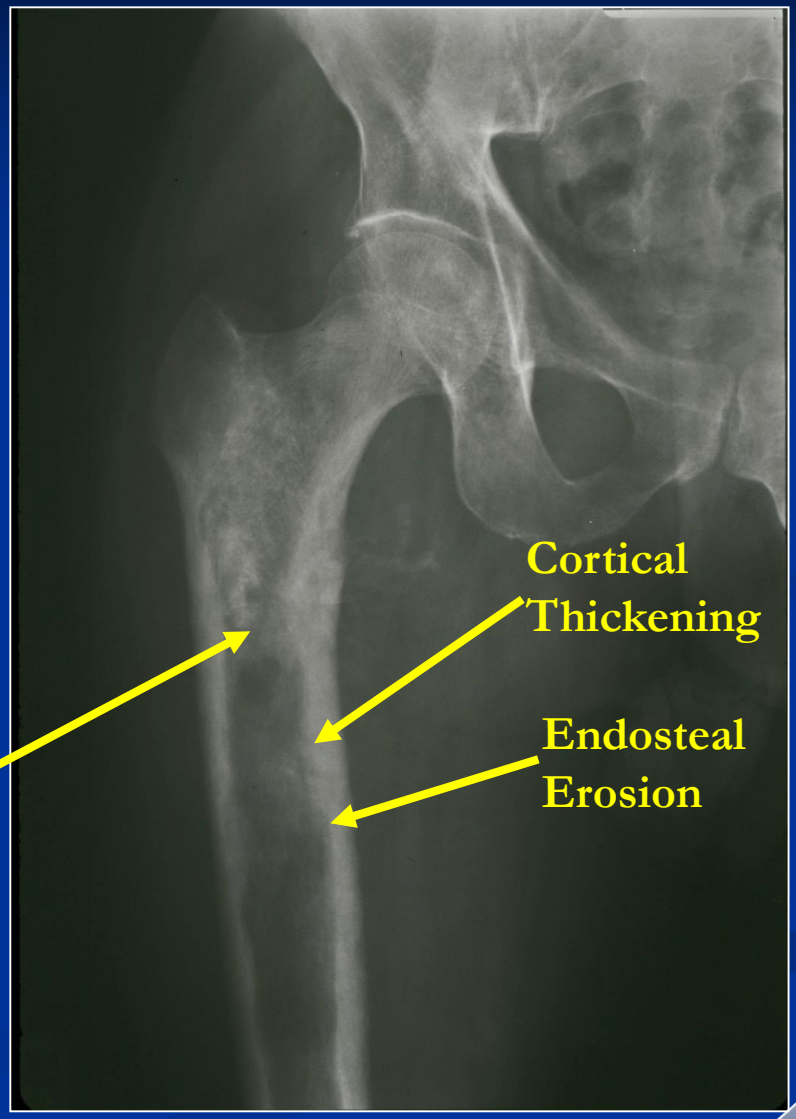


Plain X-ray: Chondrosarcoma of Proximal Femur

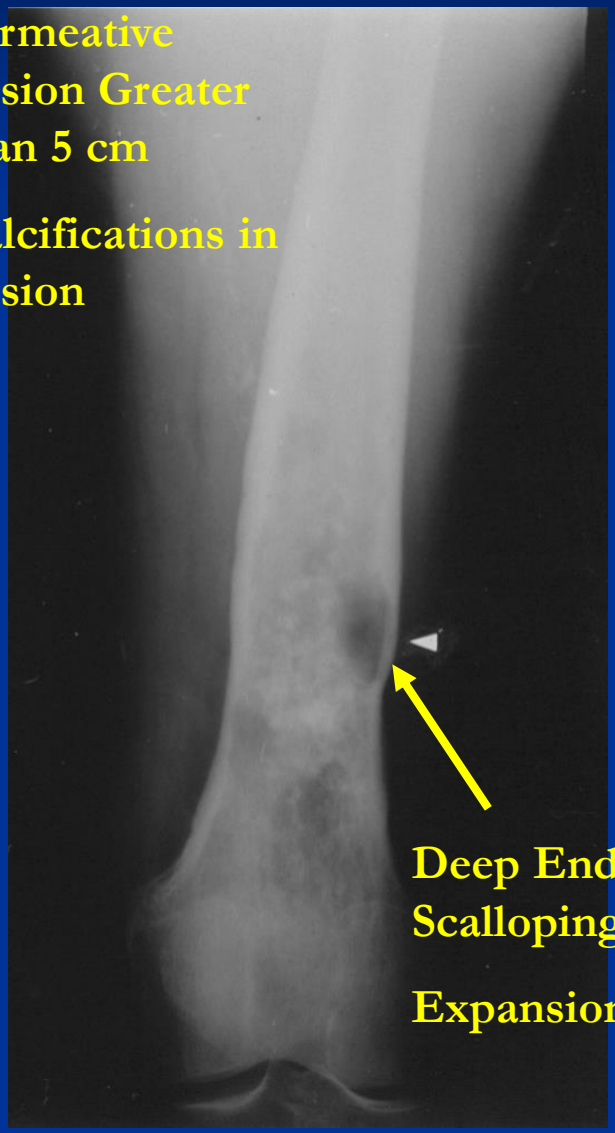
Permeative Lesion greater than 5cm

Deep Endosteal Scalloping

Cortical Thickening



Plain X-ray: Chondrosarcoma of Femur

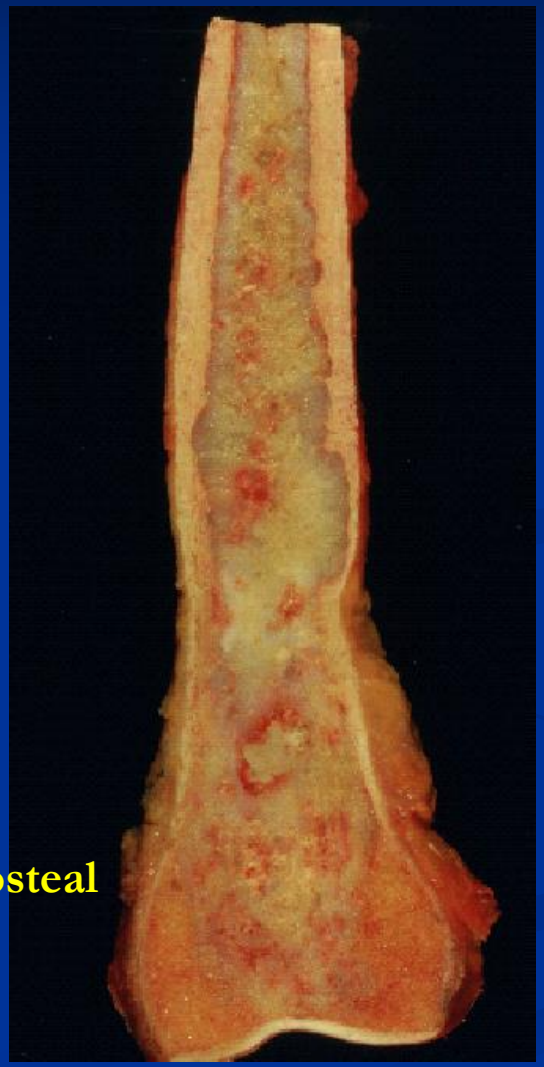


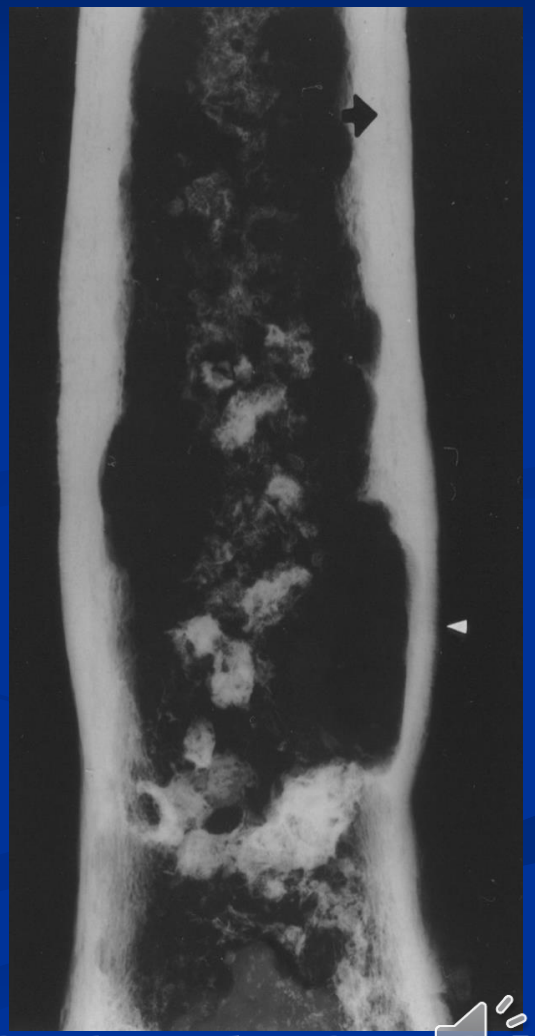
Permeative Lesion Greater than 5 cm

Calcifications in Lesion

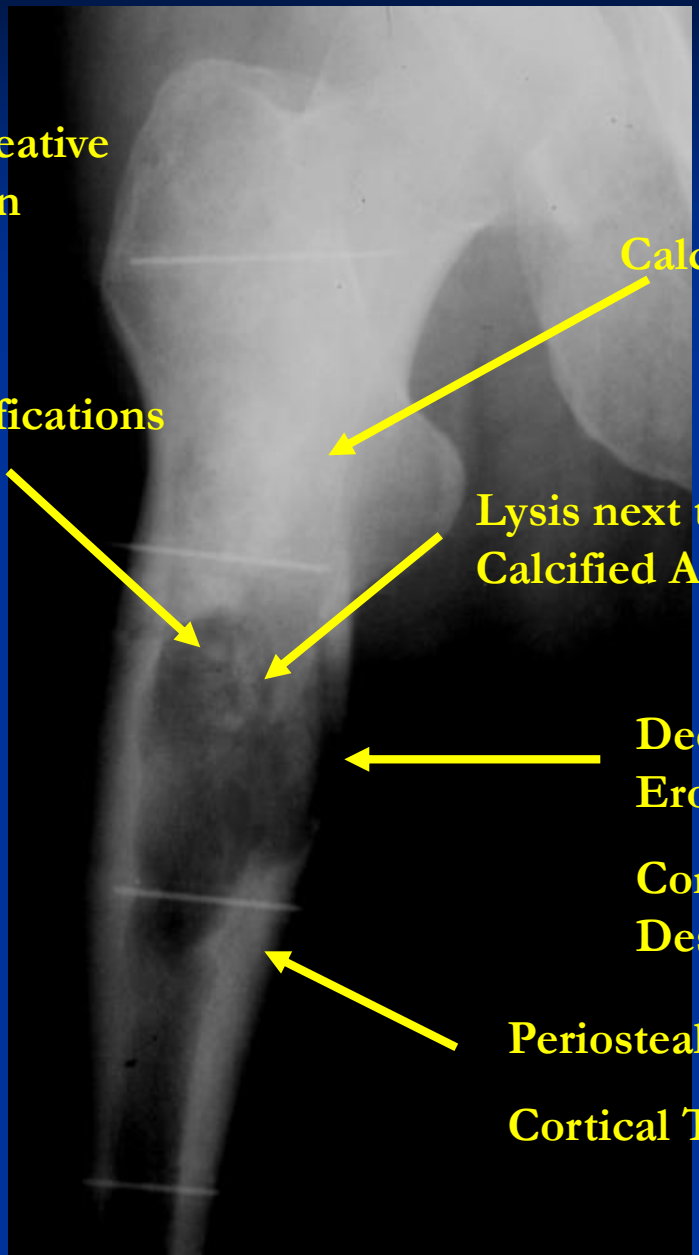
Deep Endosteal Scalloping

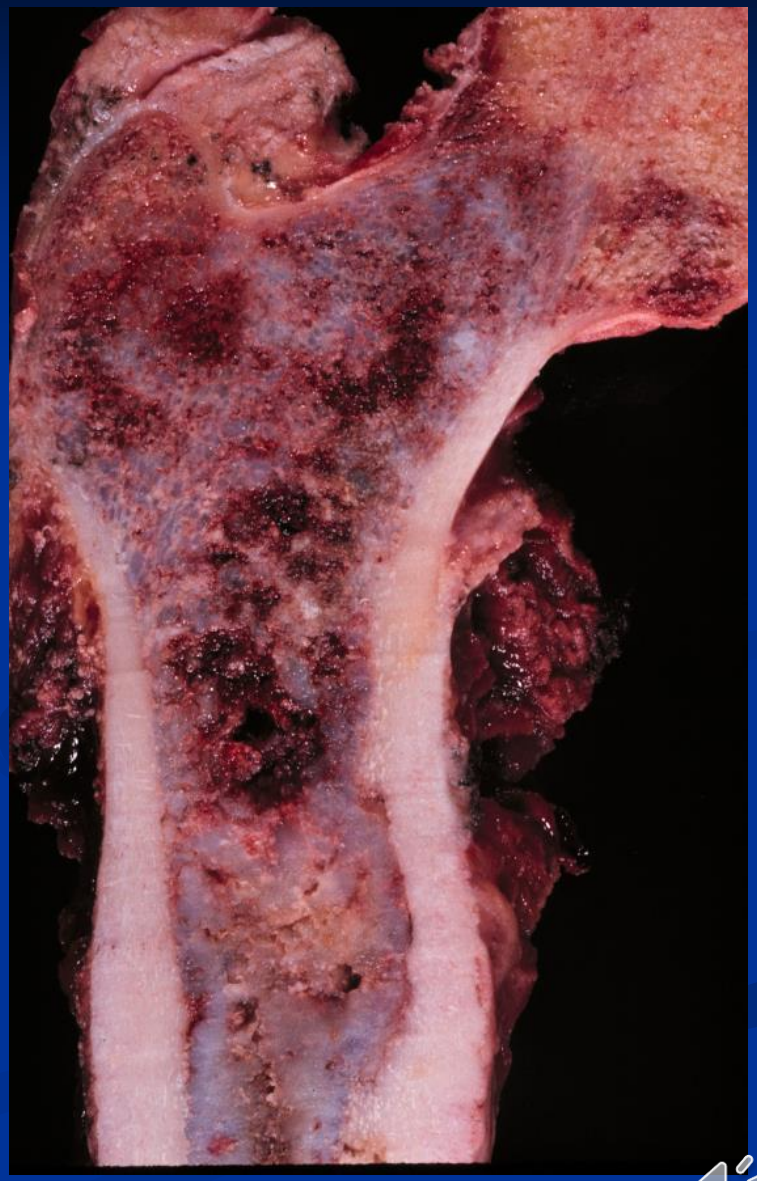
Expansion





Plain X-ray: Chondrosarcoma of Proximal Femur





Diagnostic Dilemma Long Bone: Enchondroma vs. Chondrosarcoma

- Enchondroma
  - Common in hand/foot
  - Common in long bones (1.7% femora)
  - Rare in axial skeleton
  - Rare in pelvis
  - Never has an associated soft tissue component
- Chondrosarcoma
  - Common in axial skeleton
  - Common in long bones
  - Rare in hand/foot
  - May or may not have an associated soft tissue mass
  - Low grade chondrosarcomas do not often have an associated soft tissue mass and are most difficult to differentiate from an enchondroma

Long Bone Enchondroma

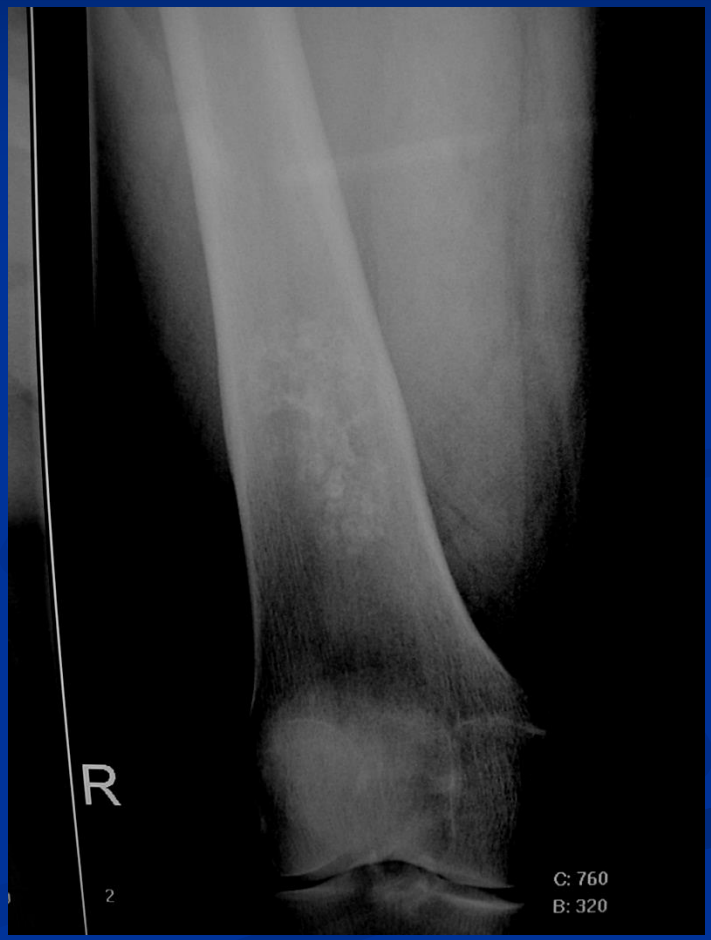
- **Clinicoradiological Aspects:**
  - Age <50; Pain not attributable to lesion
  - Size:
    - <5cm (CT/MRI)
  - Bone Scan =/< ASIS* 79%
  - Majority in diaphysis
  - Endosteal scalloping depth <2/3 cortex (90-95%)
  - No cortical thickening
  - No periosteal reaction
  - NO cortical destruction
  - NO soft tissue mass
  - MRI peripheral enhancement?
    - *AIC = Anterior Iliac Crest

Long Bone Chondrosarcoma

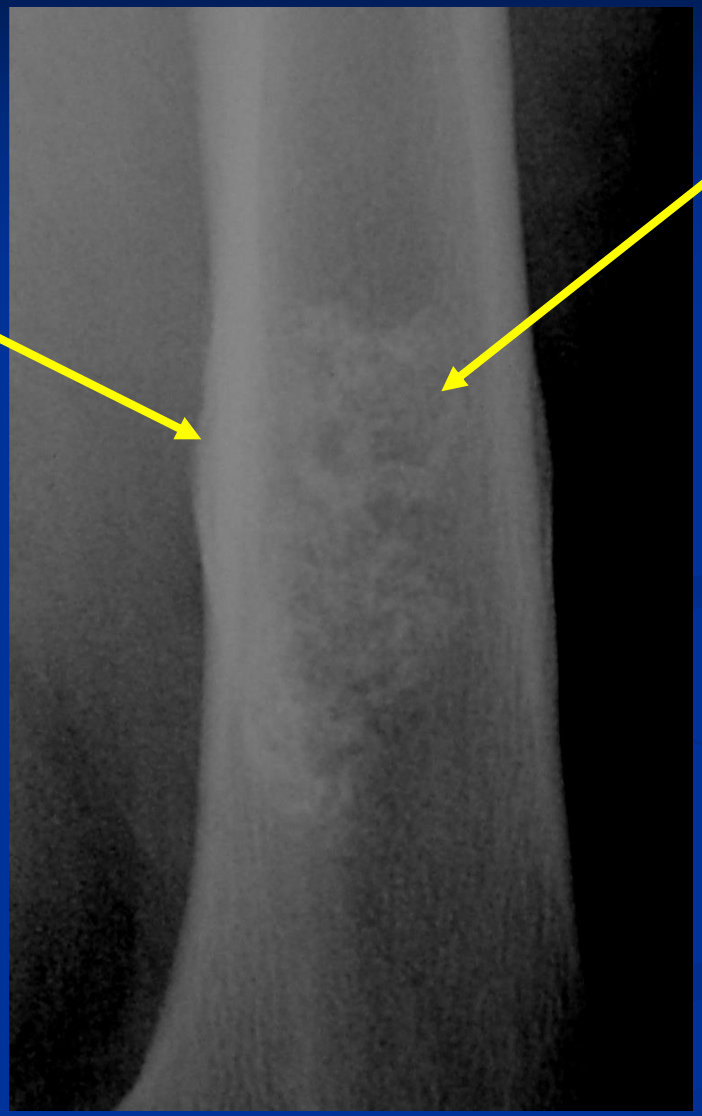
- **Clinicoradiological Aspects:**
  - Age>50; Pain attributable to lesion
  - Size:
    - >5cm (CT/MRI)
  - Bone Scan =/> ASIS 82%
  - Endosteal scalloping depth > 2/3 cortex (75-90%)
  - Cortical Thickening (47%)
  - Periosteal Reaction (51%)
  - Soft Tissue Mass (Variable; May not have a soft tissue mass)
  - Epiphyseal Extension (majority metaphysis)
  - MRI peripheral and septal enhancement?
    - *AIC = Anterior Iliac Crest

Grade I Chondrosarcoma

- Calcifications in ring and arc-like manner; stippled calcifications
- Mild bony expansion
- >5cm
- Endosteal scalloping > 2/3 cortical thickness



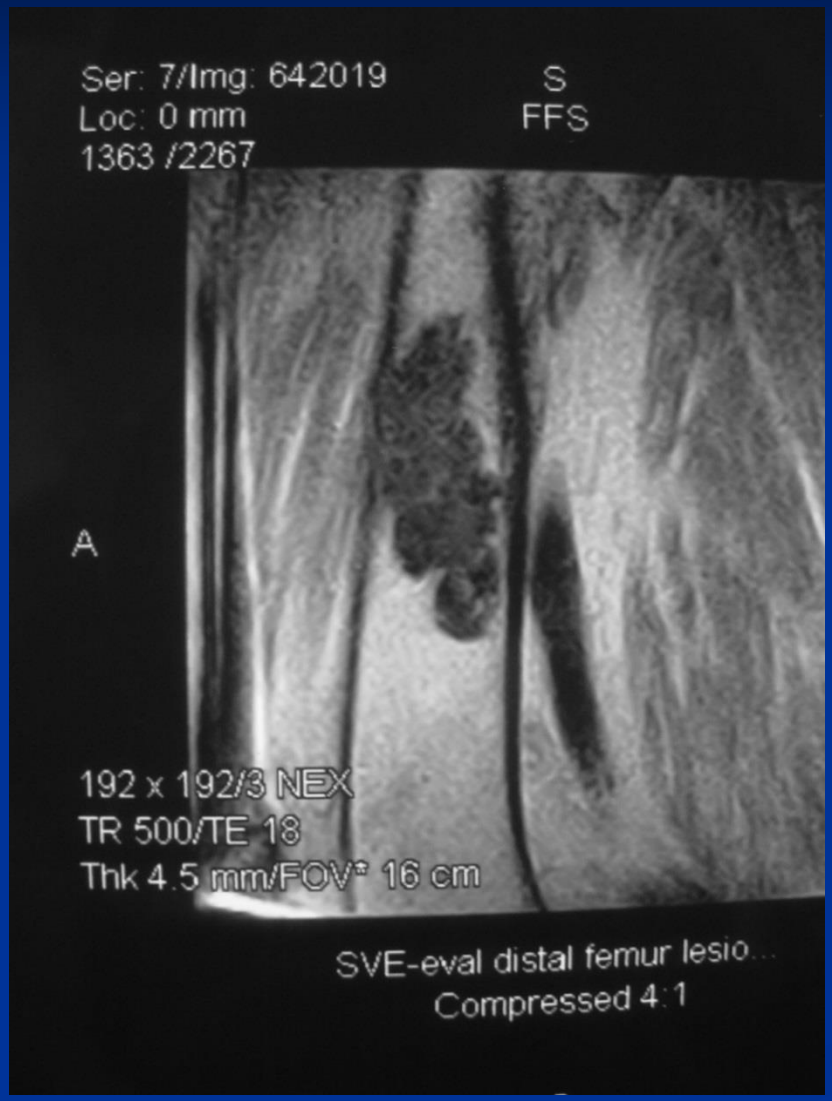
Grade I Chondrosarcoma

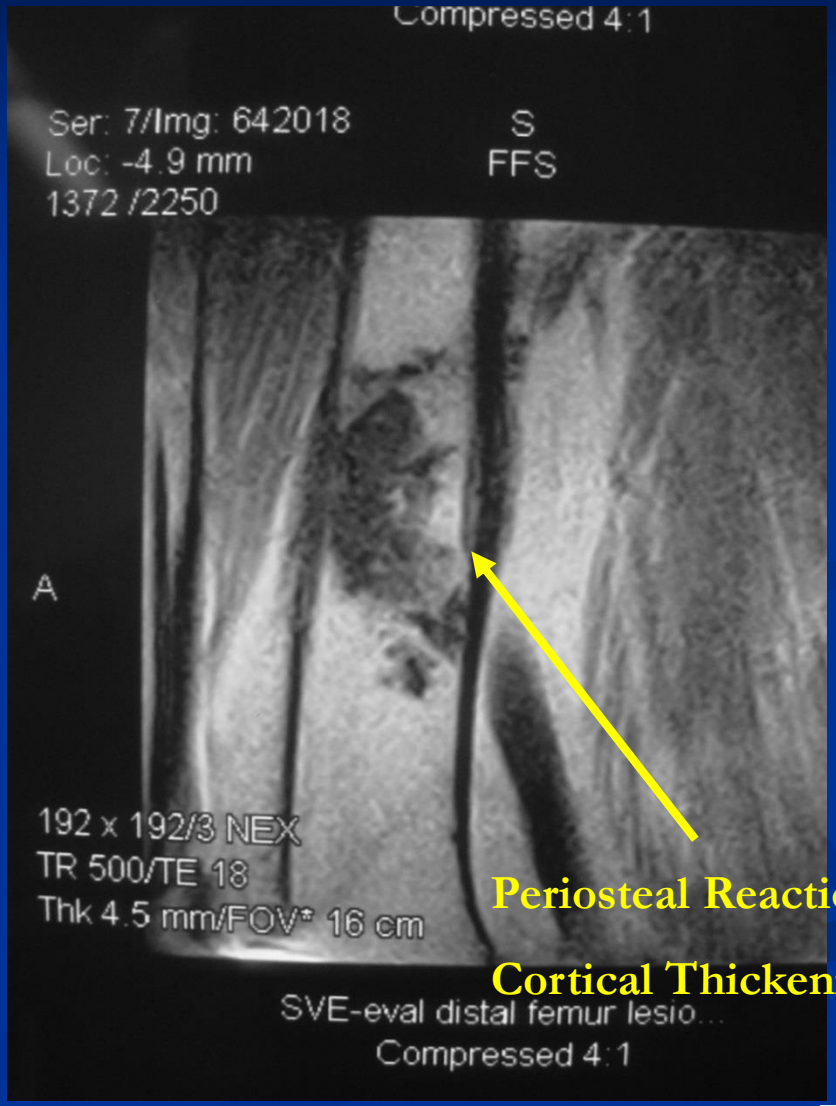


Subtle Cortical Thickening and Periosteal Reaction

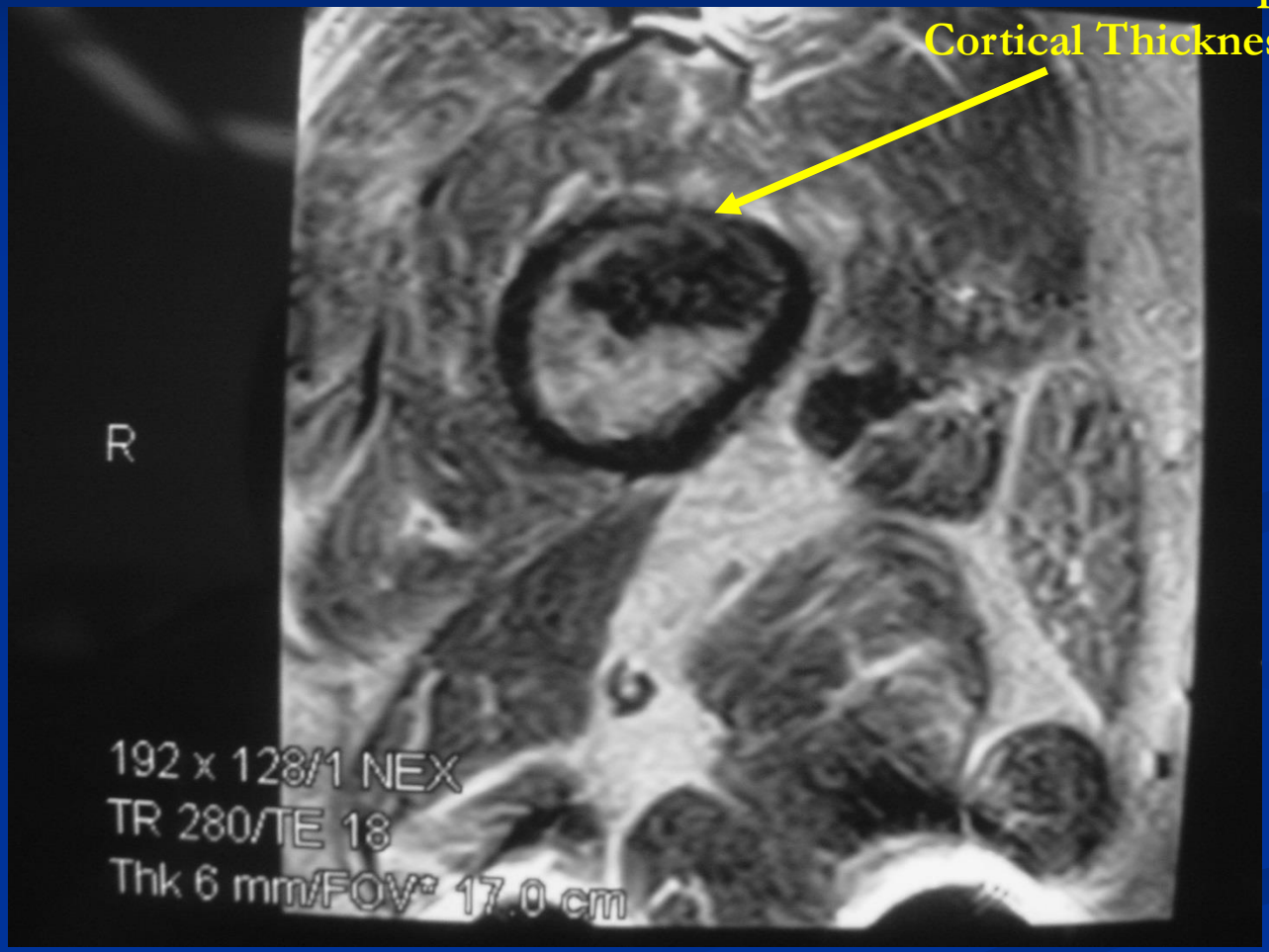
Ring and Arc Calcifications

Grade I Chondrosarcoma
T1 Weighted MRI

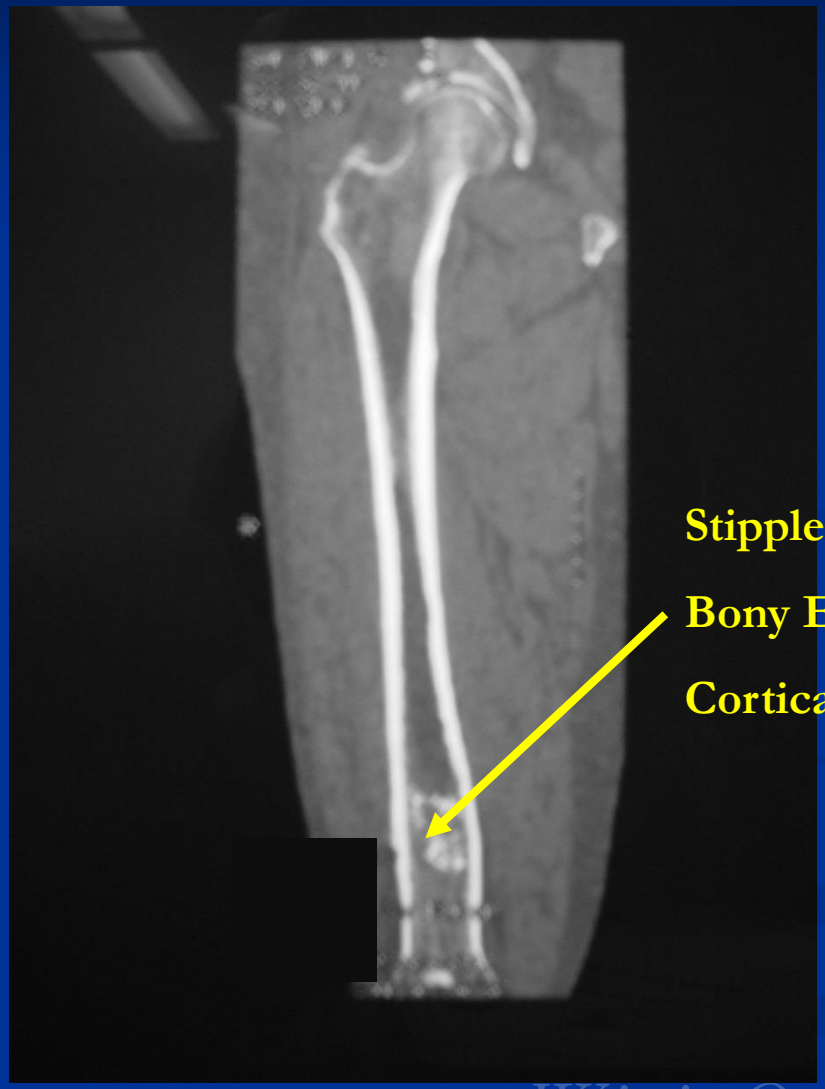




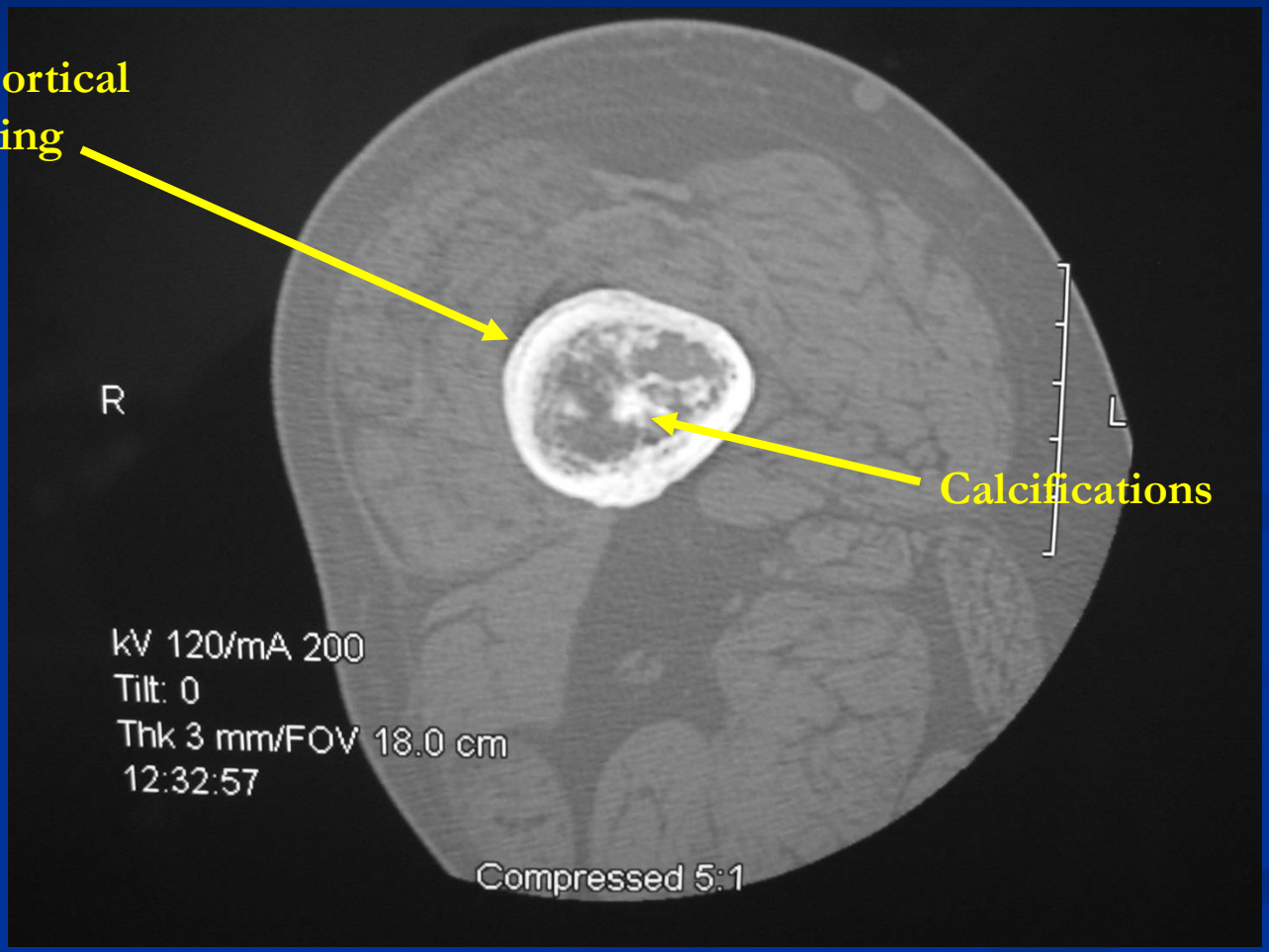
MRI Low Grade Chondrosarcoma
Endosteal Scalloping



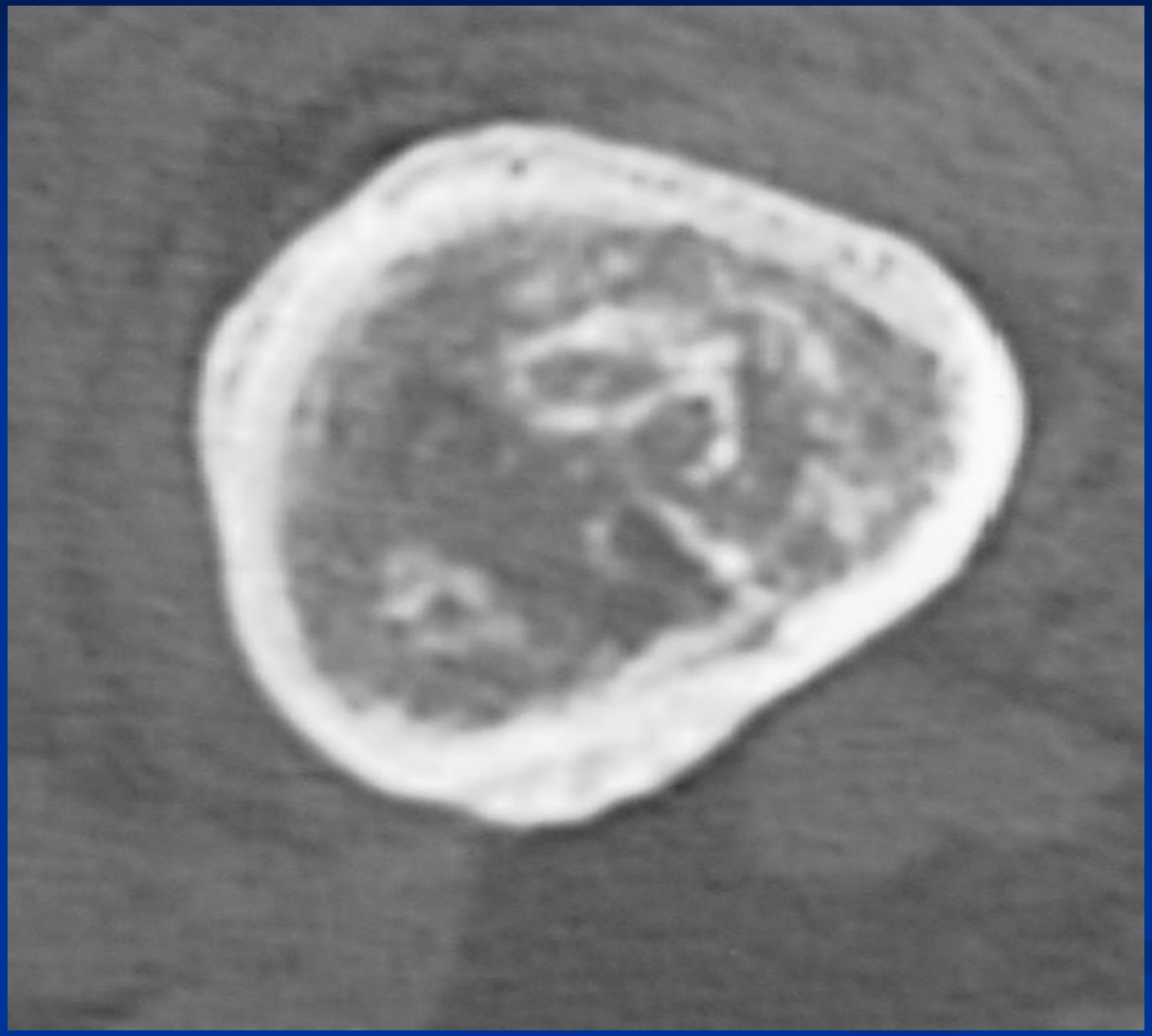
CT Scan: Grade I Chondrosarcoma



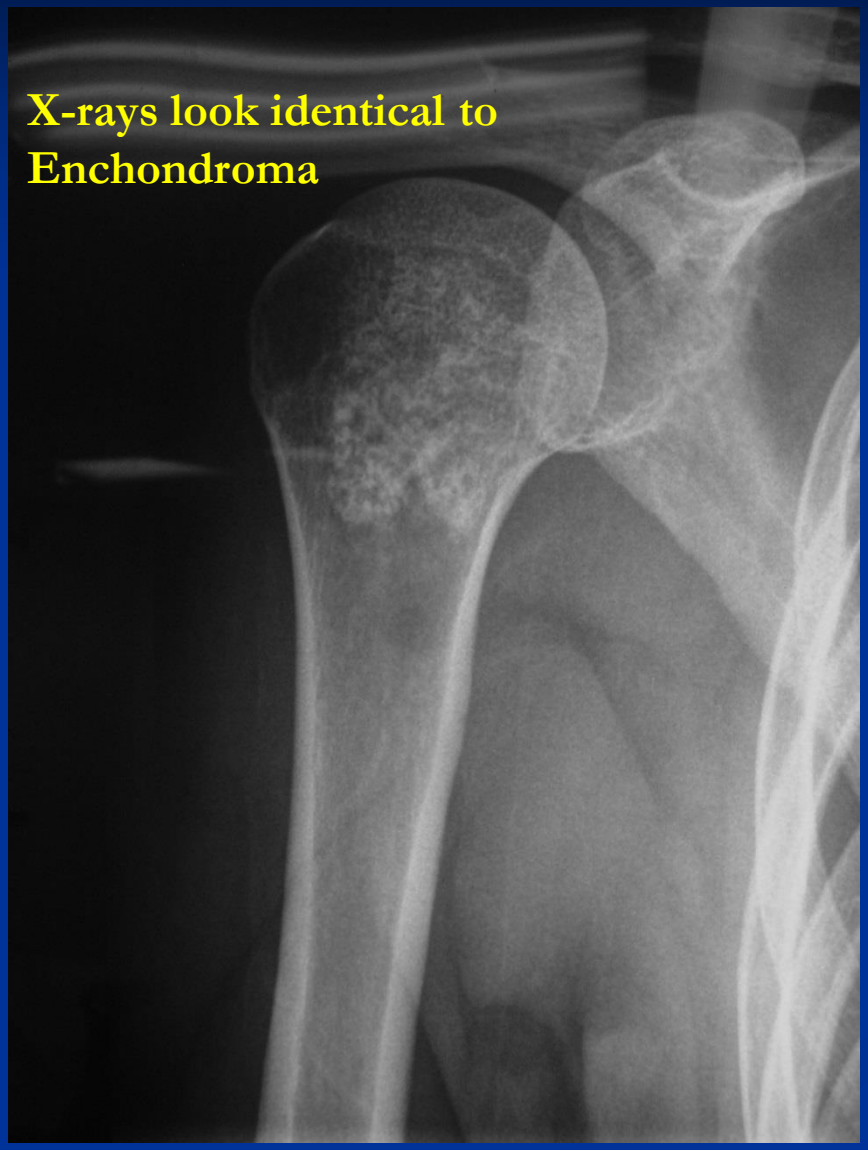
CT Scan Axial Section
Grade I Chondrosarcoma



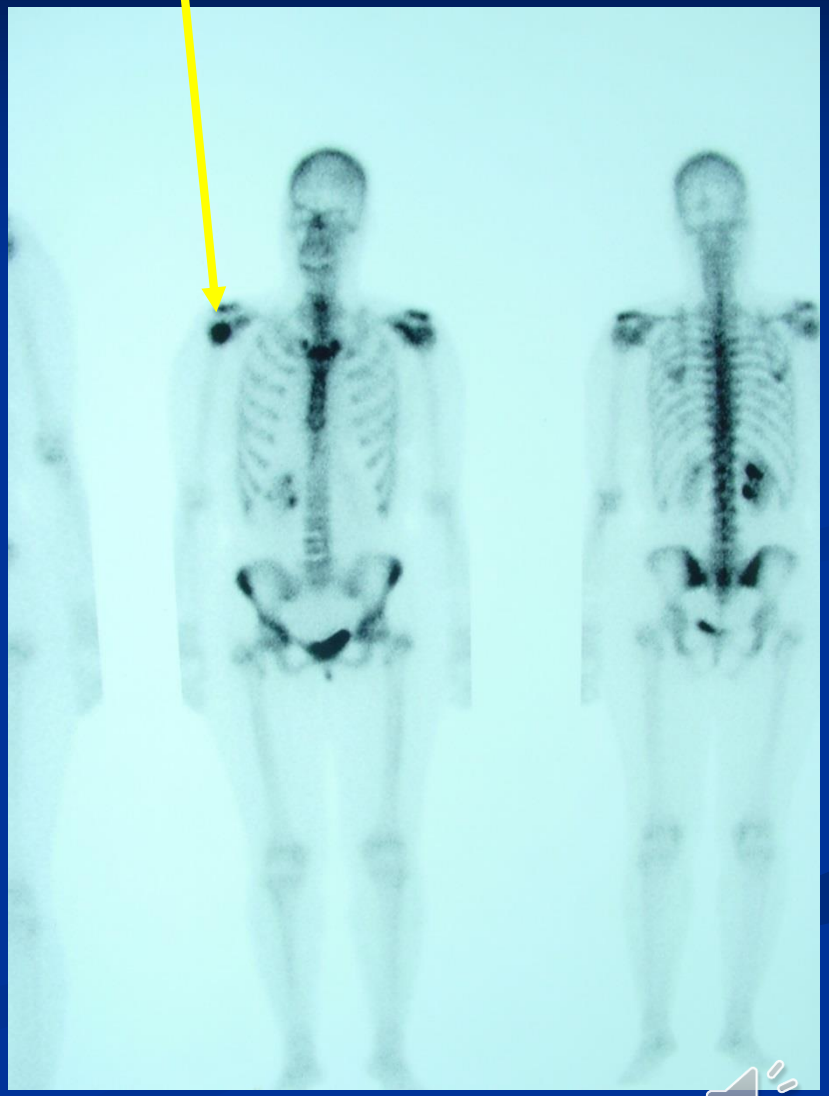
CT Scan: Grade I Chondrosarcoma



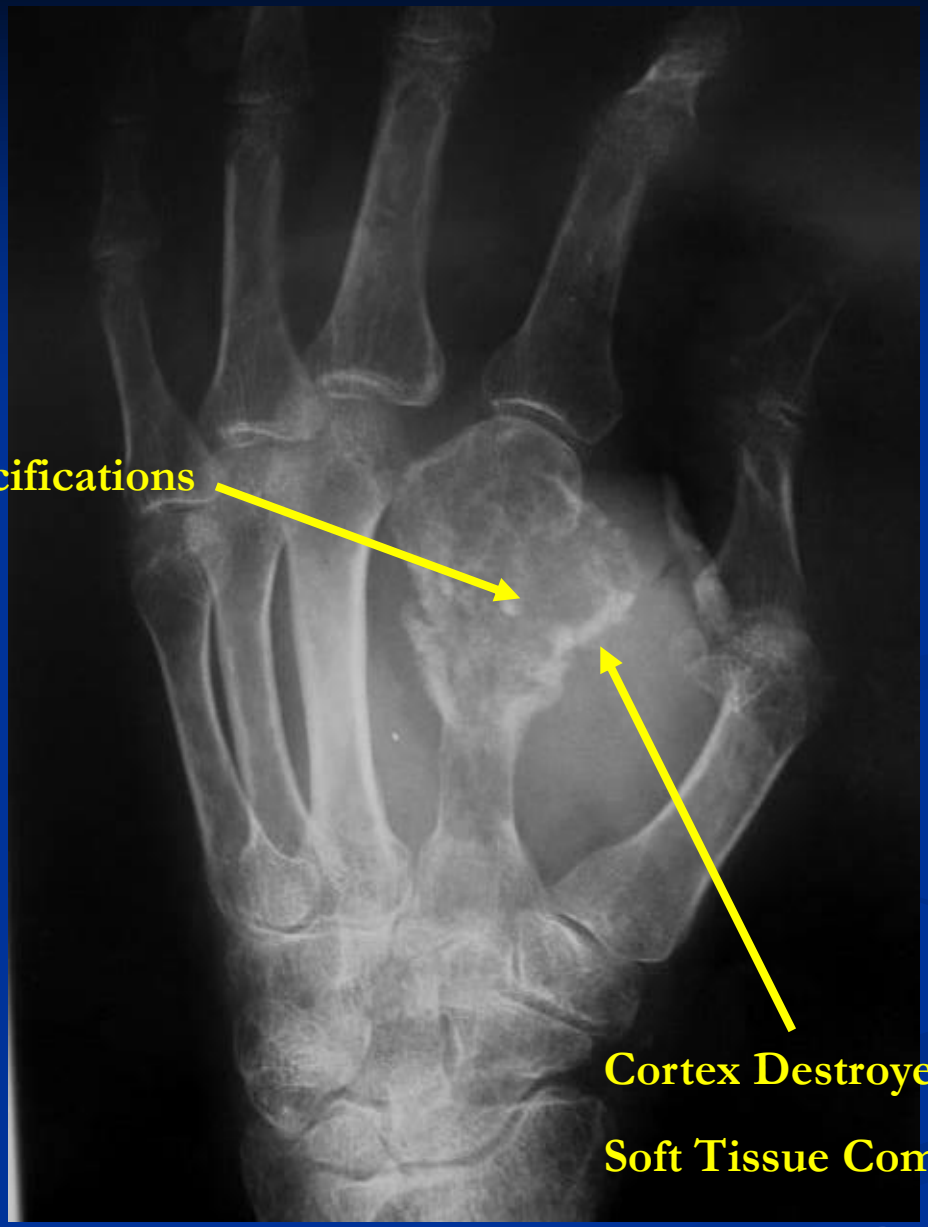
Plain X-Ray/Bone Scan: Grade I Chondrosarcoma of Proximal Humerus



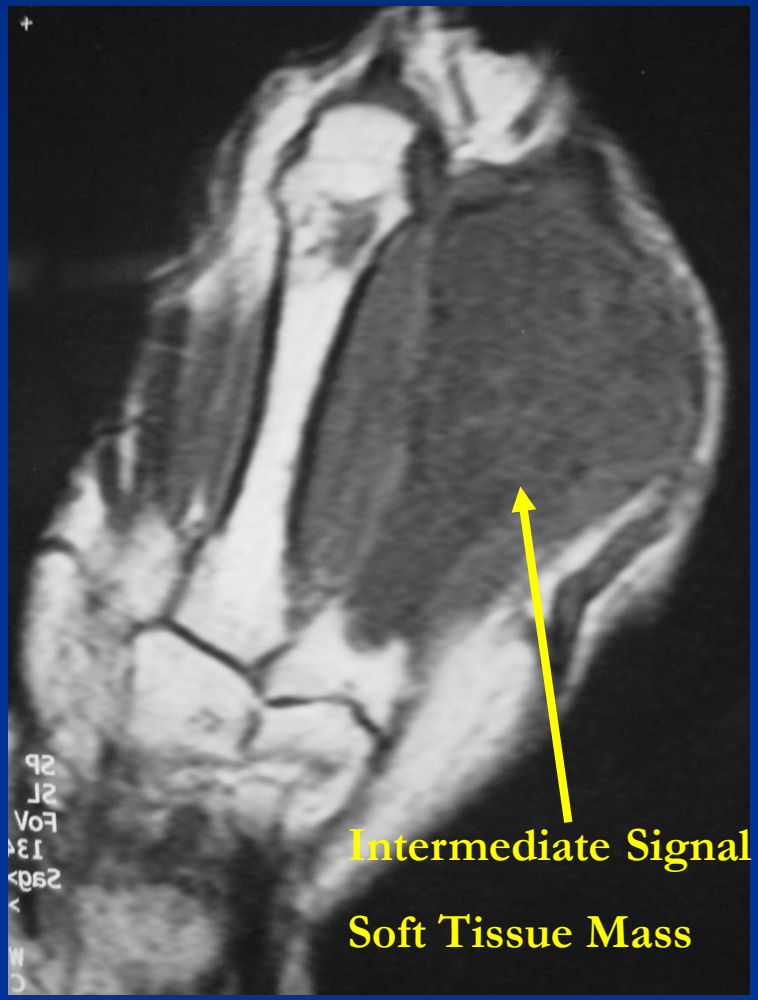
Uptake Hotter than ASIS



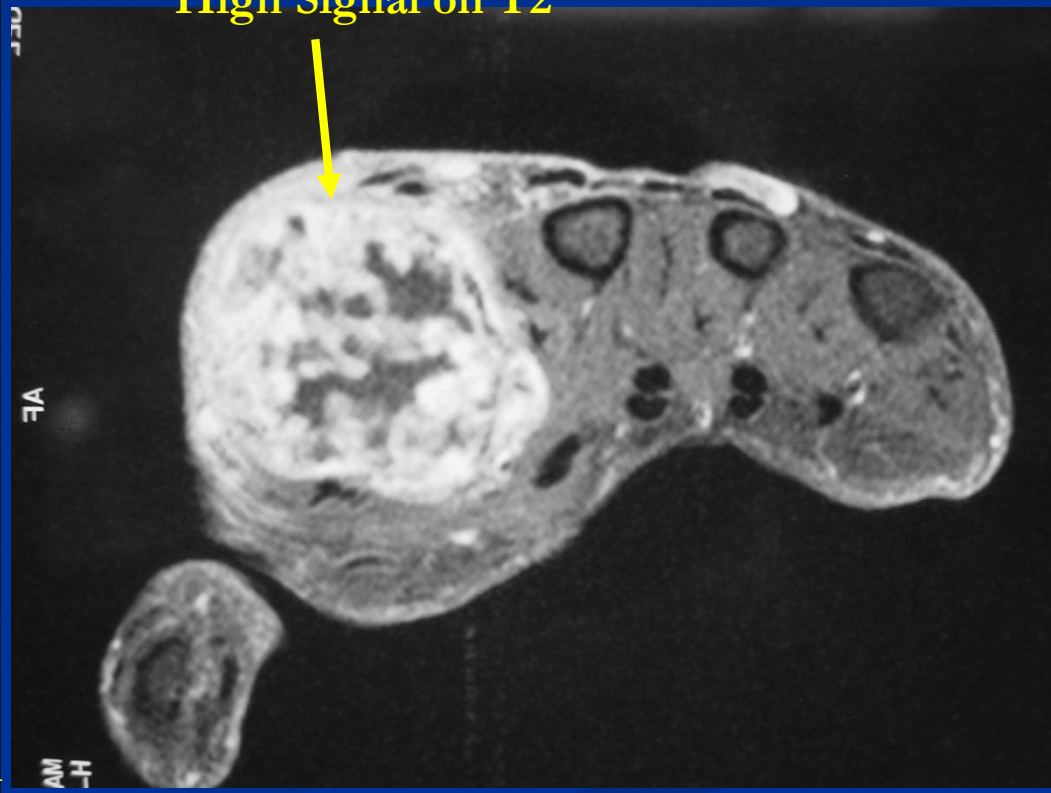
Plain X-Ray: Grade I Chondrosarcoma of Metacarpal of Hand



MRI: Grade I Chondrosarcoma of Hand

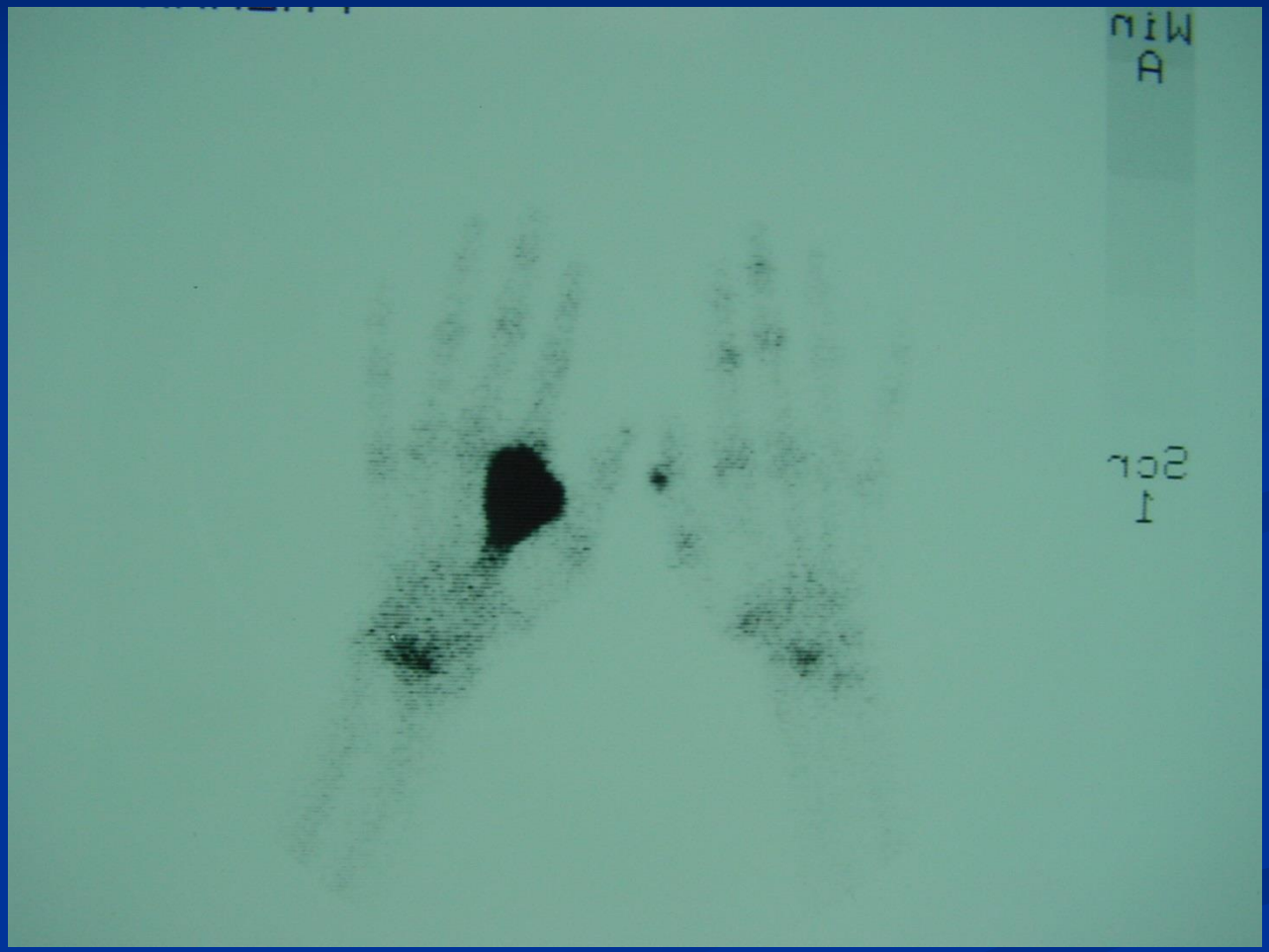


T1 Weighted Image

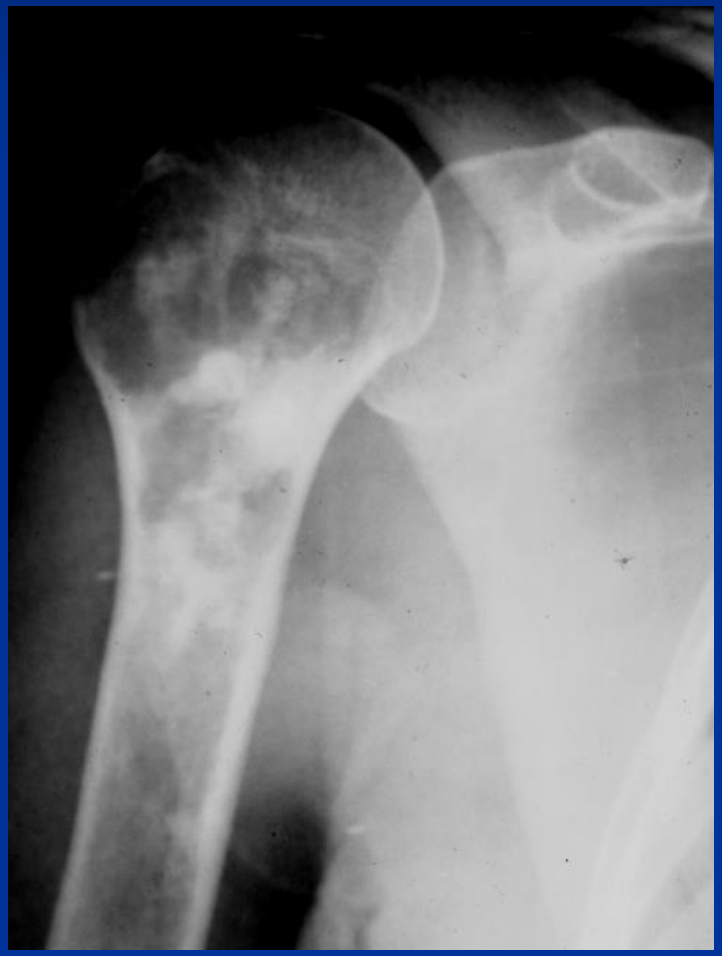


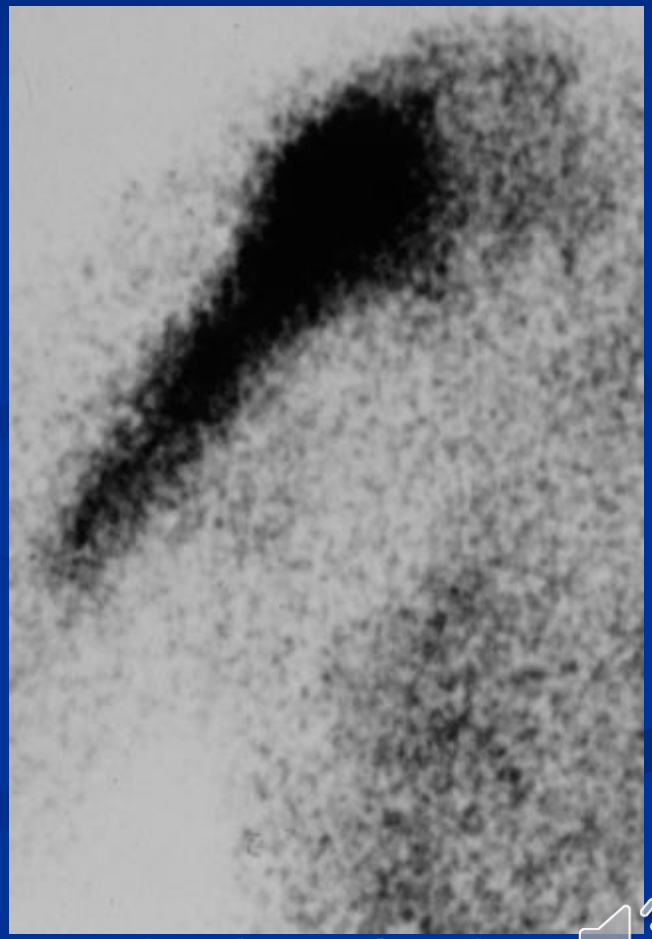
T2 Weighted image

Bone Scan: Chondrosarcoma of Metacarpal

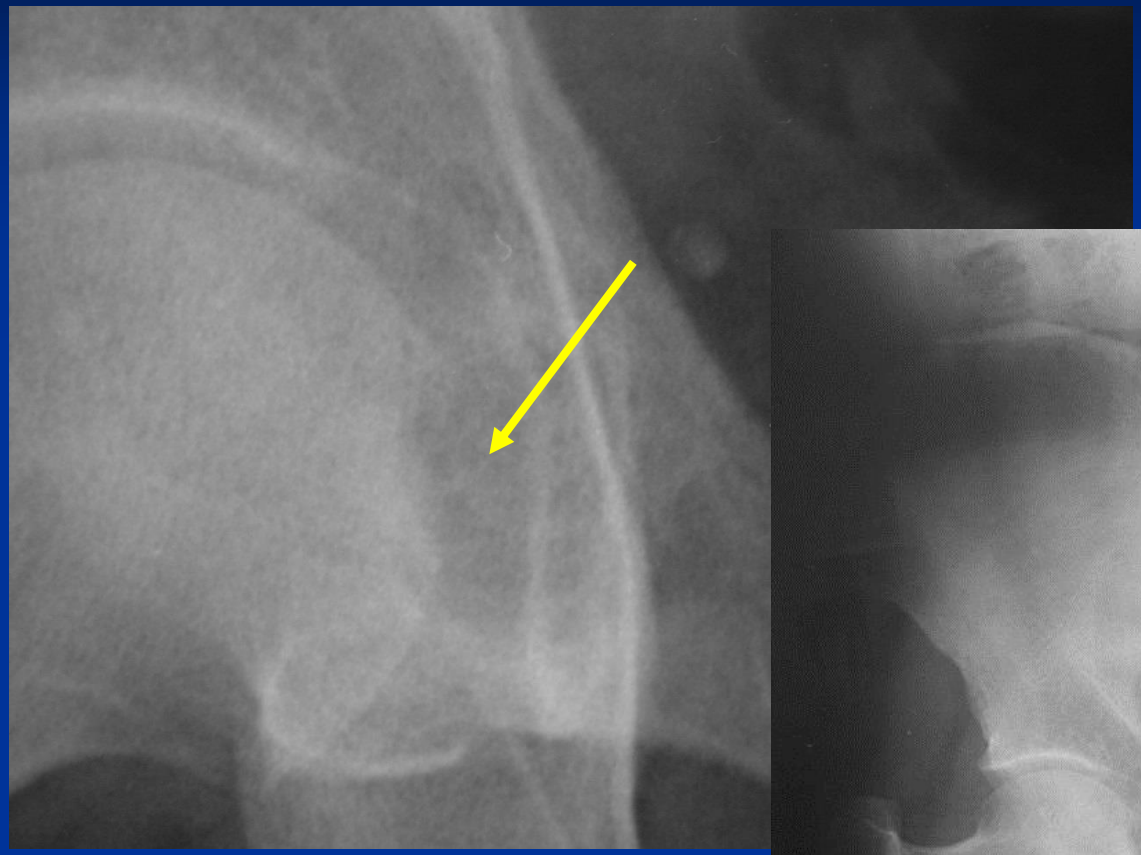


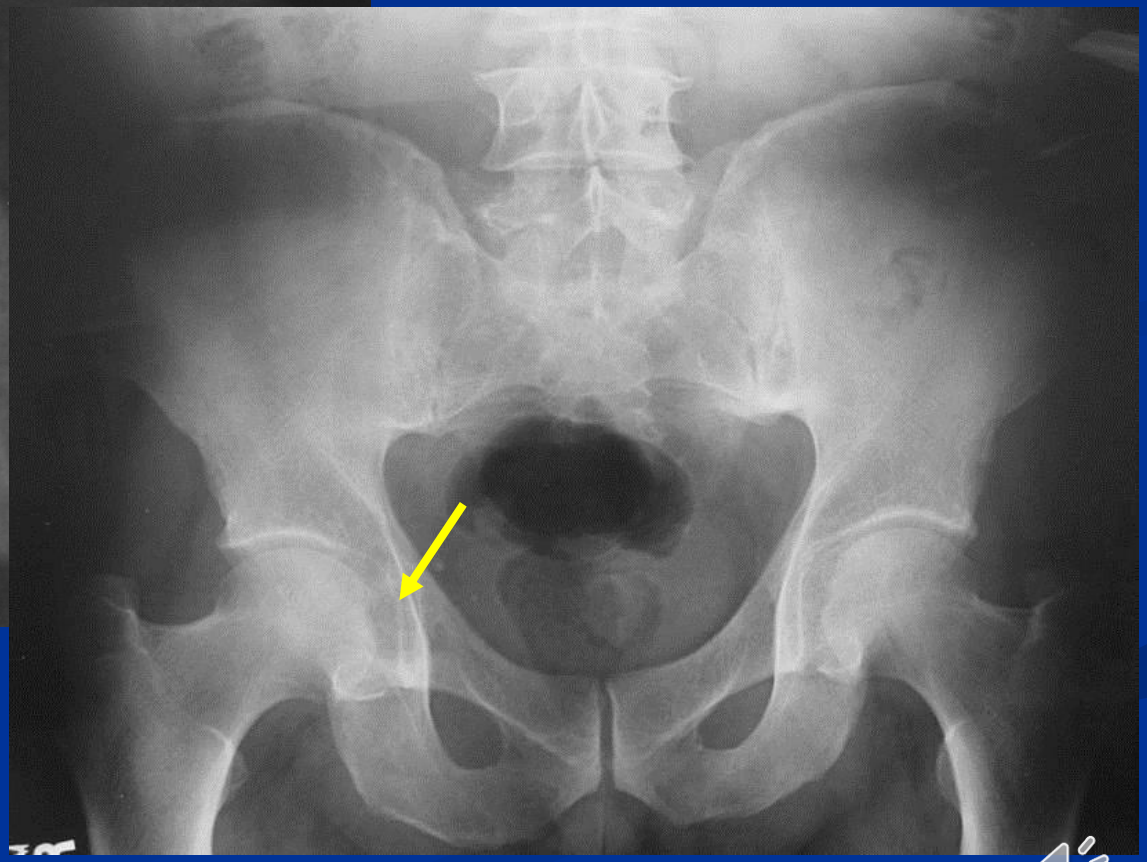
Grade I Chondrosarcoma of Proximal Humerus





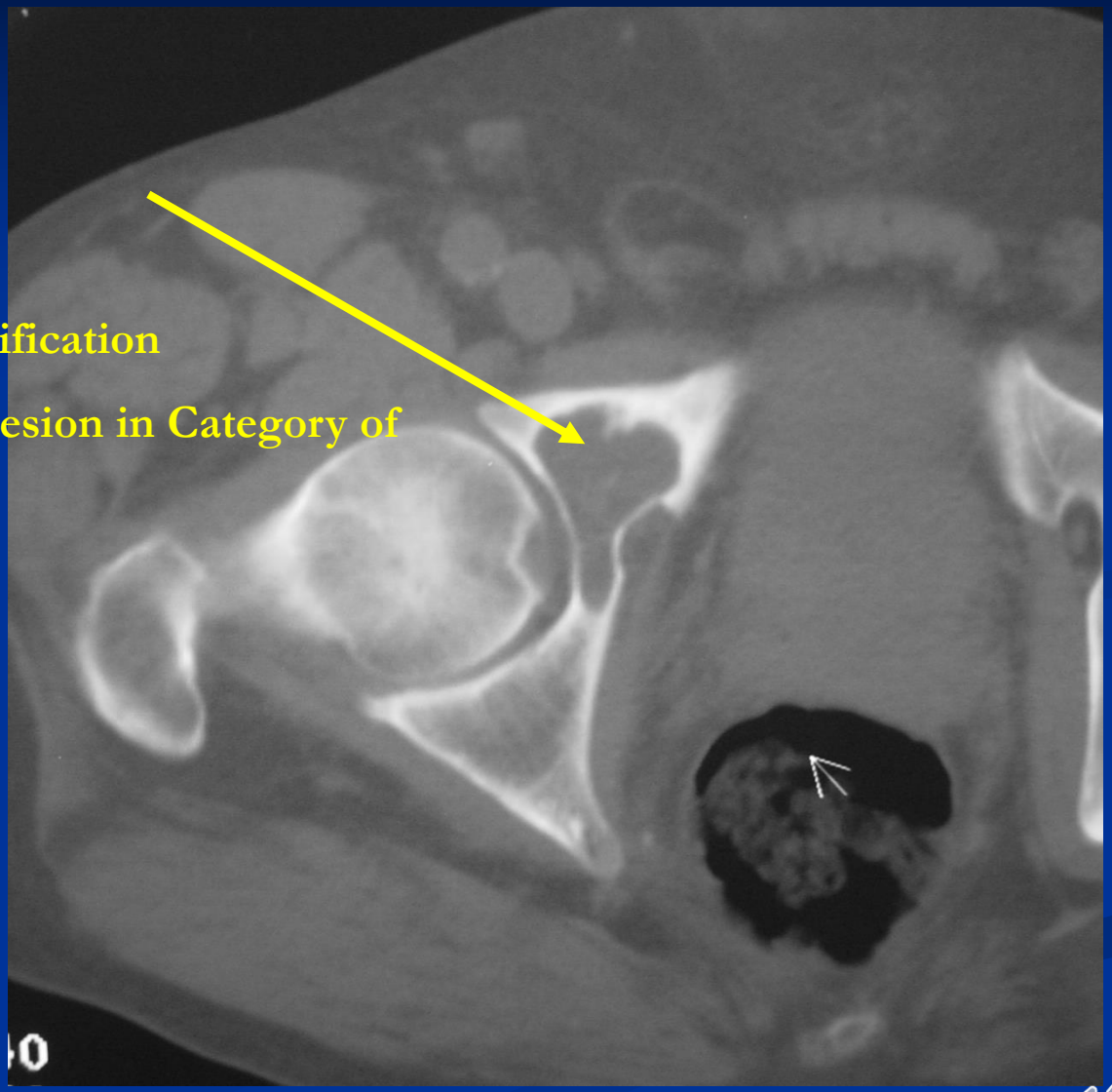
Plain X-rays: Grade II Chondrosarcoma of Acetabulum



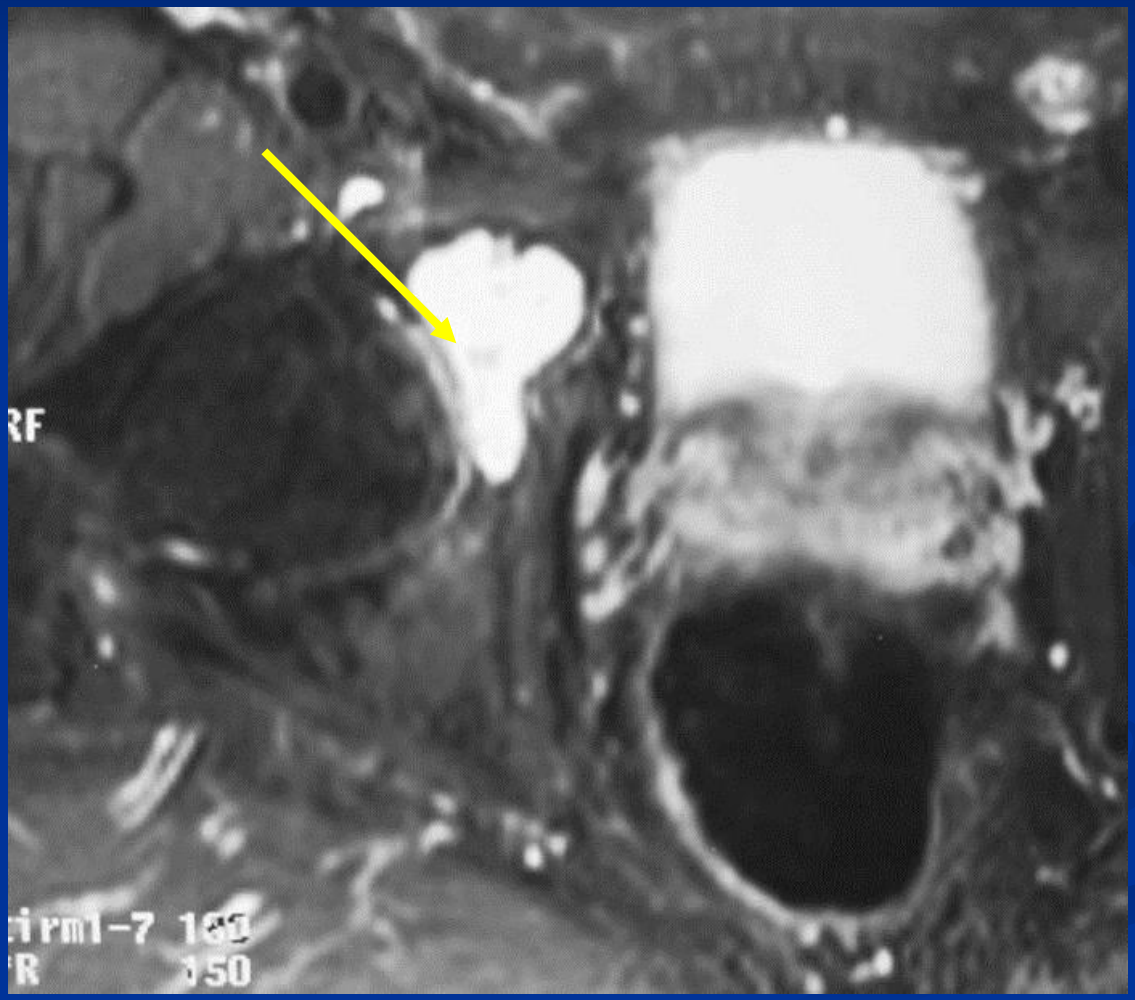


CT Scan: Grade II Chondrosarcoma of Acetabulum

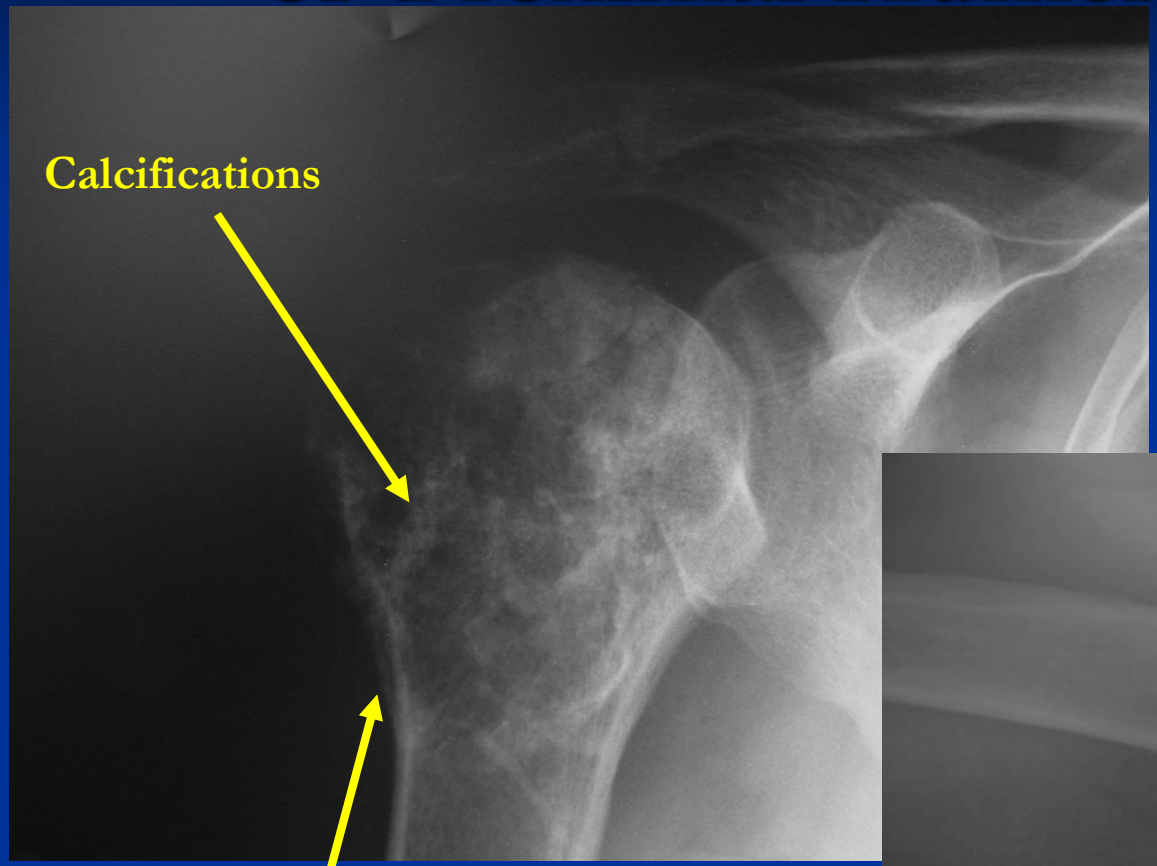
- Lytic Lesion
- Surrounding Sclerosis
- Subtle Intralesional Calcification
- Pelvic Location Places Lesion in Category of Chondrosarcoma

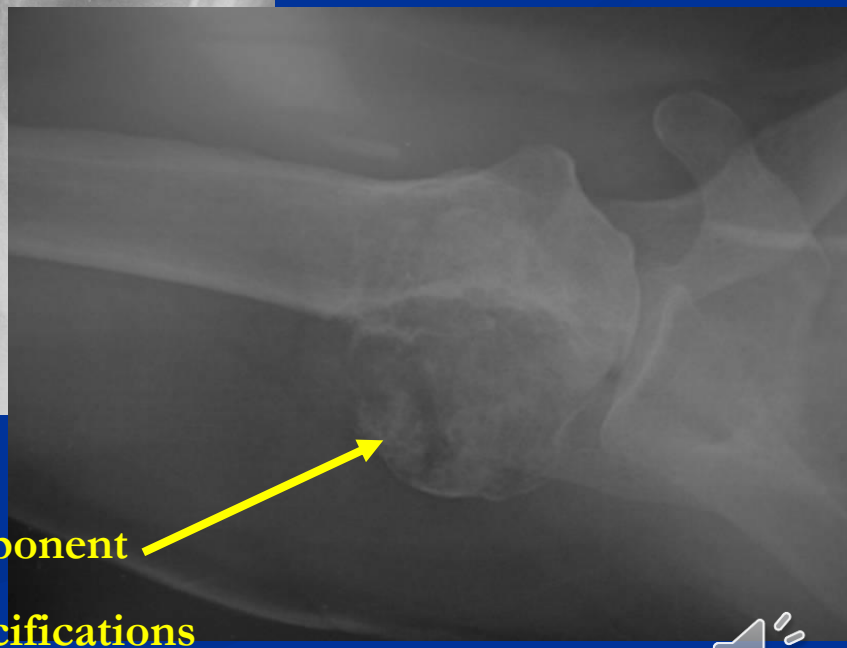


MRI: Grade II Chondrosarcoma of Acetabulum
High Signal on T2 may be misinterpreted as a cyst

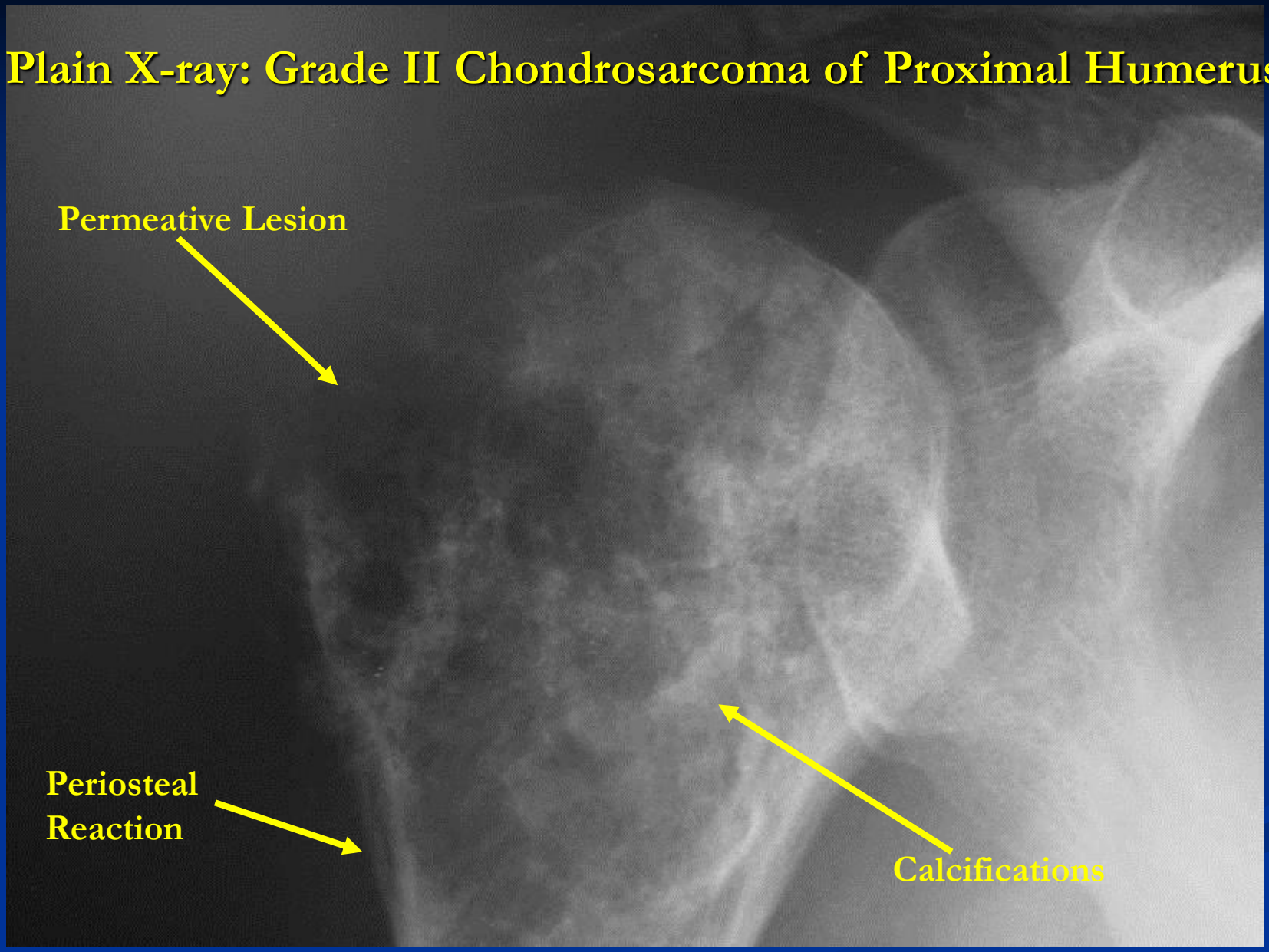


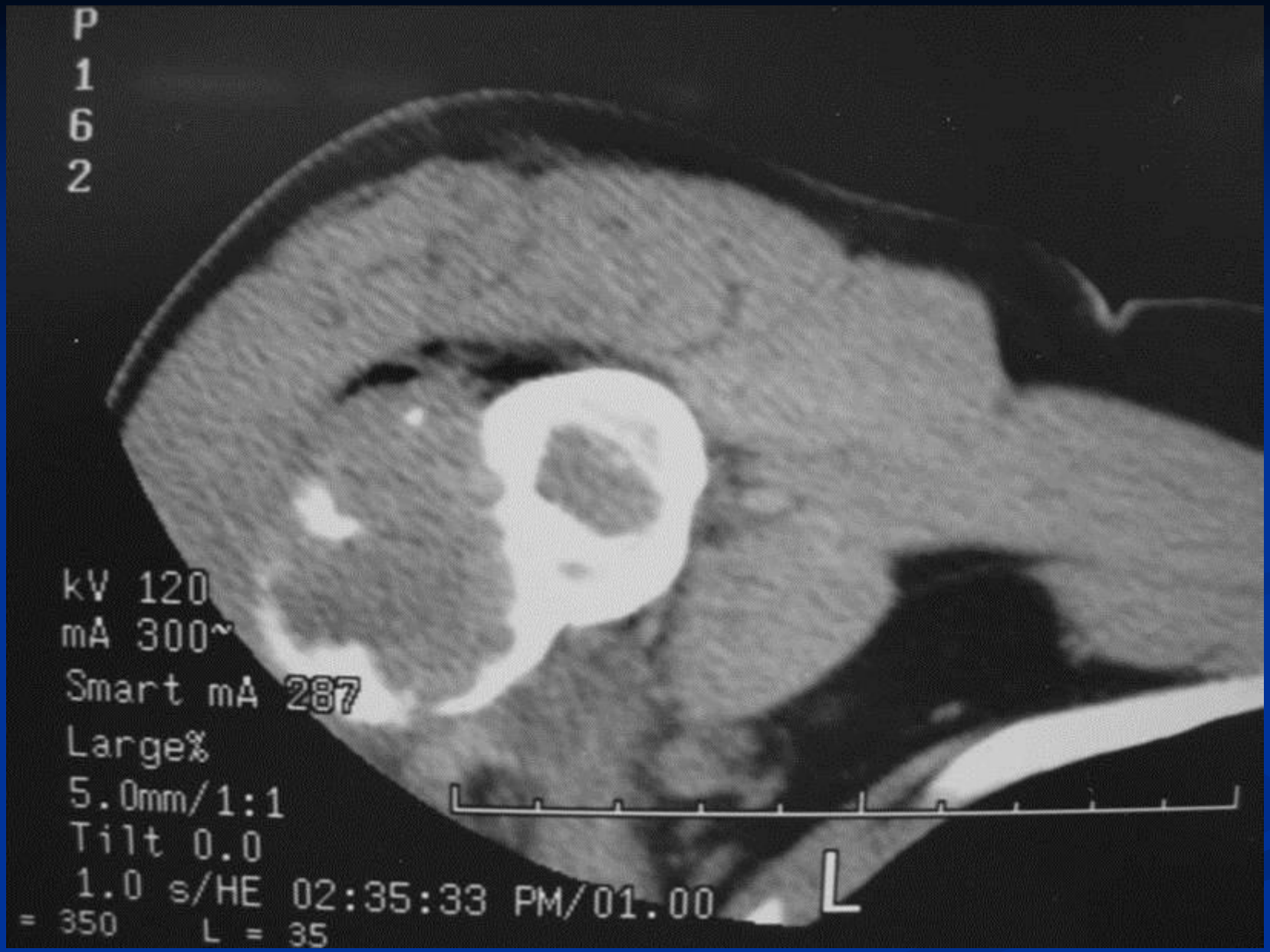
Plain X-rays: Grade II Chondrosarcoma of Proximal Humerus



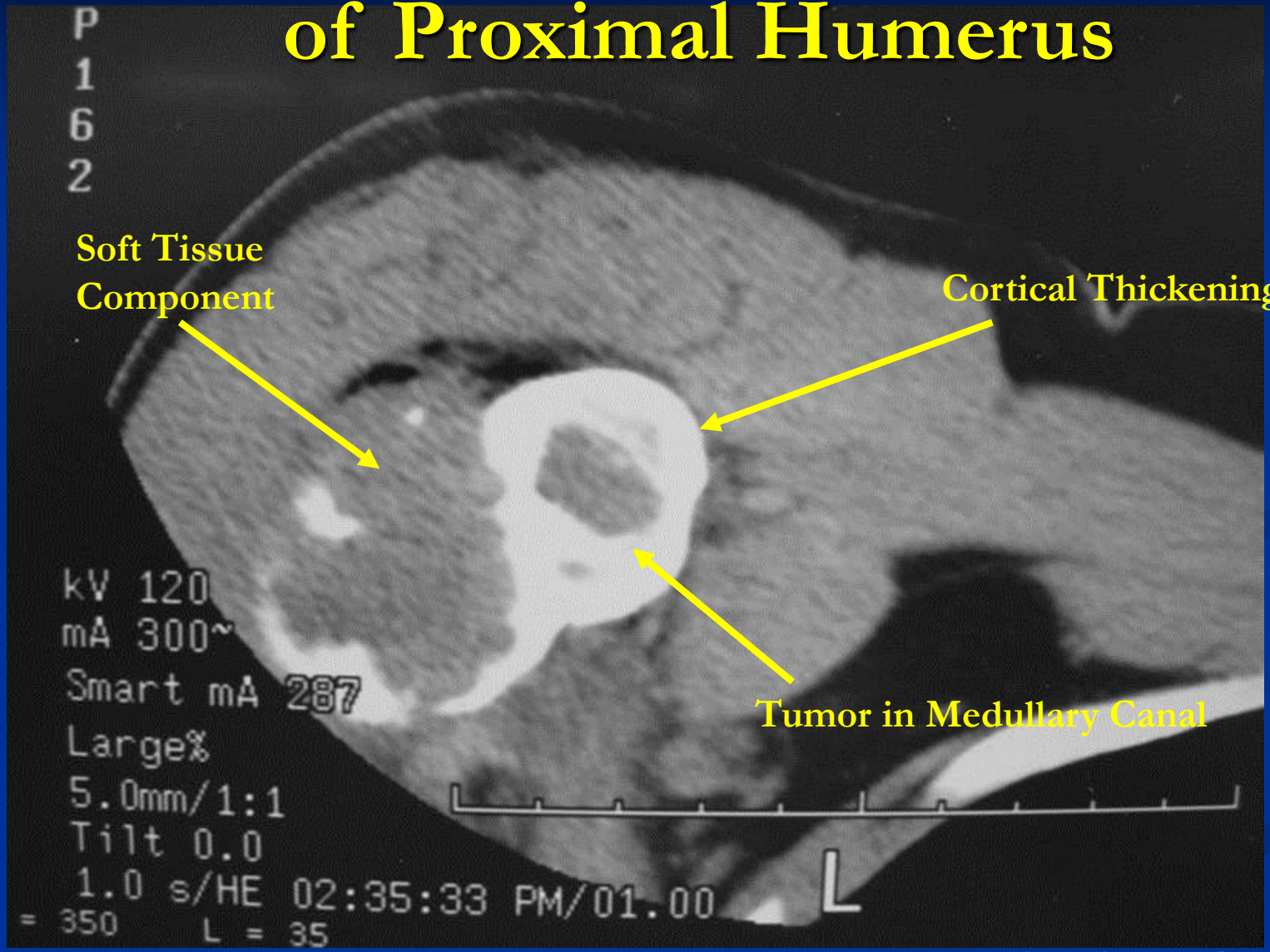


Plain X-ray: Grade II Chondrosarcoma of Proximal Humerus



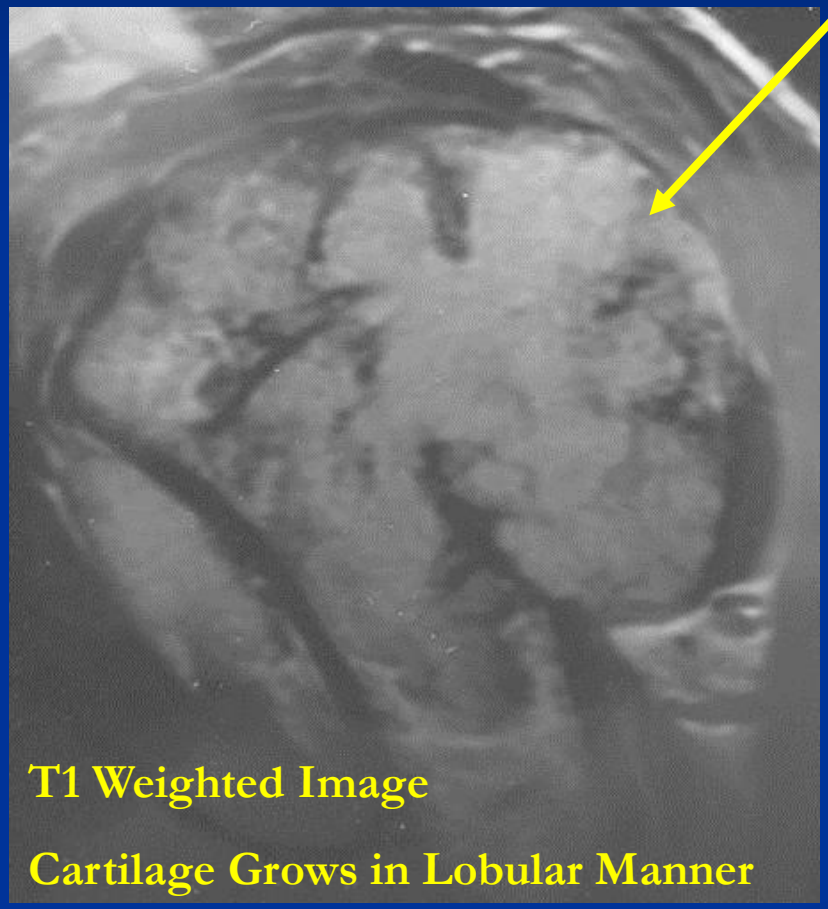

P
1
6
2
kV 120
mA 300~
Smart mA 287
Large%
5.0mm/1:1
Tilt 0.0
1.0 s/HE 02:35:33 PM/01.00
= 350
L = 35
L

CT Scan: Grade II Chondrosarcoma of Proximal Humerus



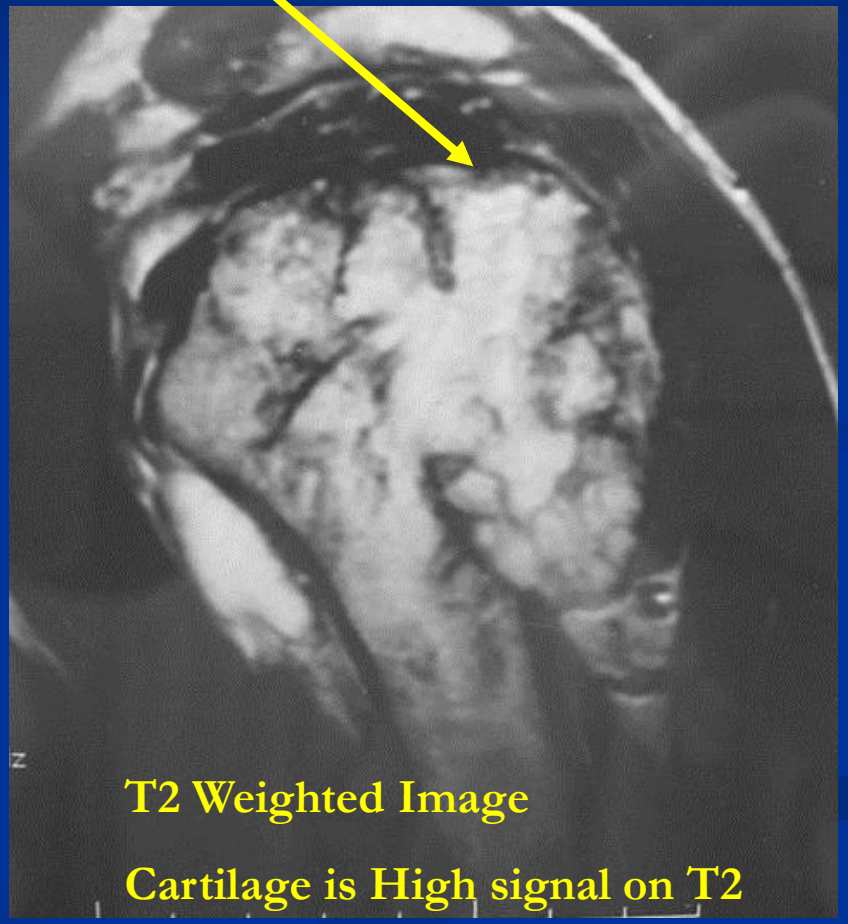
MRI: Grade II Chondrosarcoma of Proximal Humerus

Soft Tissue Component Indicative of Chondrosarcoma



T1 Weighted Image

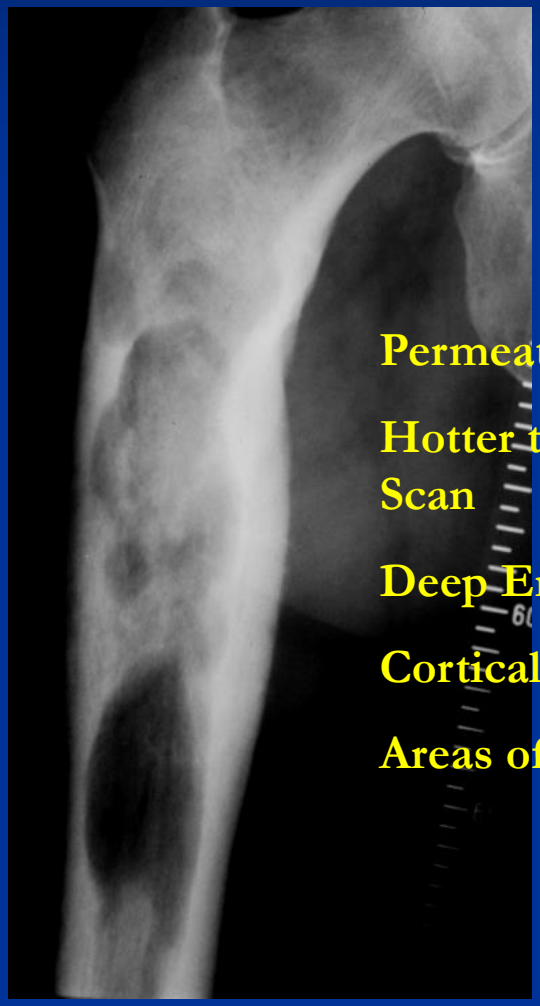
Cartilage Grows in Lobular Manner



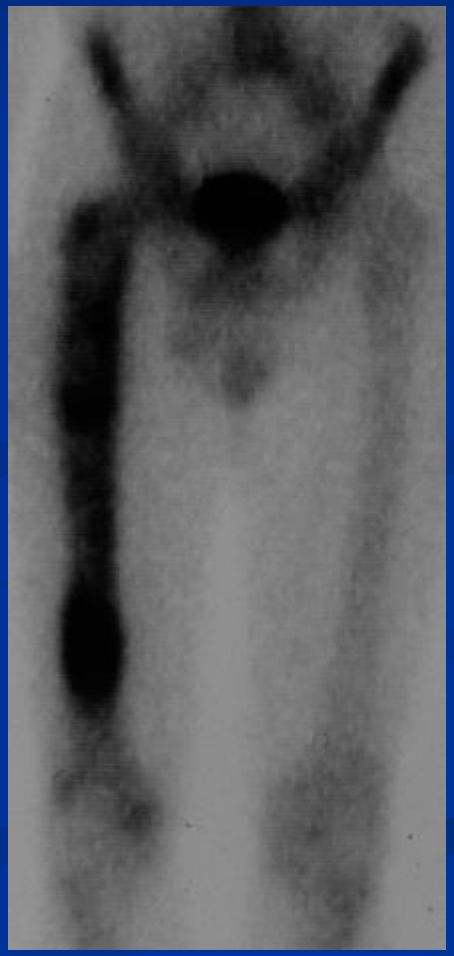
T2 Weighted Image

Cartilage is High signal on T2

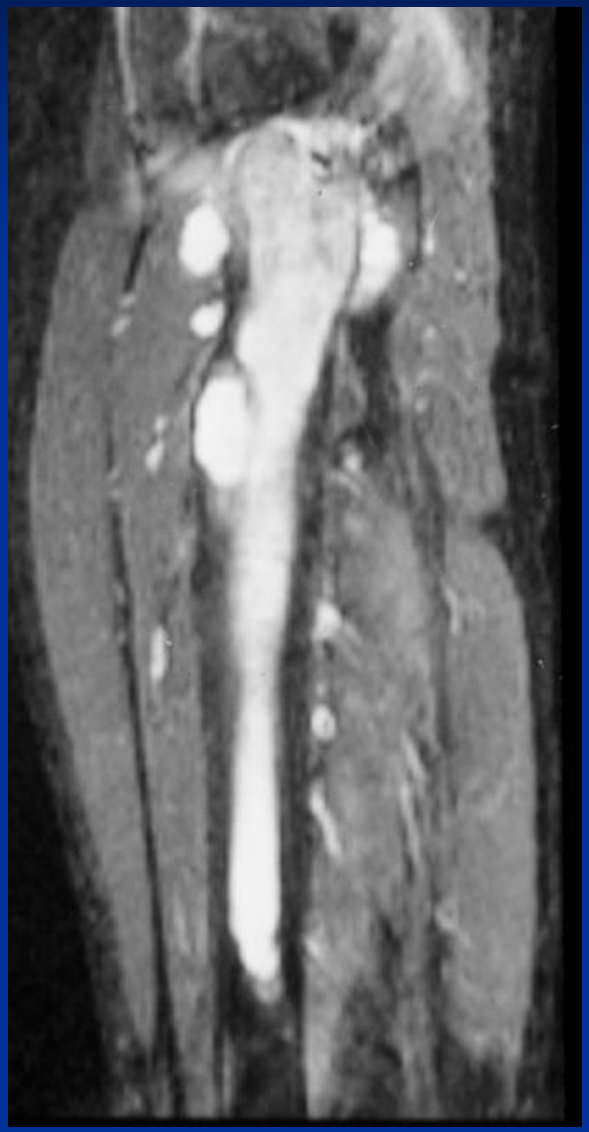
Plain X-Ray and Bone Scan Grade II Chondrosarcoma of Proximal Femur

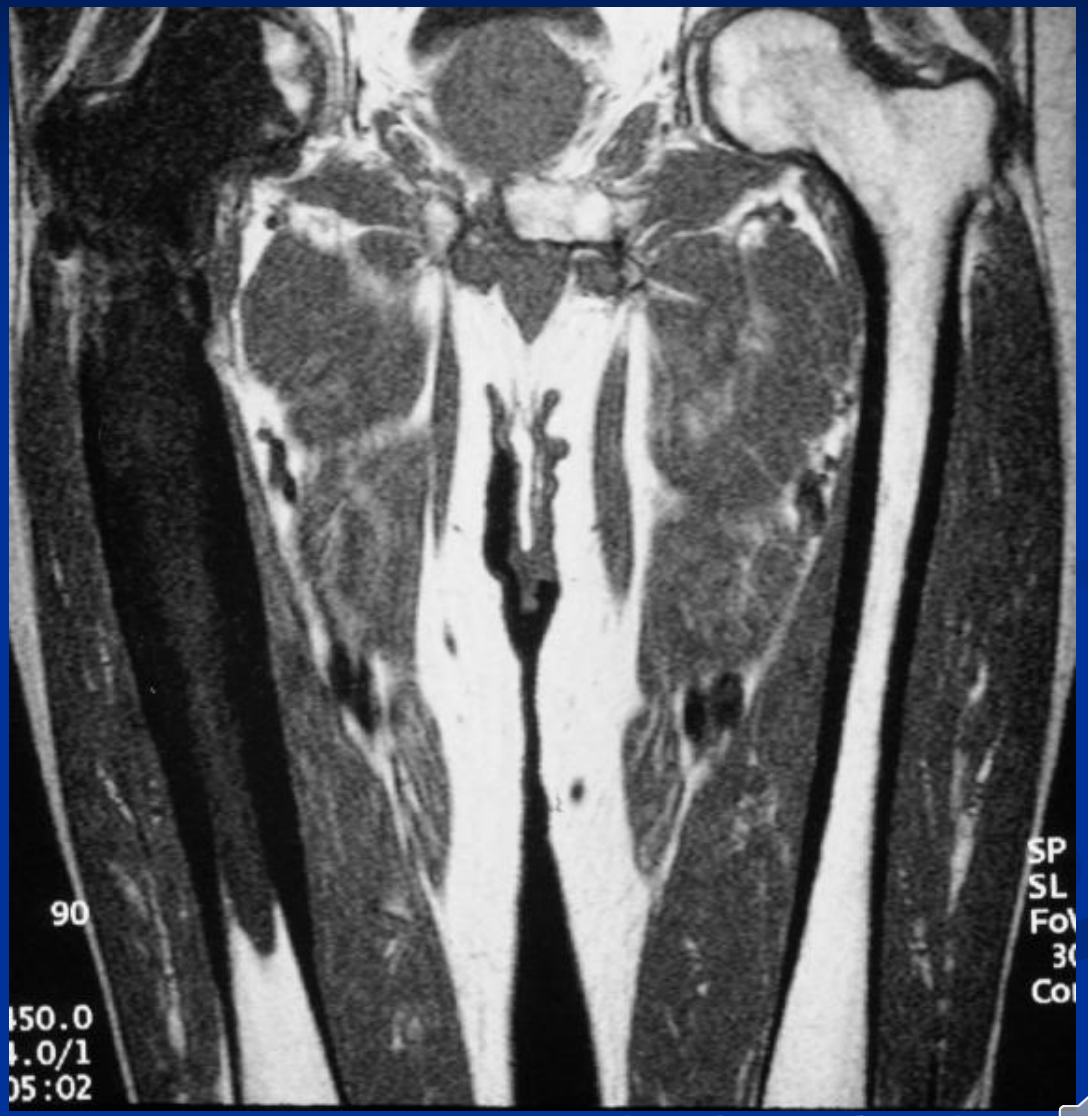


- Permeative Lesion >5cm
- Hotter than ASIS on bone Scan
- Deep Endosteal Scalloping
- Cortical Thickening
- Areas of Lysis



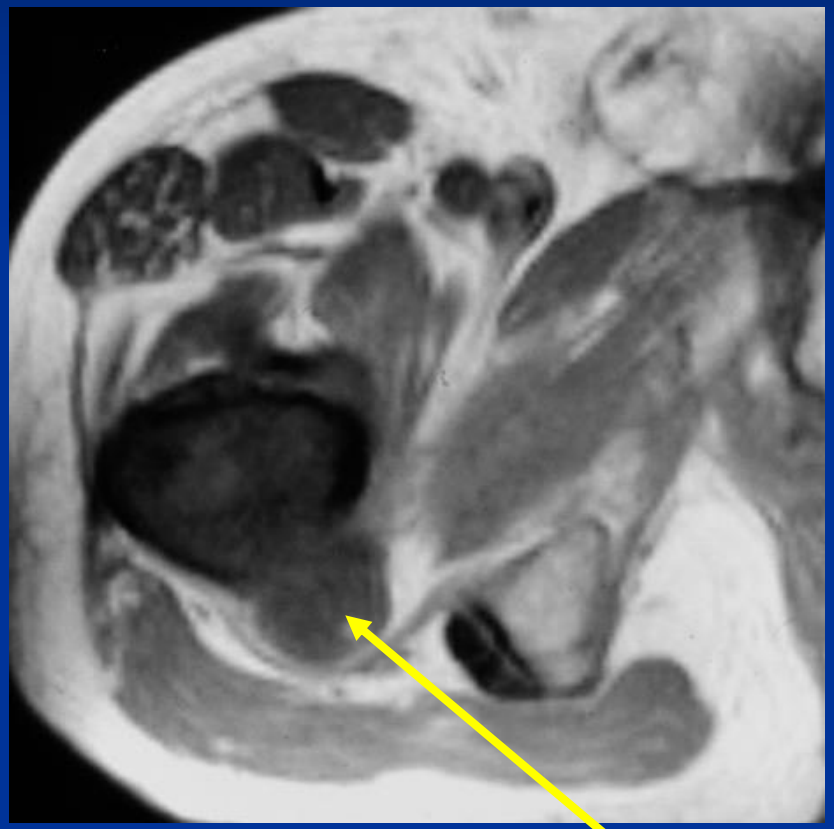
MRI: grade II Chondrosarcoma of Proximal Femur



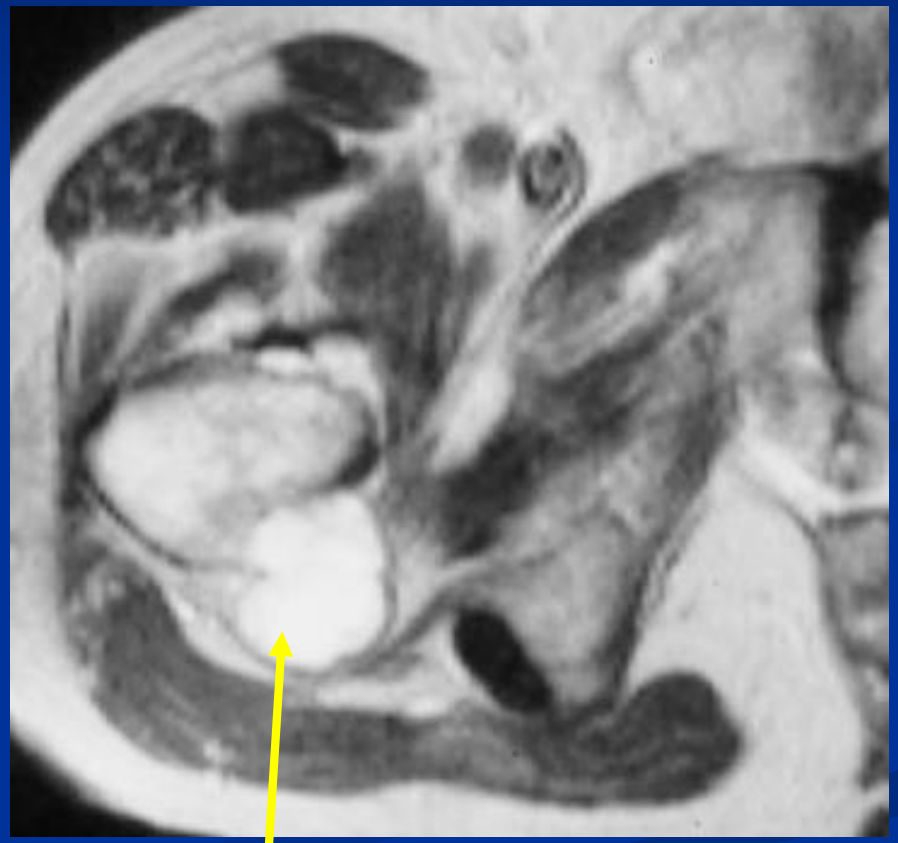


MRI: Grade II Chondrosarcoma of Proximal Femur

Soft Tissue Component not detected on X-ray

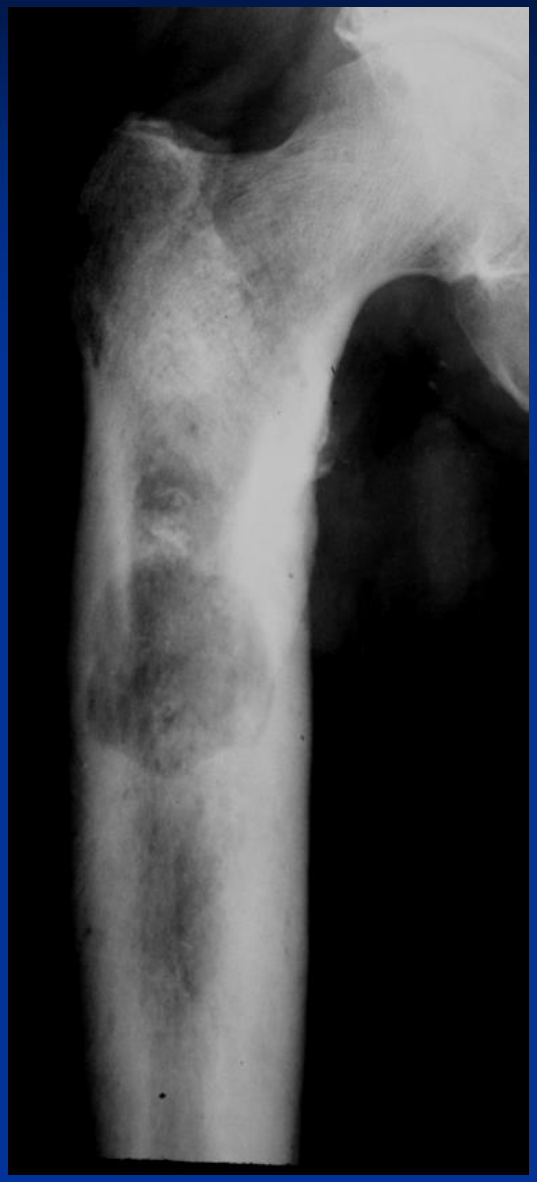


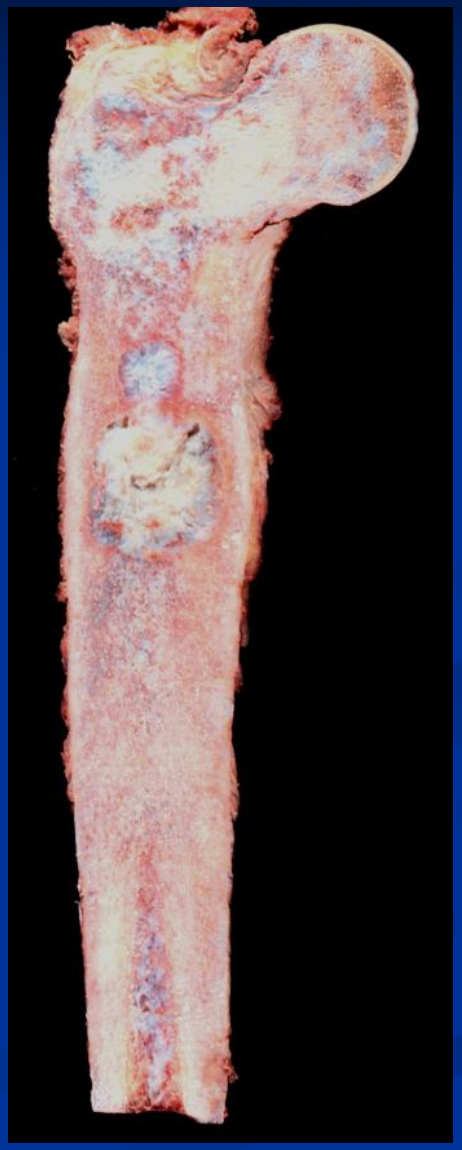
T1 Image



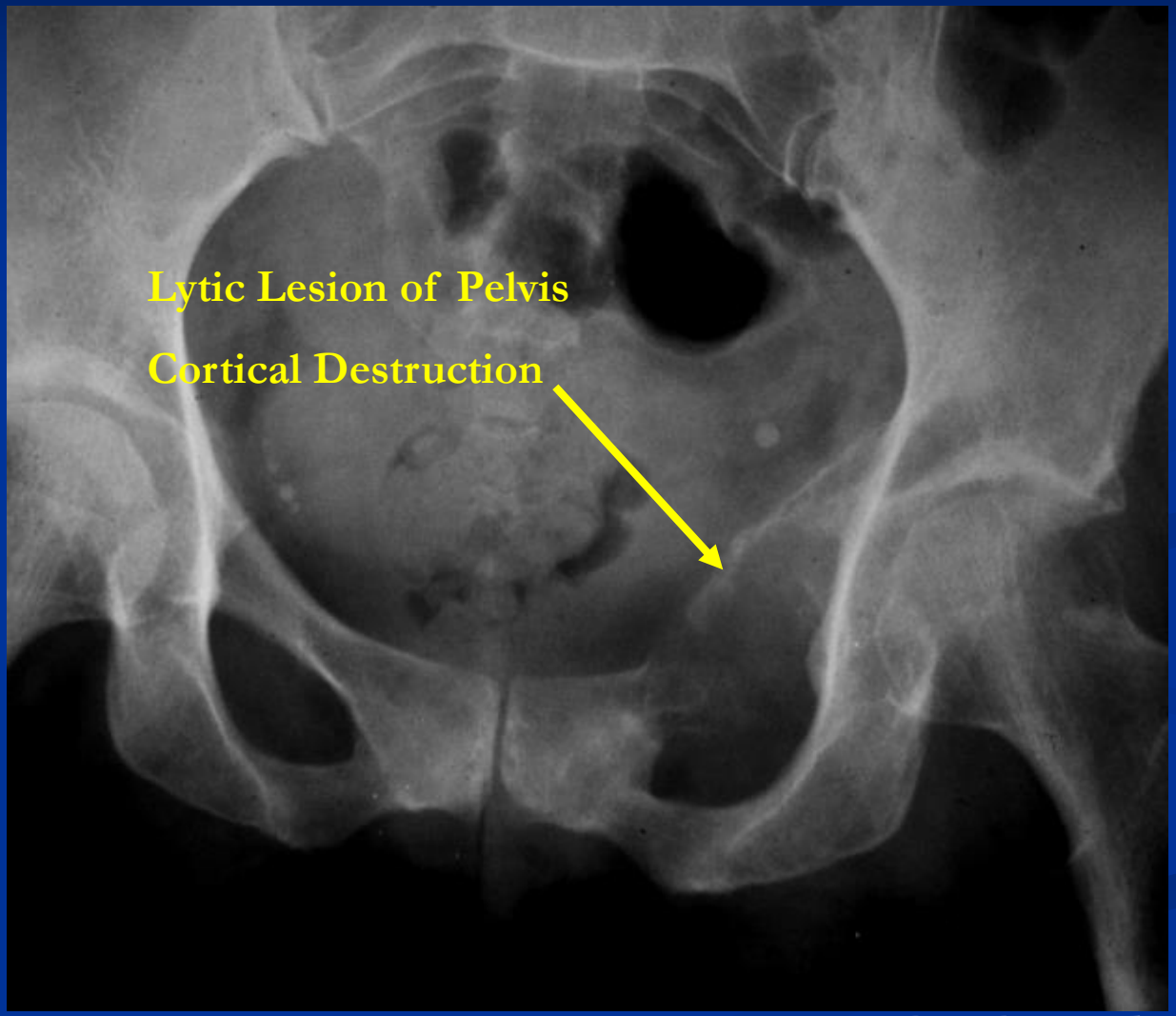
T2 Image

Plain Xray: Grade II Chondrosarcoma of Proximal Femur





Plain X-ray: Grade III Conventional Chondrosarcoma of Pelvis



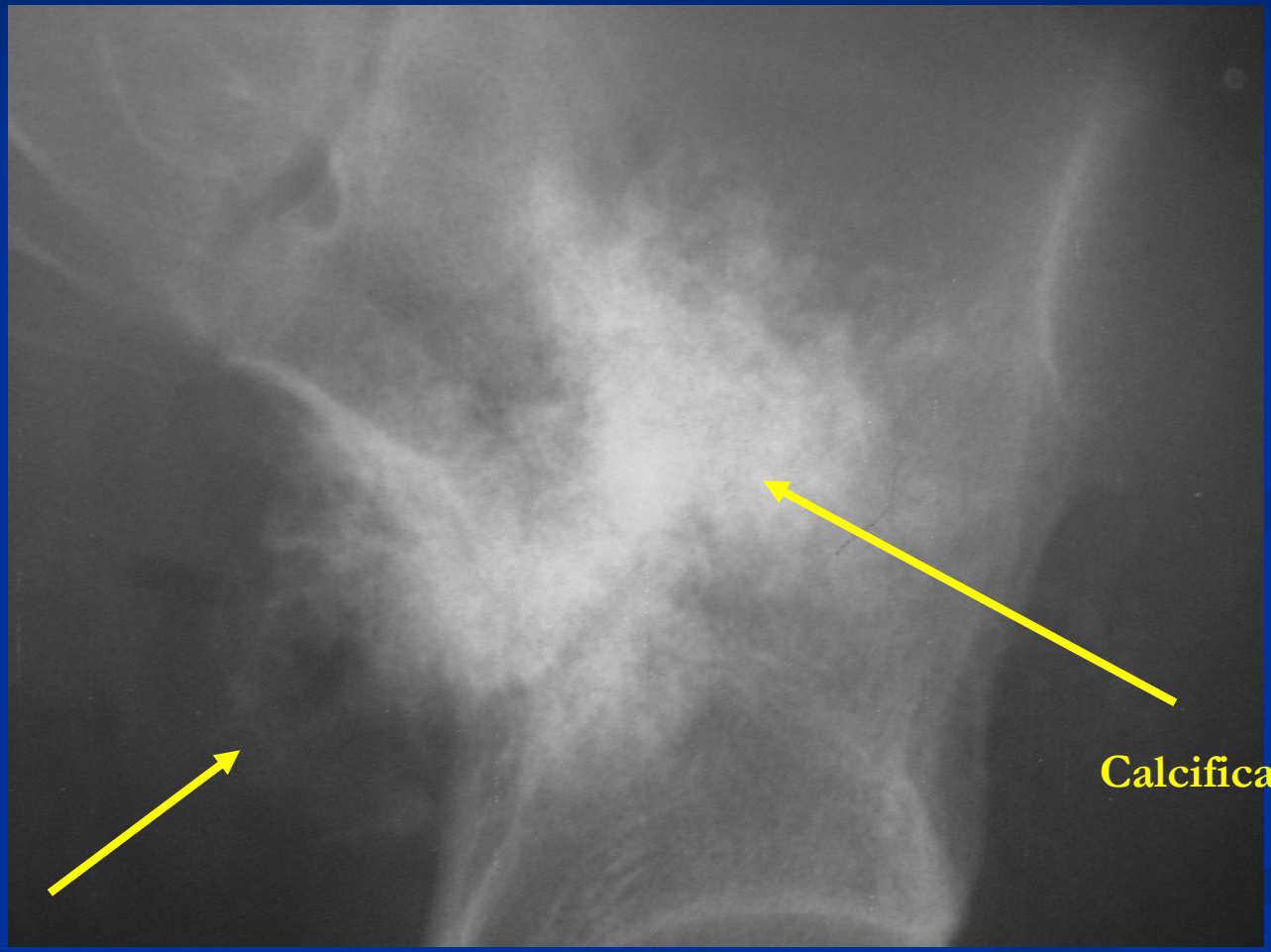
Secondary Chondrosarcoma

- Secondary Chondrosarcomas arise from a pre-existing lesion such as an osteochondroma or enchondroma
- Most arise from osteochondromas
  - Scapula, ribs, pelvis and proximal femur
- Most are low grade and cured by wide excision
- Dedifferentiation possible

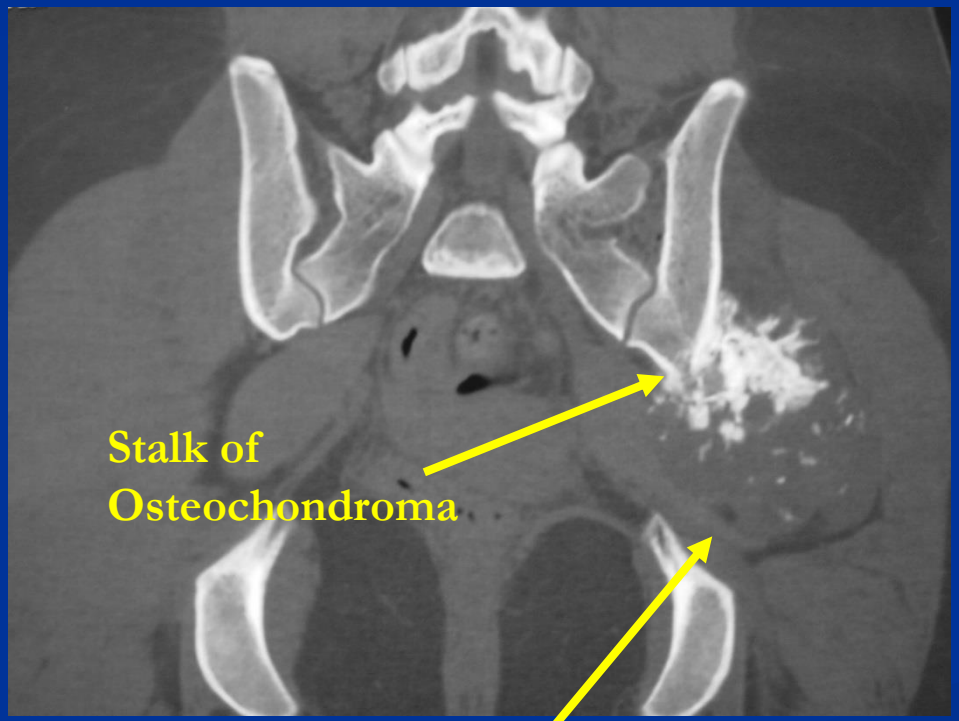
Osteochondroma vs. Secondary Chondrosarcoma

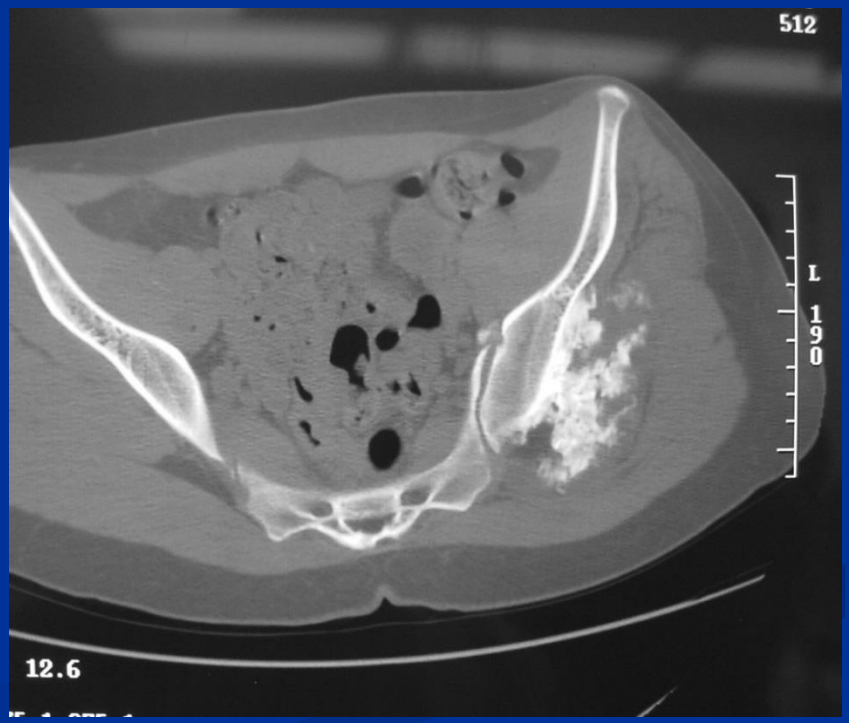
- Malignant transformation is suggested by:
  - Cartilaginous cap thickness greater than 2cm
  - Cortical destruction
  - Backgrowth of the cartilaginous cap into the stalk or medullary canal
  - Lysis of calcifications in cap

Plain X-ray: Secondary Chondrosarcoma of Pelvis

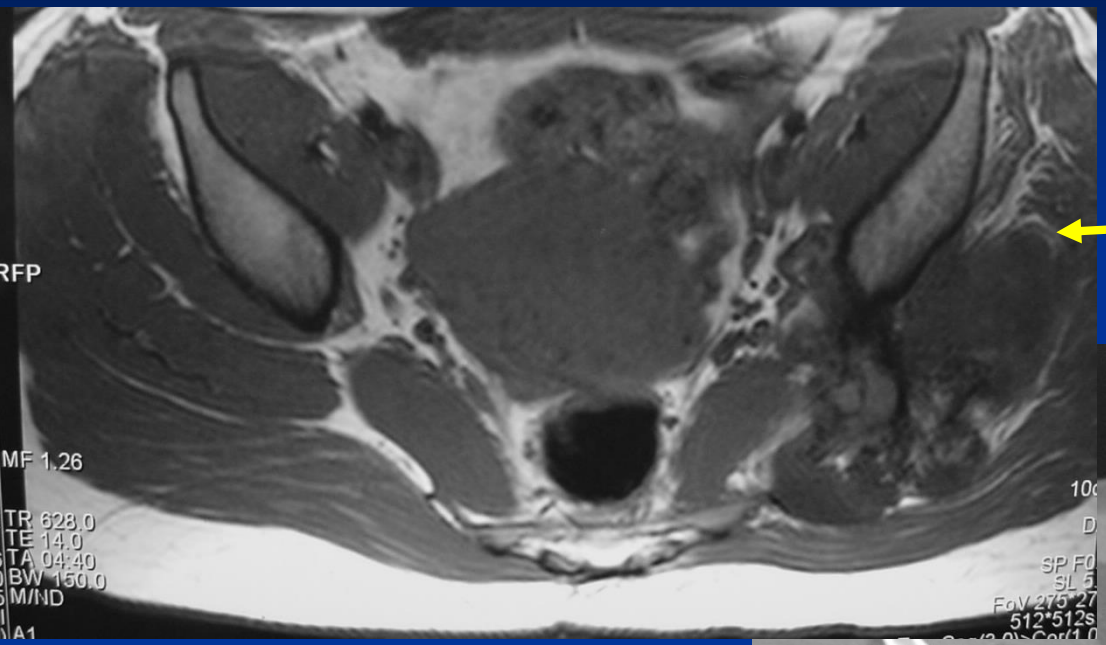


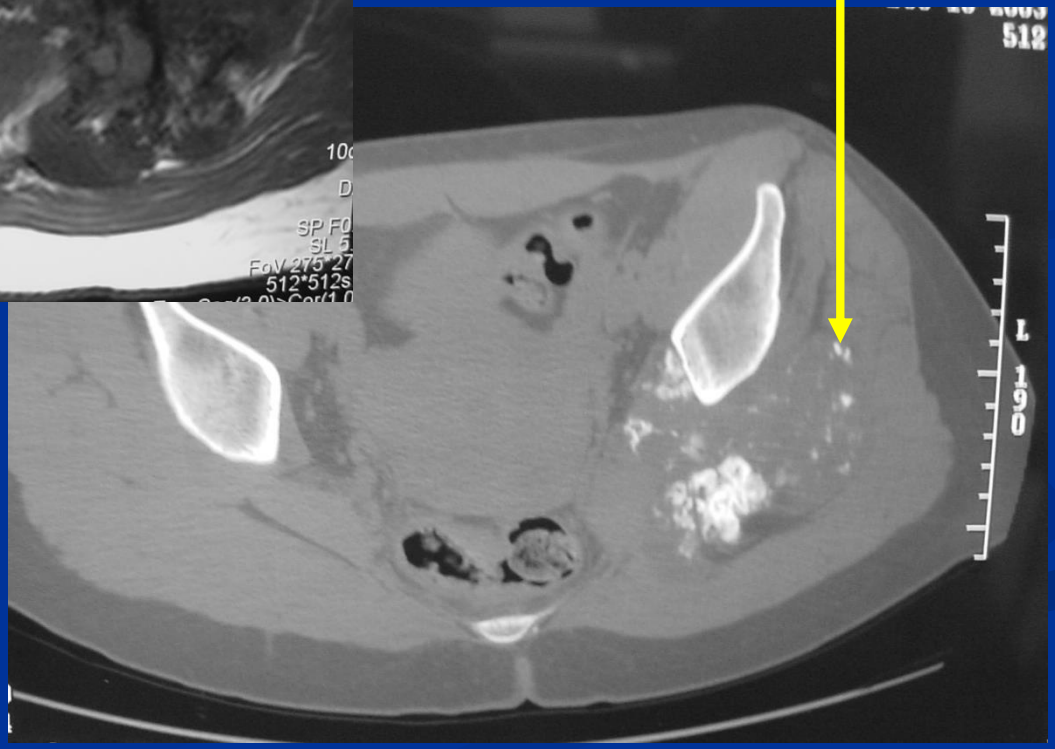
Secondary Chondrosarcoma of Pelvis





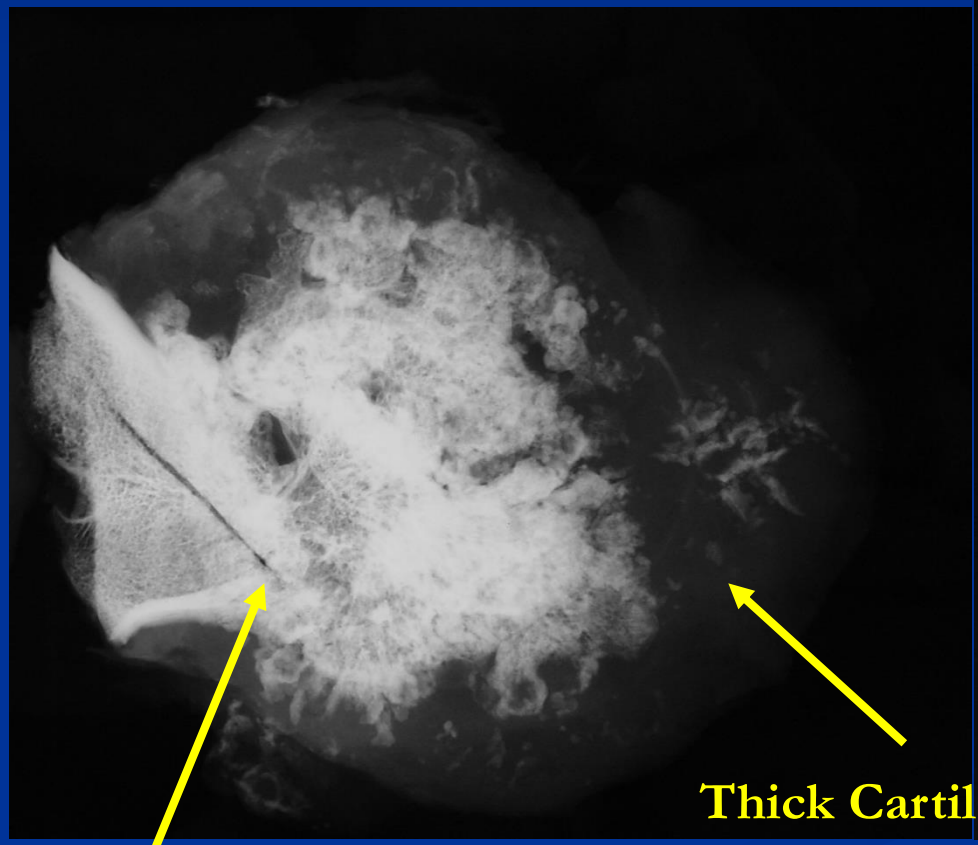
MRI and CT: Secondary Chondrosarcoma

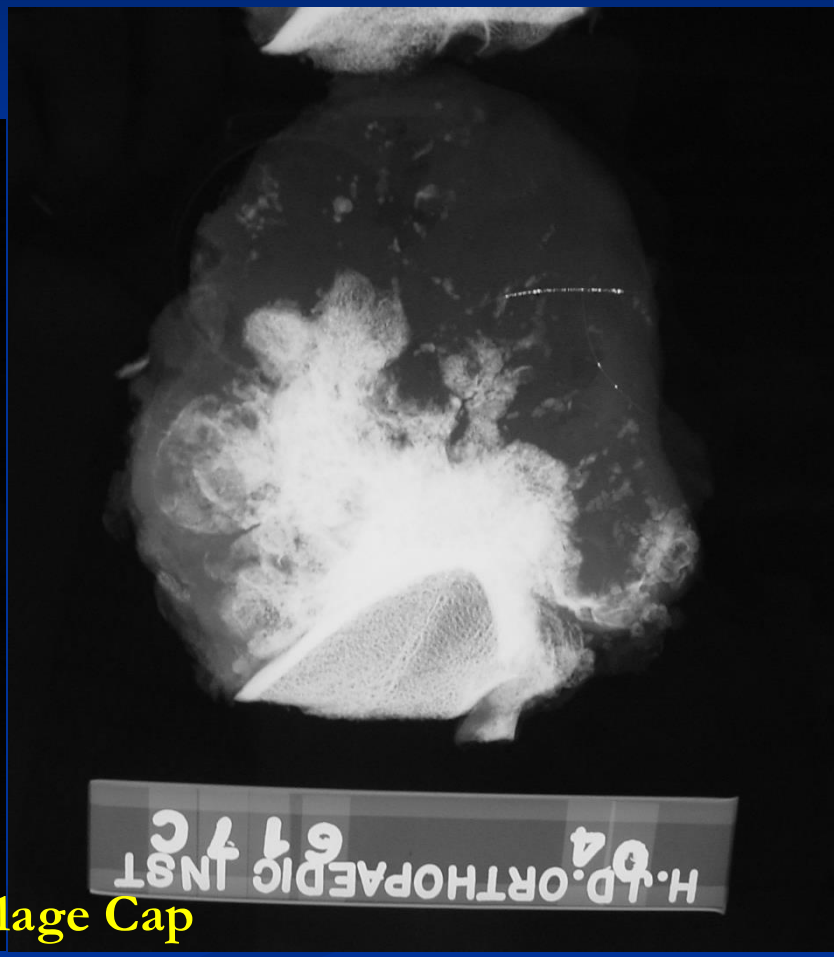




Thick Cartilage Cap

Specimen Radiograph: Secondary Chondrosarcoma of Pelvis

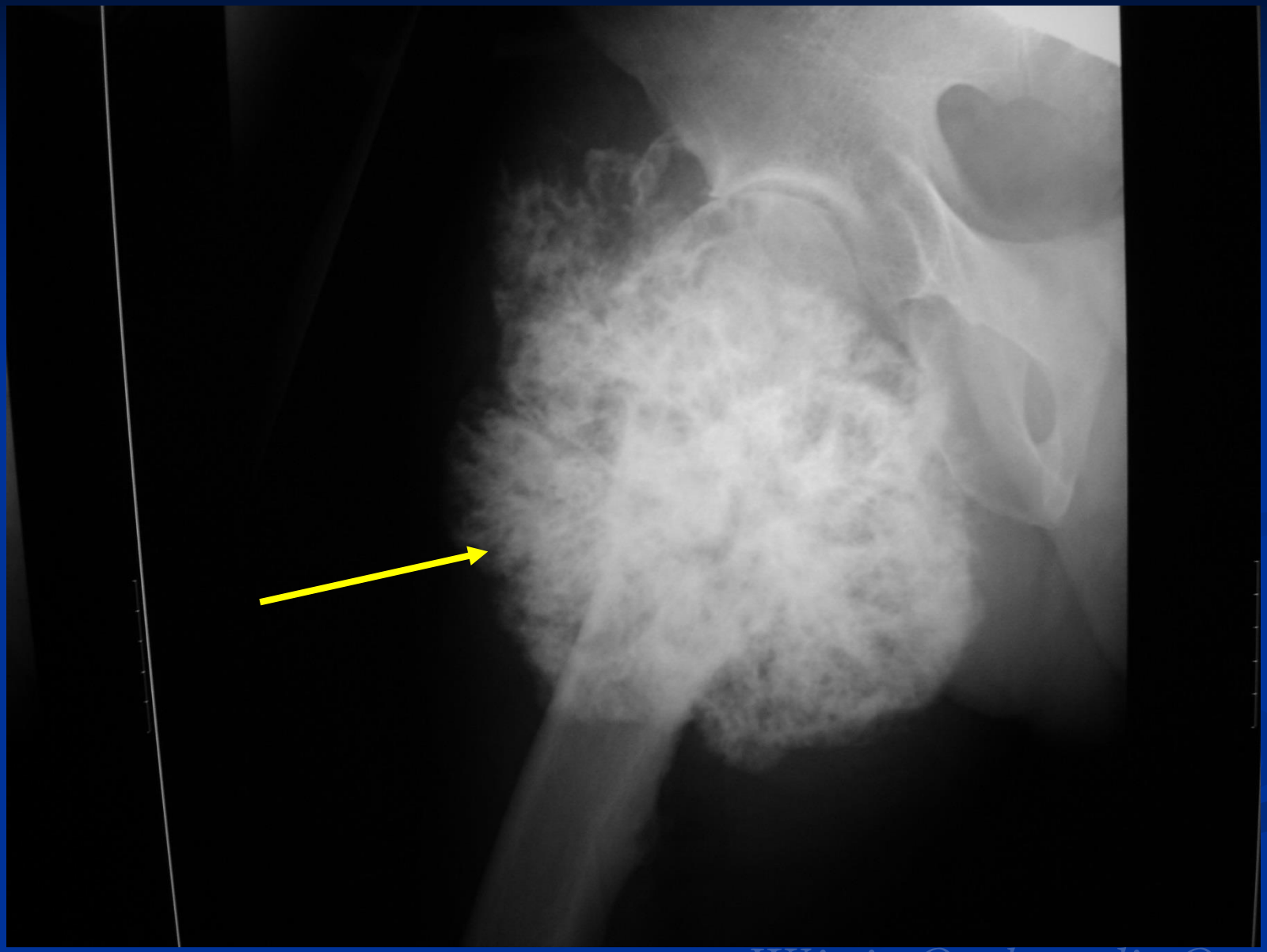




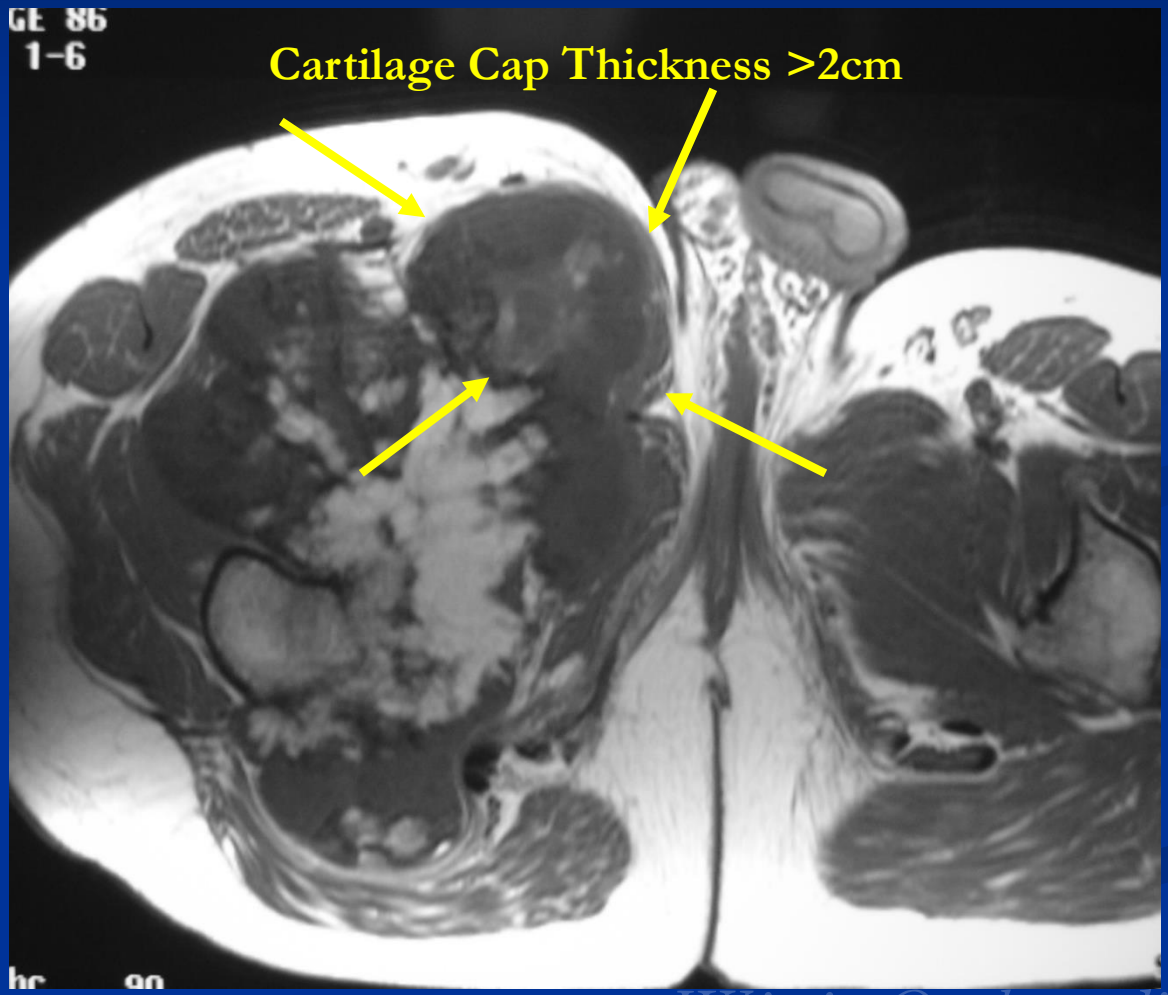
Thick Cartilage Cap

Stalk of Osteochondroma

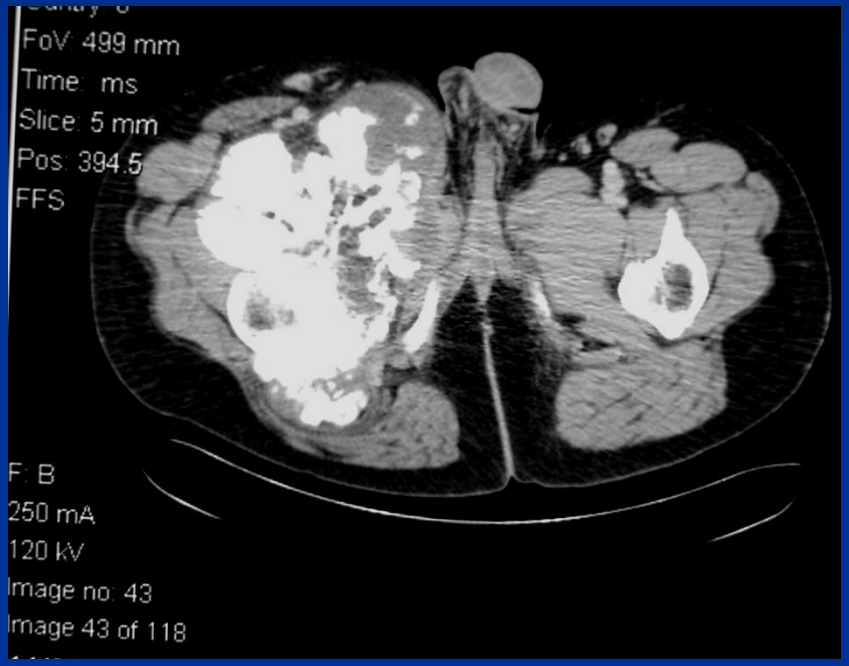
Plain X-ray: Secondary Chondrosarcoma of Proximal Femur

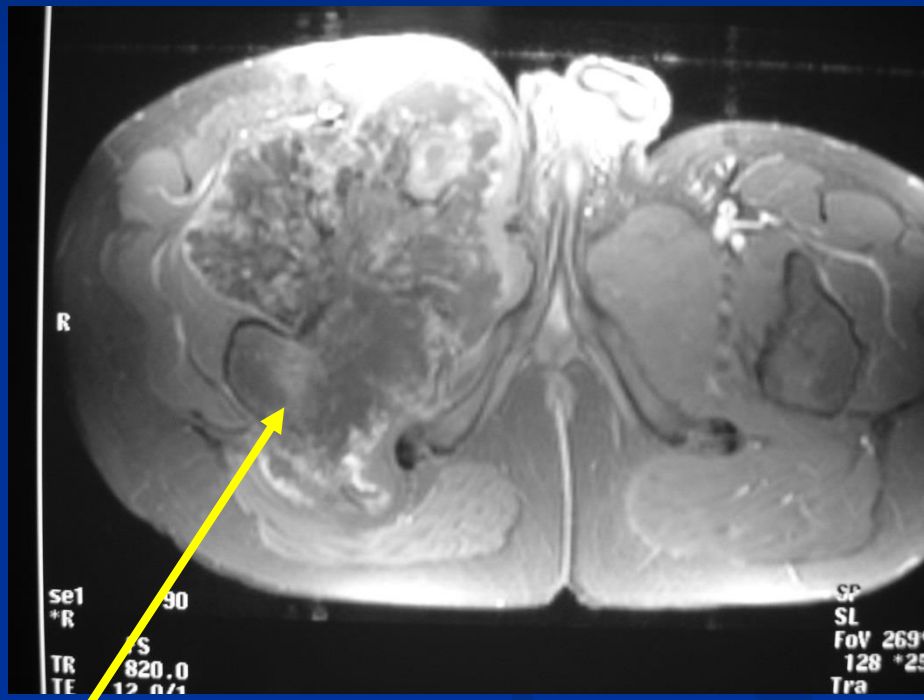


MRI: Secondary Chondrosarcoma of Proximal Femur: Thick Cartilage Cap (>2cm)



CT and MRI: Secondary Chondrosarcoma of Proximal Femur





Base of Osteochondroma

Microscopic Pathology

- Broad spectrum of microscopic appearances that depends on Grade
- Entrapment of pre-existing trabeculae by chondrosarcoma is important for distinguishing low grade chondrosarcoma from enchondroma (The chondrosarcoma surrounds pre-existing trabeculae)

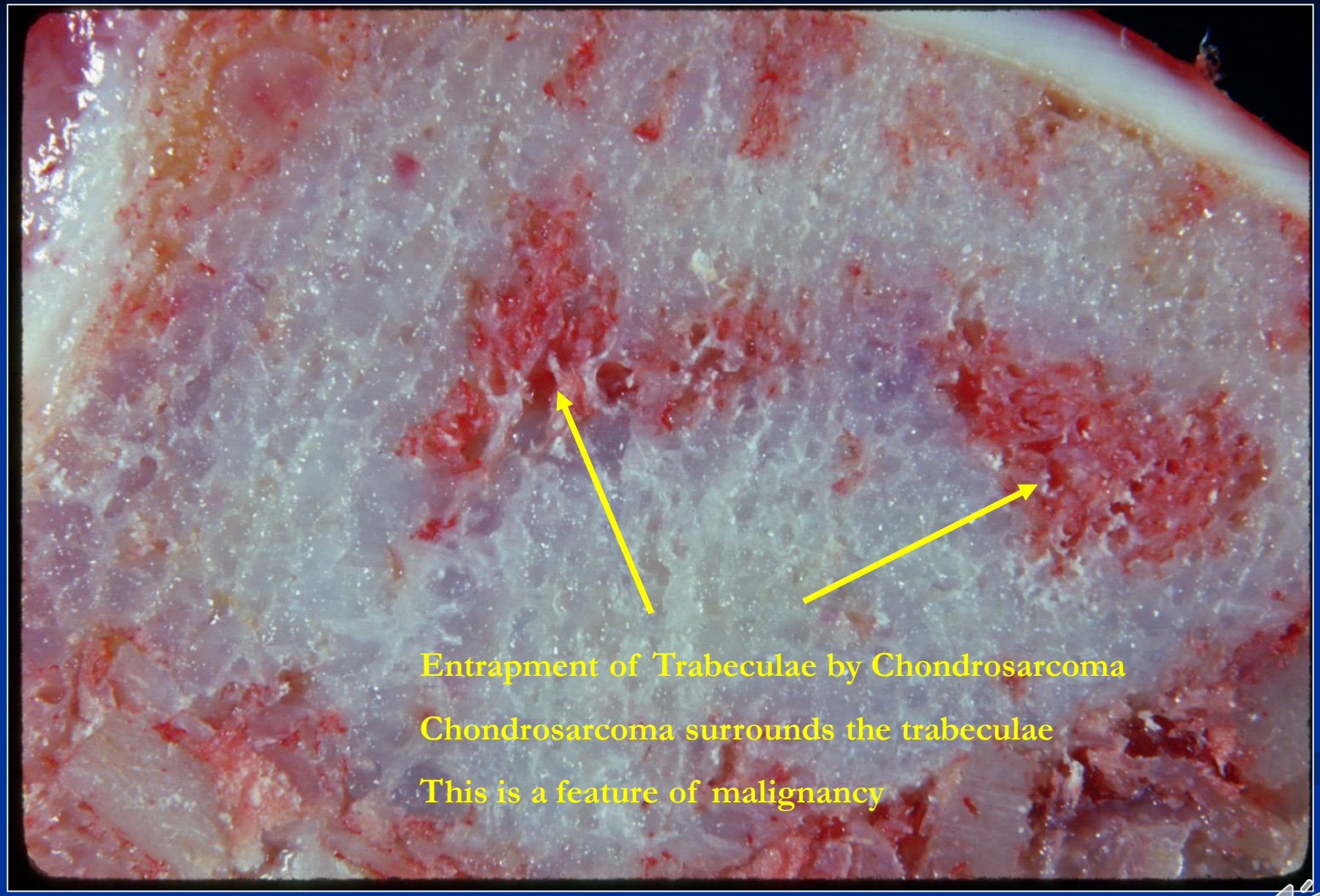
Microscopic Pathology

- Three Grade System
- I, II, III
- Cellularity, myxoid change, nuclear pleomorphism, multinucleated lacunae and mitoses increase as go from Grade I to III

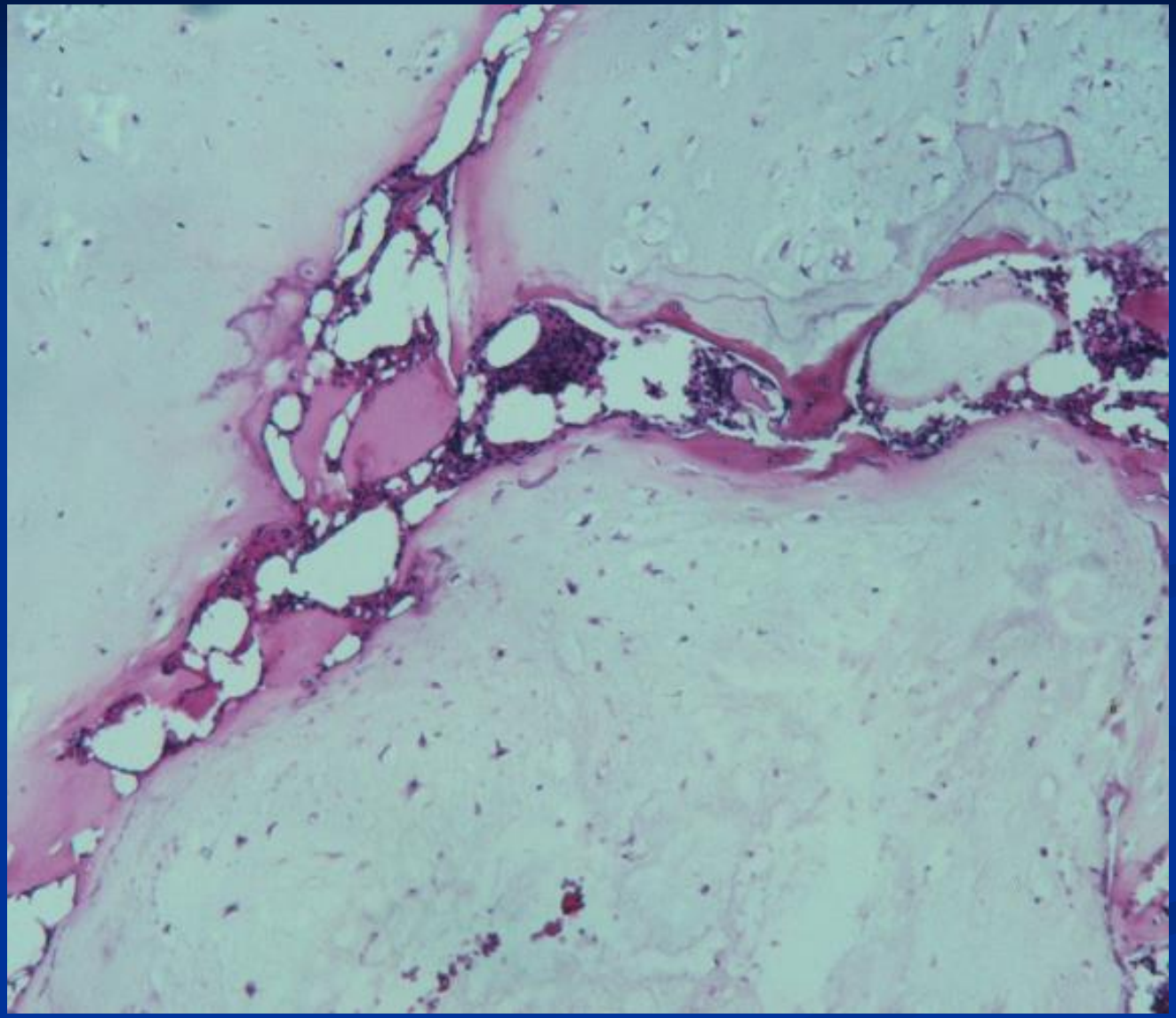
Conventional Chondrosarcoma

Grade I (Low Grade Chondrosarcoma)

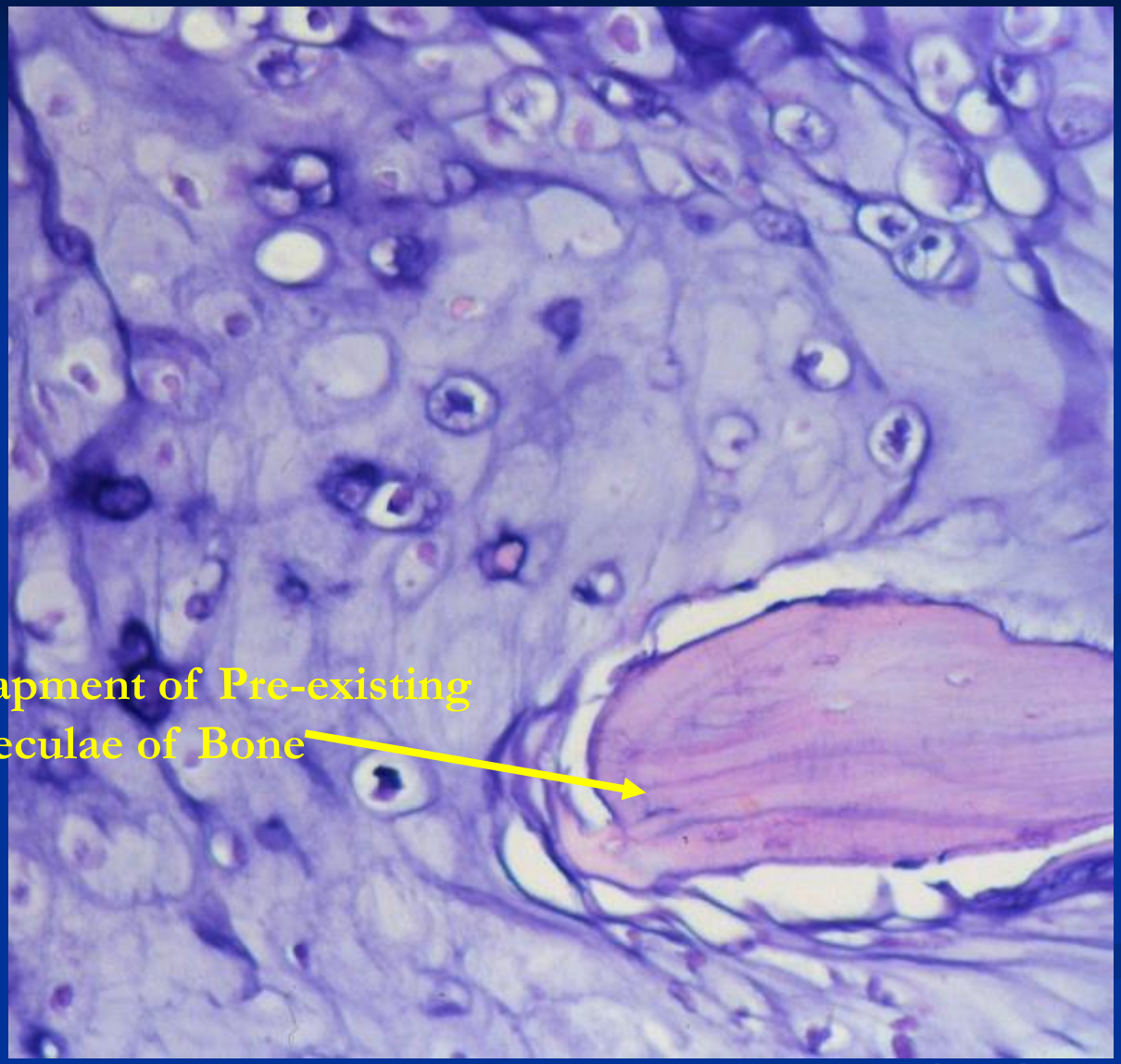
- Similar microscopic features to Enchondroma
- Require clinical and radiographic data to support diagnosis
- Relatively low cellularity
- Mitotic figures not typically present
- **Bone Entrapment of pre-existing trabeculae is important**
- More than occasional double nuclei



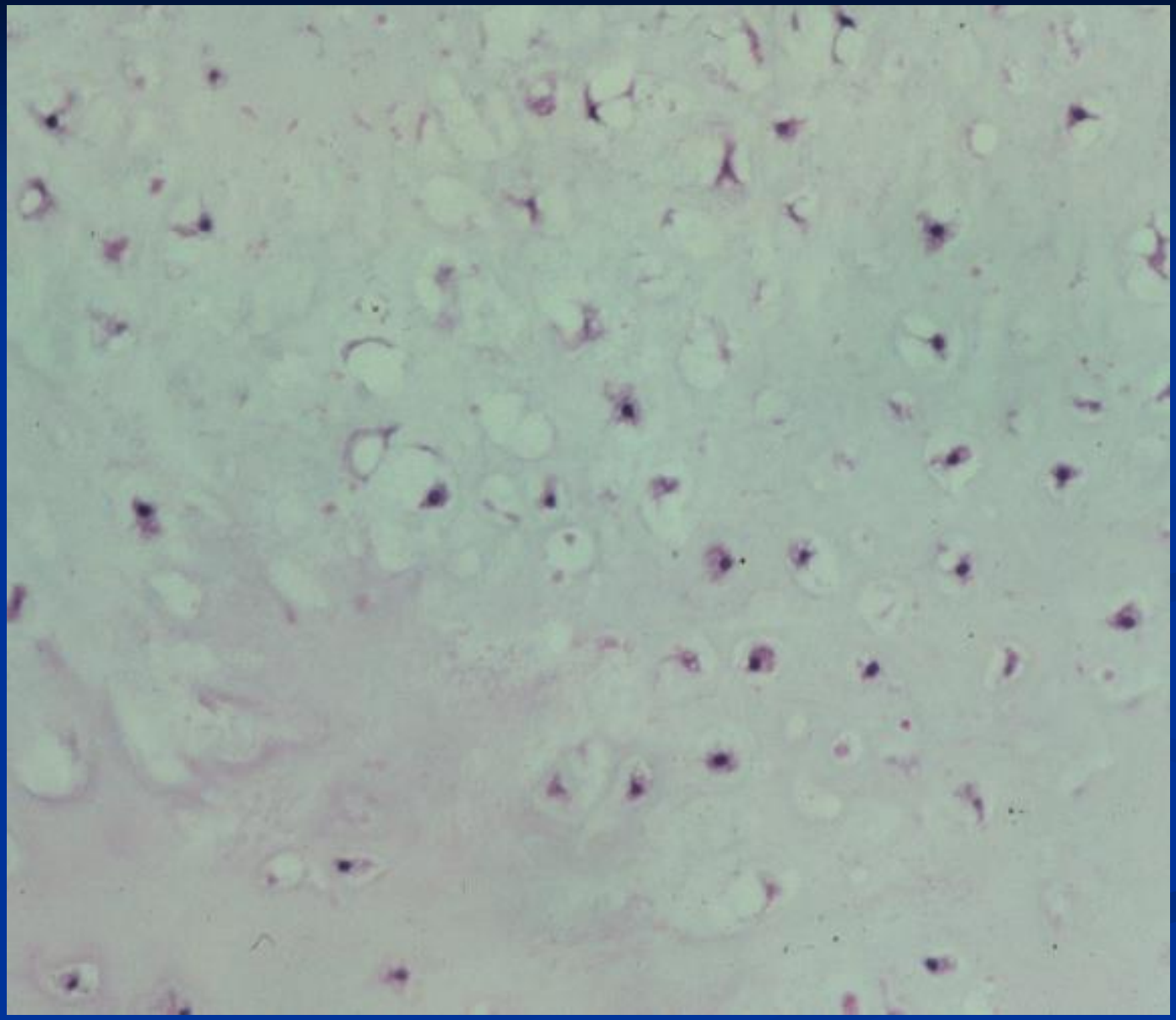
Microscopic Pathology: Grade I Chondrosarcoma



Microscopic Pathology: Grade I Chondrosarcoma



Microscopic Pathology: Grade I Chondrosarcoma

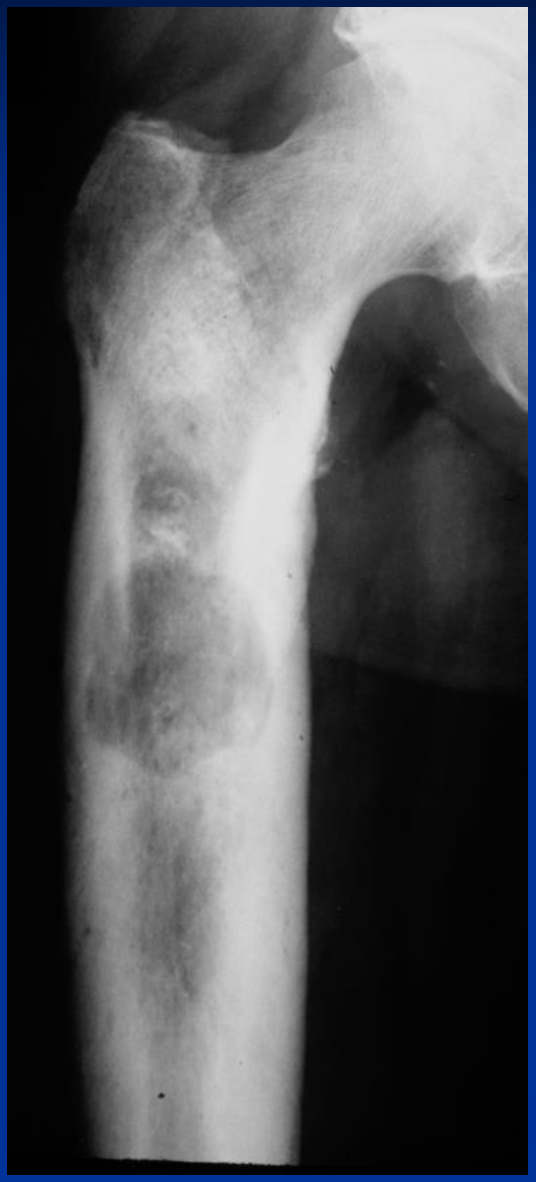


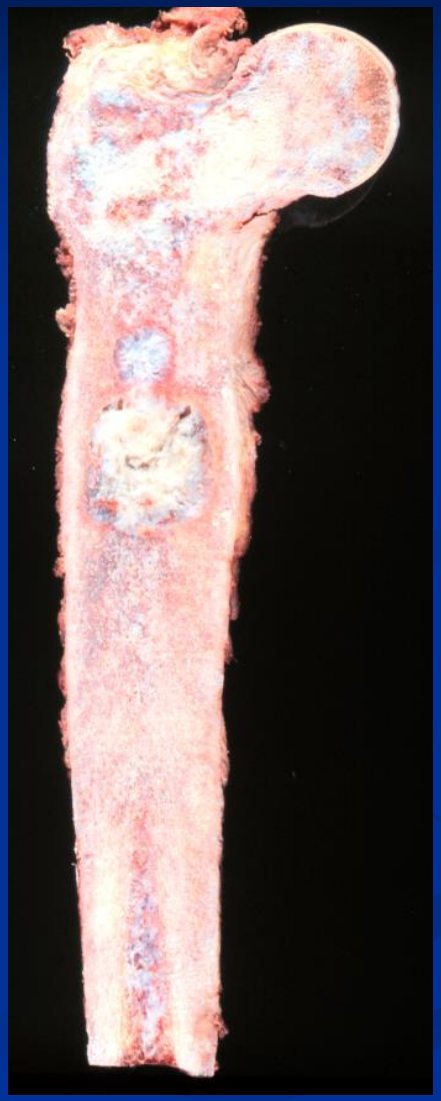
Conventional Chondrosarcoma

Grade II (Intermediate Grade Chondrosarcoma)

- Increased cellularity evenly distributed in a cartilaginous matrix
- Plump cartilage cells with enlarged nuclei and distinct nucleoli
- Greater nuclear pleomorphism
- Frequent binucleated, trinucleated cells
- Occasional mitotic figures

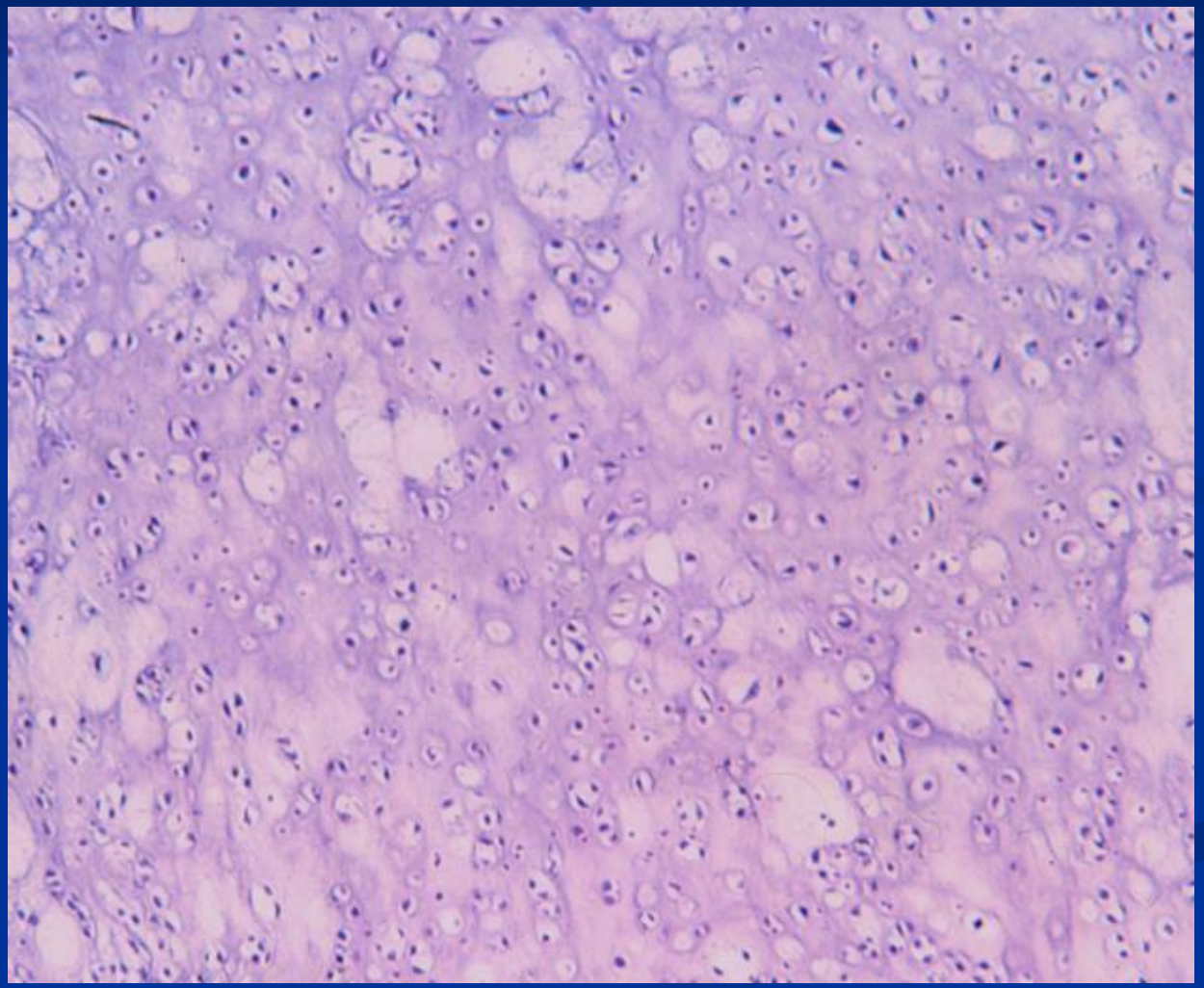
Grade II Chondrosarcoma



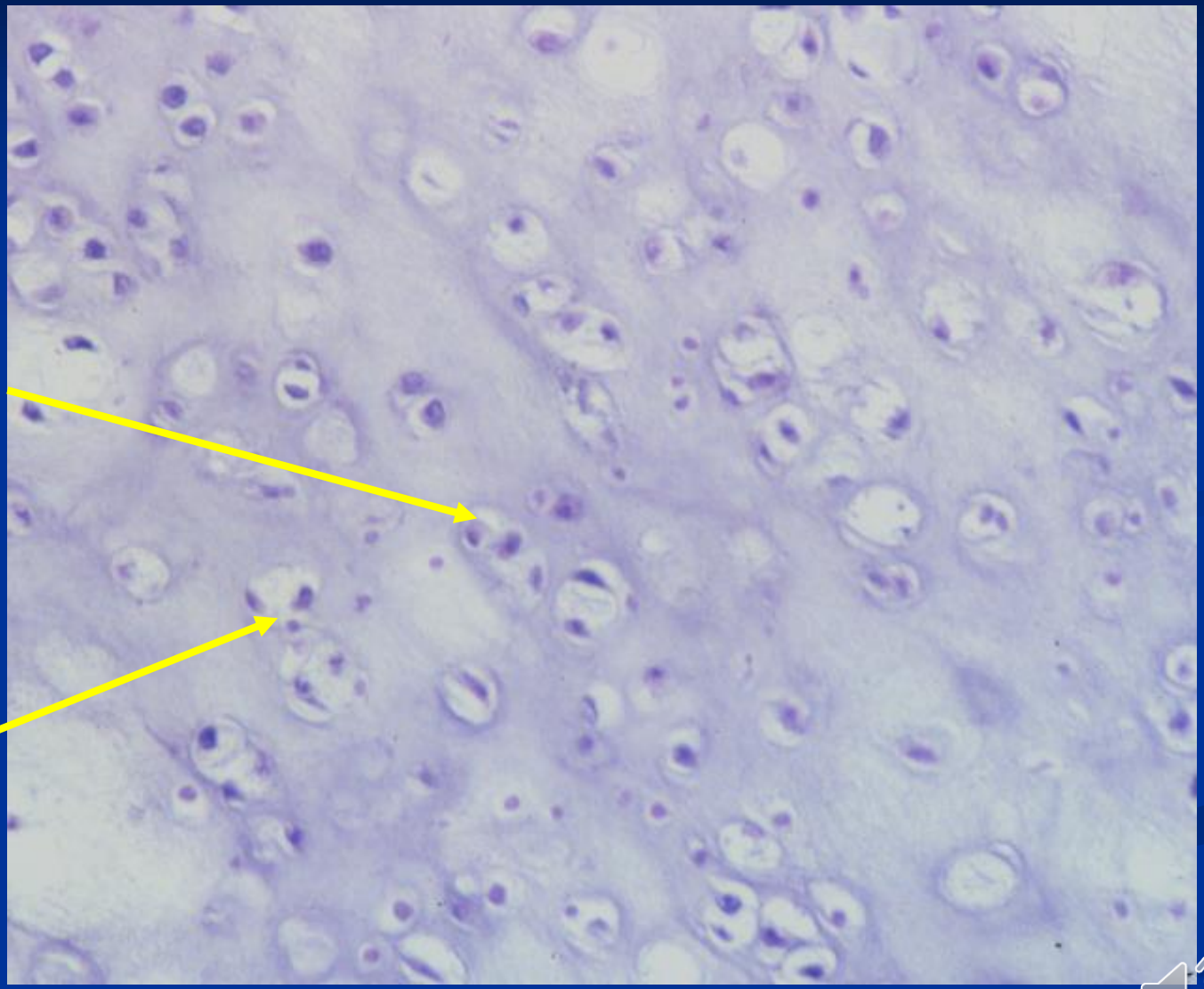


Microscopic Pathology: Grade II Chondrosarcoma

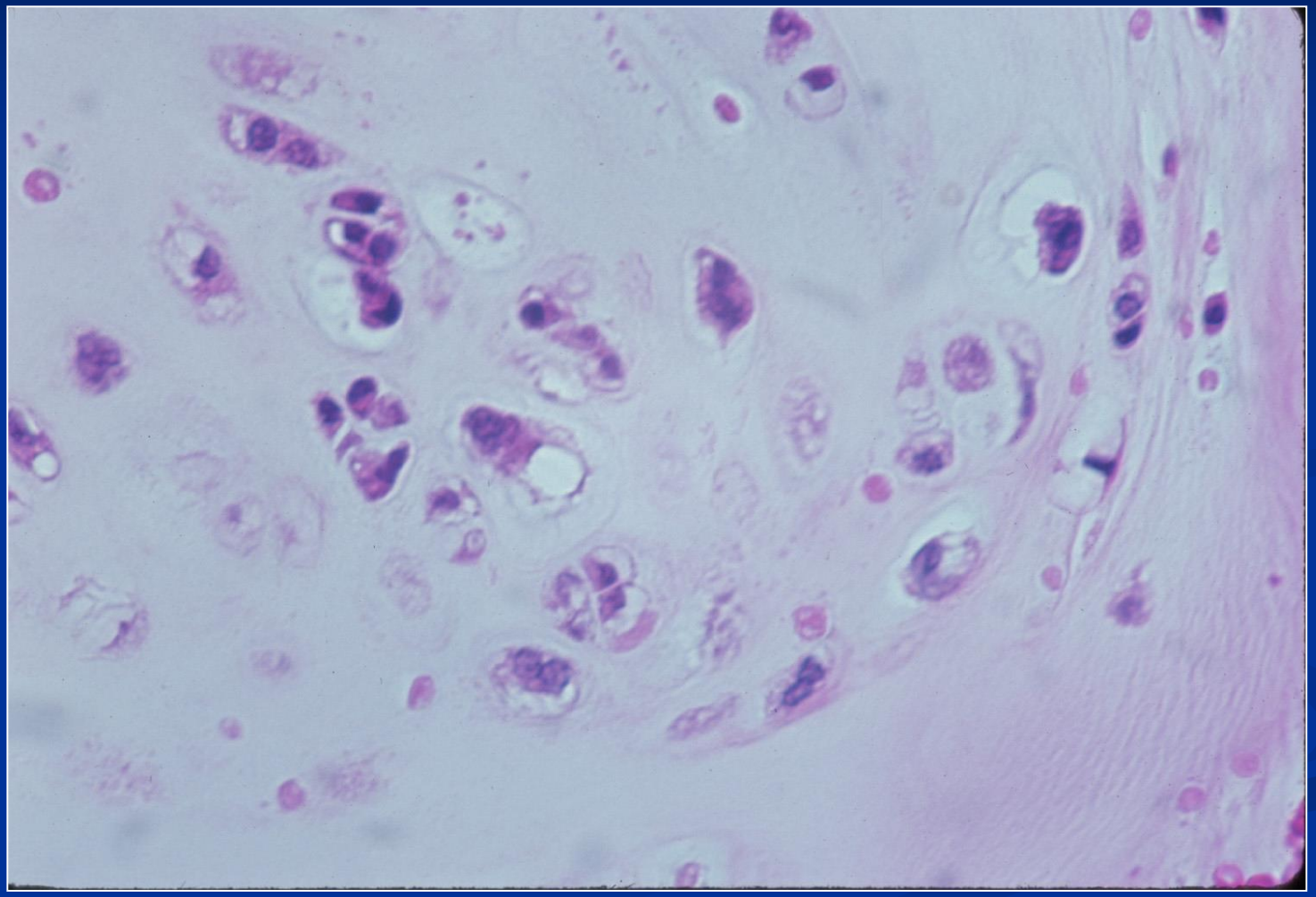
- Hypercellular
- Cells are crowded
- Binucleated cells common



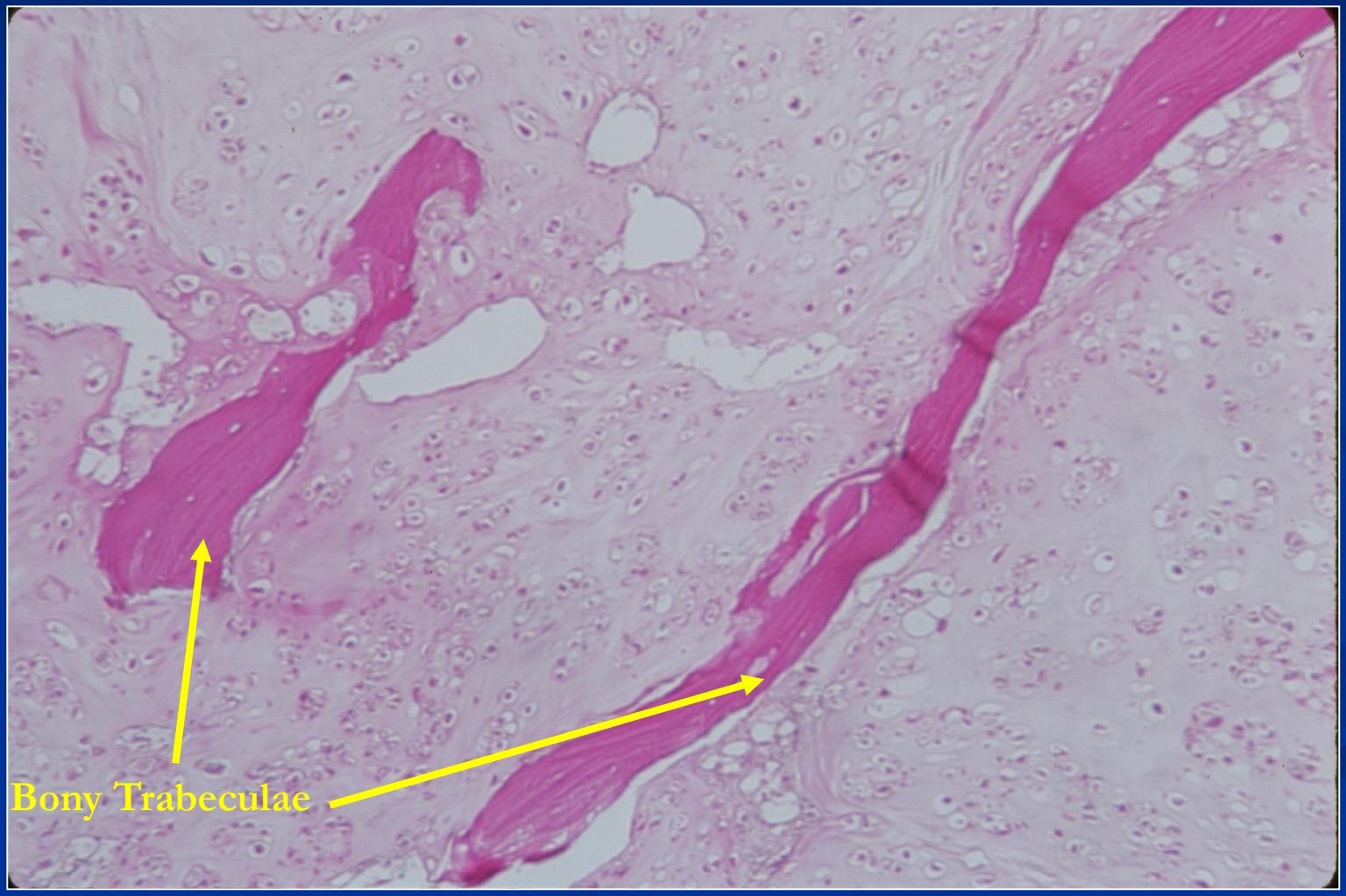
Microscopic Pathology: Grade II Chondrosarcoma



Microscopic Pathology: Grade II Chondrosarcoma



Microscopic Pathology: Grade II Chondrosarcoma and Bony Entrapment

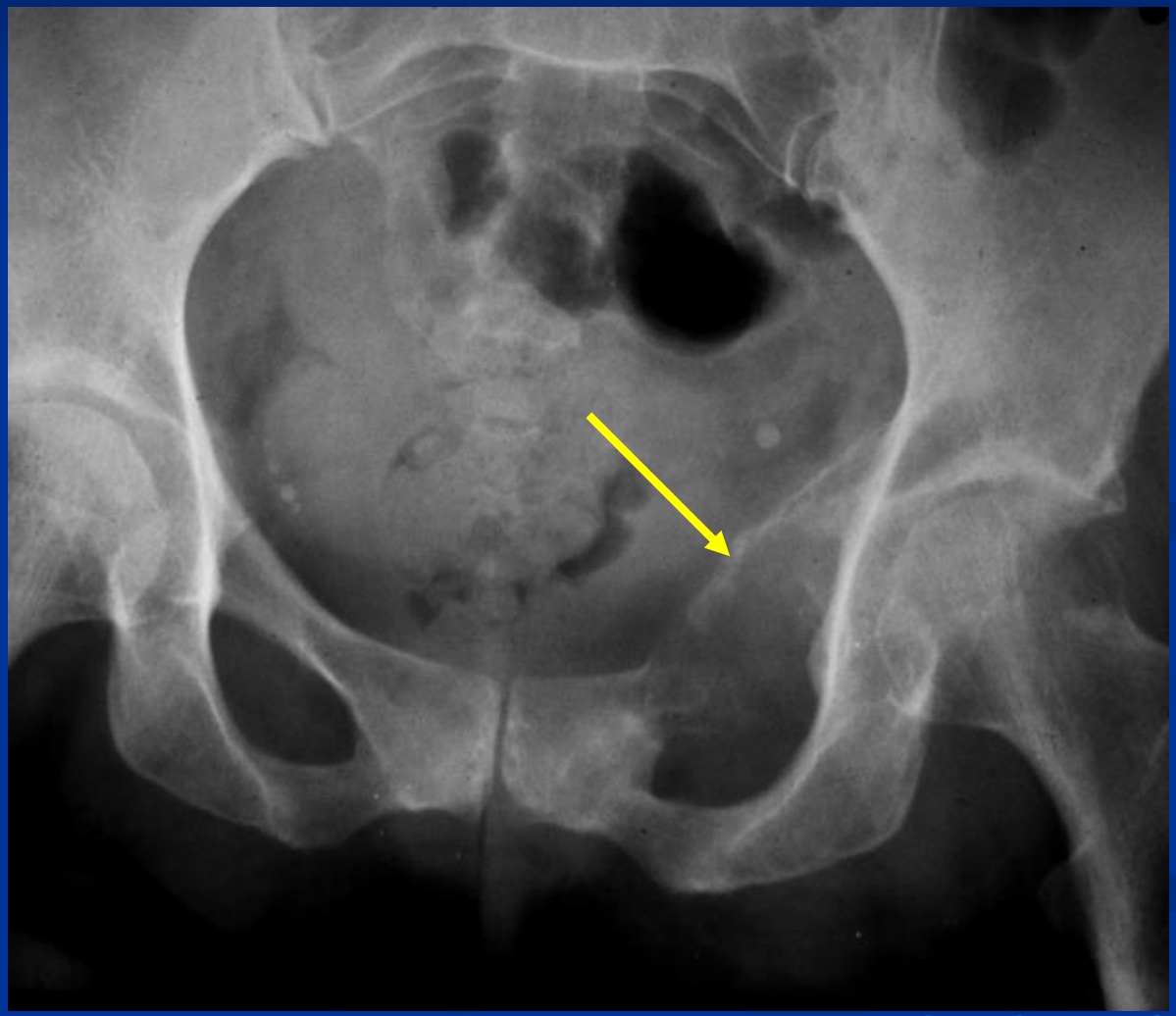


Conventional Chondrosarcoma

Grade III (High Grade Chondrosarcoma)

- Higher cellularity and greater degree of cellular pleomorphism
- Hyaline cartilage matrix is sparse
- Cells may have stellate/spindle appearance with myxoid chondroid matrix
- Presence of mitotic figures

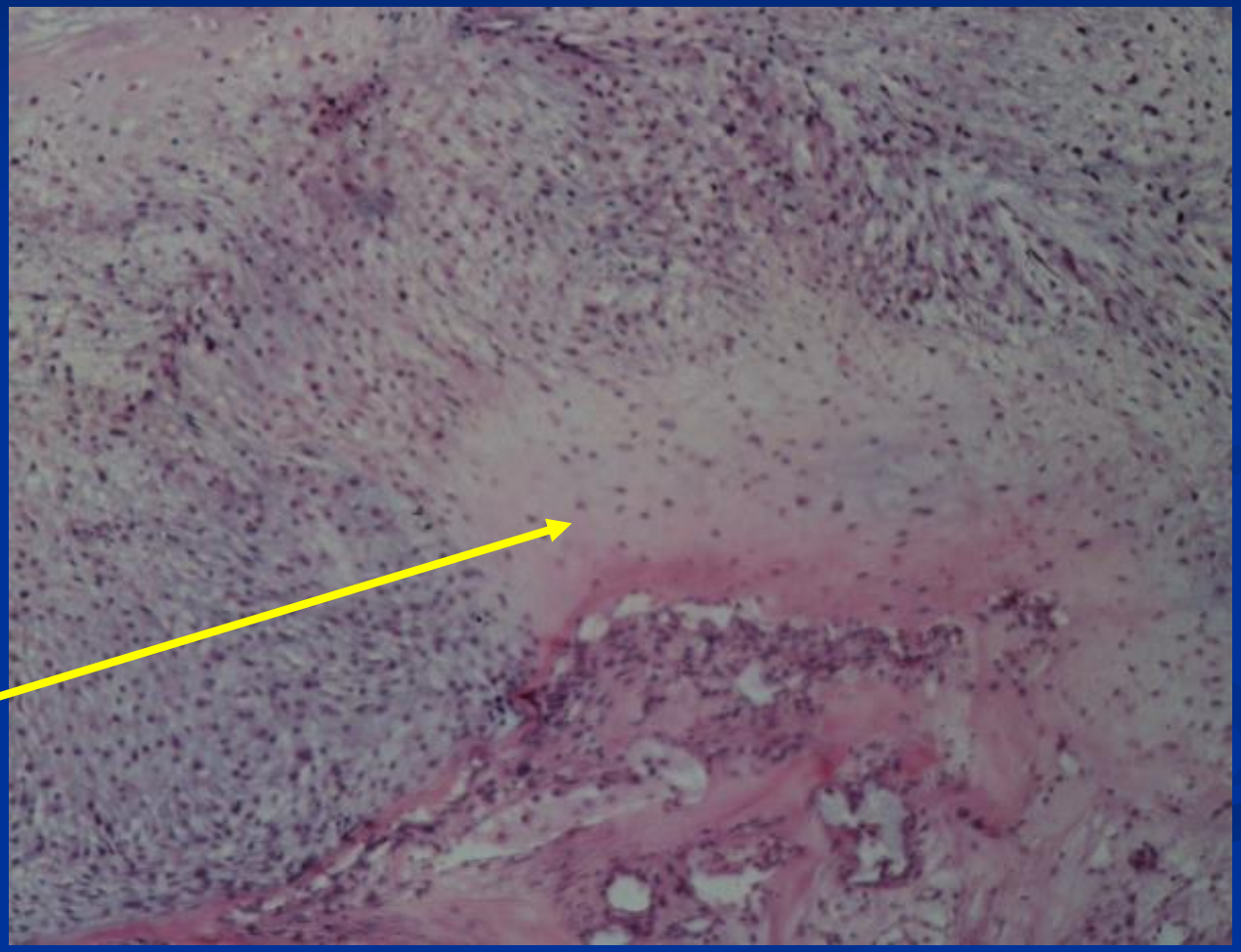
Grade III Chondrosarcoma of Pelvis



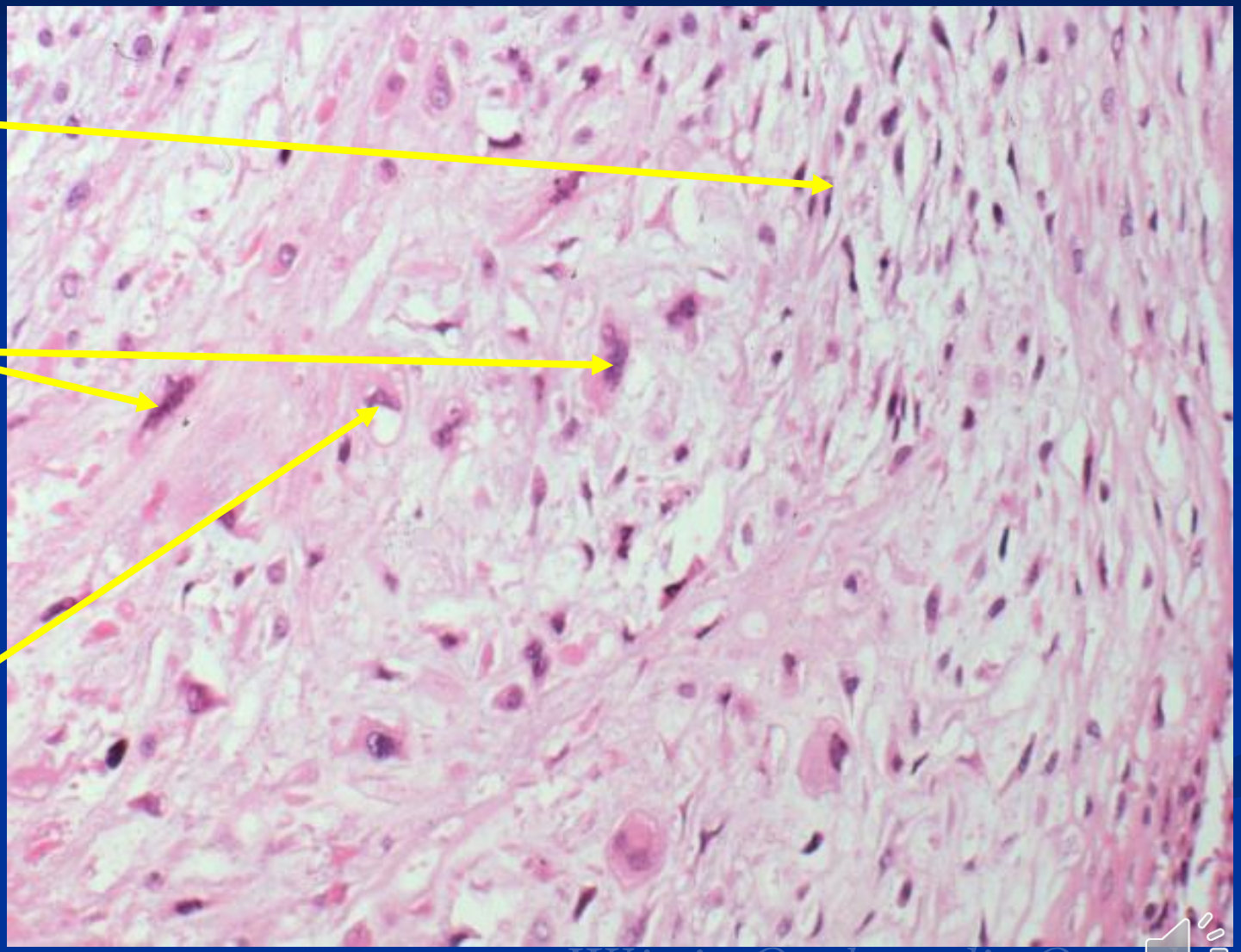
Microscopic Pathology: Grade III Chondrosarcoma

Hypercellular

Chondroid Area



Microscopic Pathology: Grade III Chondrosarcoma



Biological Behavior

- The biological behavior is related to grade
  - Grade I Chondrosarcoma rarely metastasize and grow slowly. They may dedifferentiate to high grade sarcomas such as osteosarcoma, MFH and fibrosarcoma
  - Grade II Chondrosarcomas grow locally in an aggressive manner. They metastasize in up to 33% of cases. Most commonly metastasize to the lungs and
  - Grade III Chondrosarcomas grow locally in an aggressive manner and metastasize in up to 70% of cases. Most commonly metastasize to the lungs.

Treatment

- Surgery is the main treatment.
  - Most patients can be treated with a limb sparing wide en bloc/radical resection although amputation may be needed for large tumors.
  - No Chemotherapy and No Radiation (except in rare circumstances of spine or large pelvic tumors)

Dedifferentiated Chondrosarcoma

General Information

- Dedifferetiated chondrosarcoma consists of a low grade malignant hyaline cartilage tumor associated with a high-grade nonchondroid spindle sarcoma. The two components are juxtaposed with abrupt clear demarcation line
  - Sarcoma is most commonly an MFH, osteosarcoma or fibrosarcoma
  - Extremely aggressive tumor with a high metastatic rate and dismal prognosis
  - 50% arise from a secondary chondrosarcoma

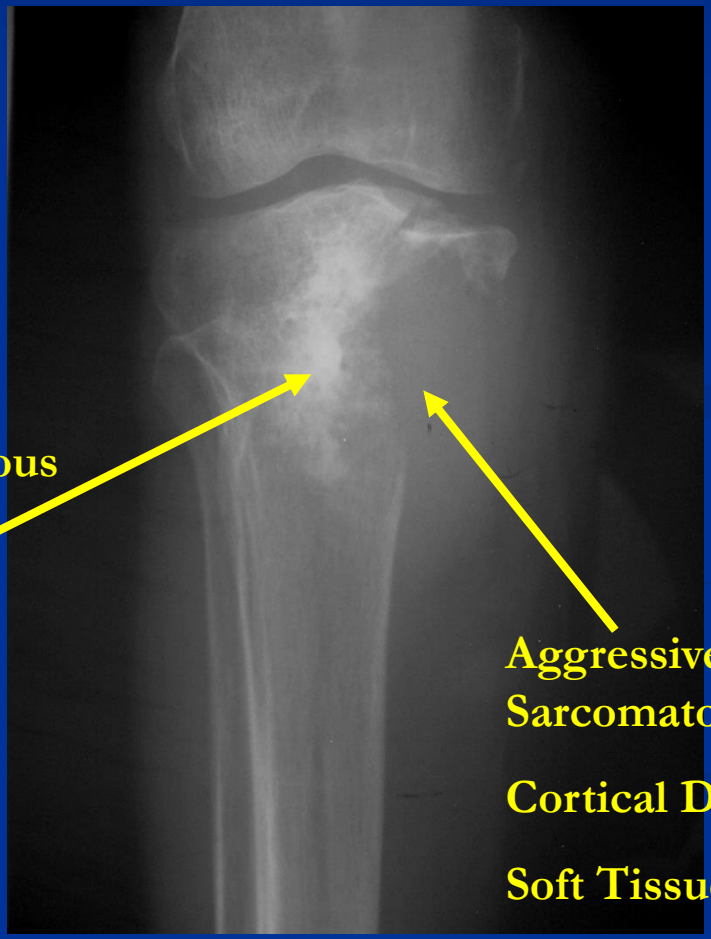
Clinical Presentation

- **Age:**
  - Most patients are older than 50
- **Sites:**
  - Pelvis, proximal femur, proximal humerus, distal femur, ribs

Radiographic Presentation

- Radiology emulates pathology: Biphasic Tumor
  - One region low grade chondrosarcoma
  - Second more aggressive area with bone destruction, lysis of calcification, soft tissue mass
  - Cortical permeation and a soft tissue mass in 70% of cases
- Characteristically abrupt transition between chondroid tumor and dedifferentiated, lytic component

Plain X-Ray: Dedifferentiated Chondrosarcoma of Proximal Tibia



Low Grade Cartilaginous Area

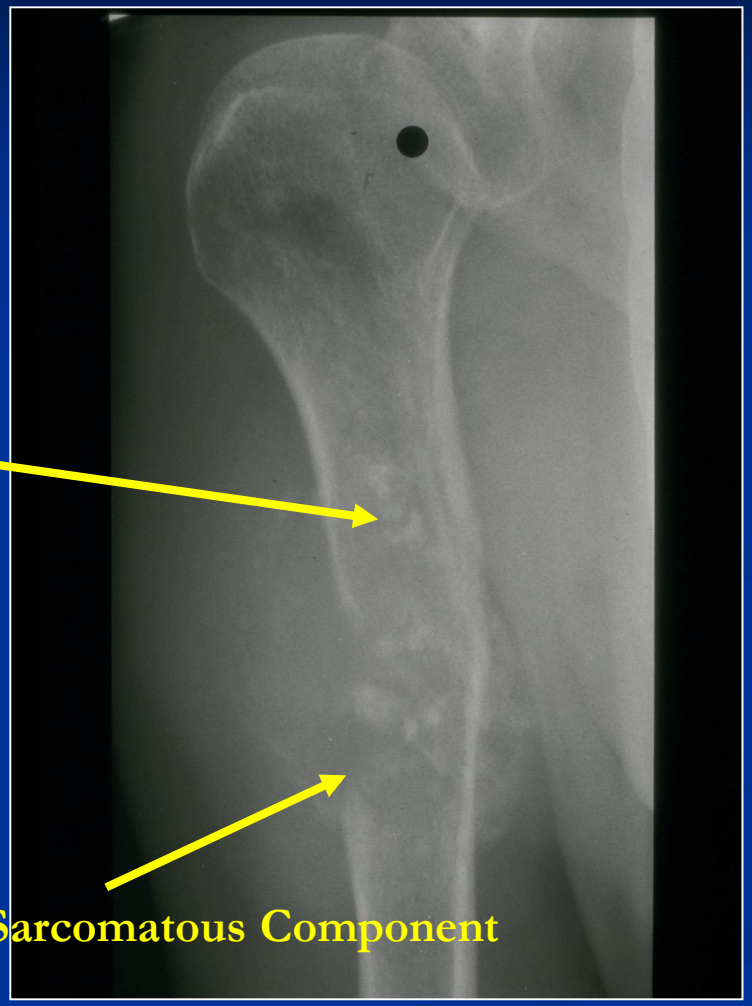
Heavily Calcified

Aggressive Lytic Area (Dedifferentiated Sarcomatous Component)

Cortical Destruction

Soft Tissue Mass without Calcification

Plain X-ray: Dedifferentiated Chondrosarcoma of Humerus



Low Grade Cartilage Component

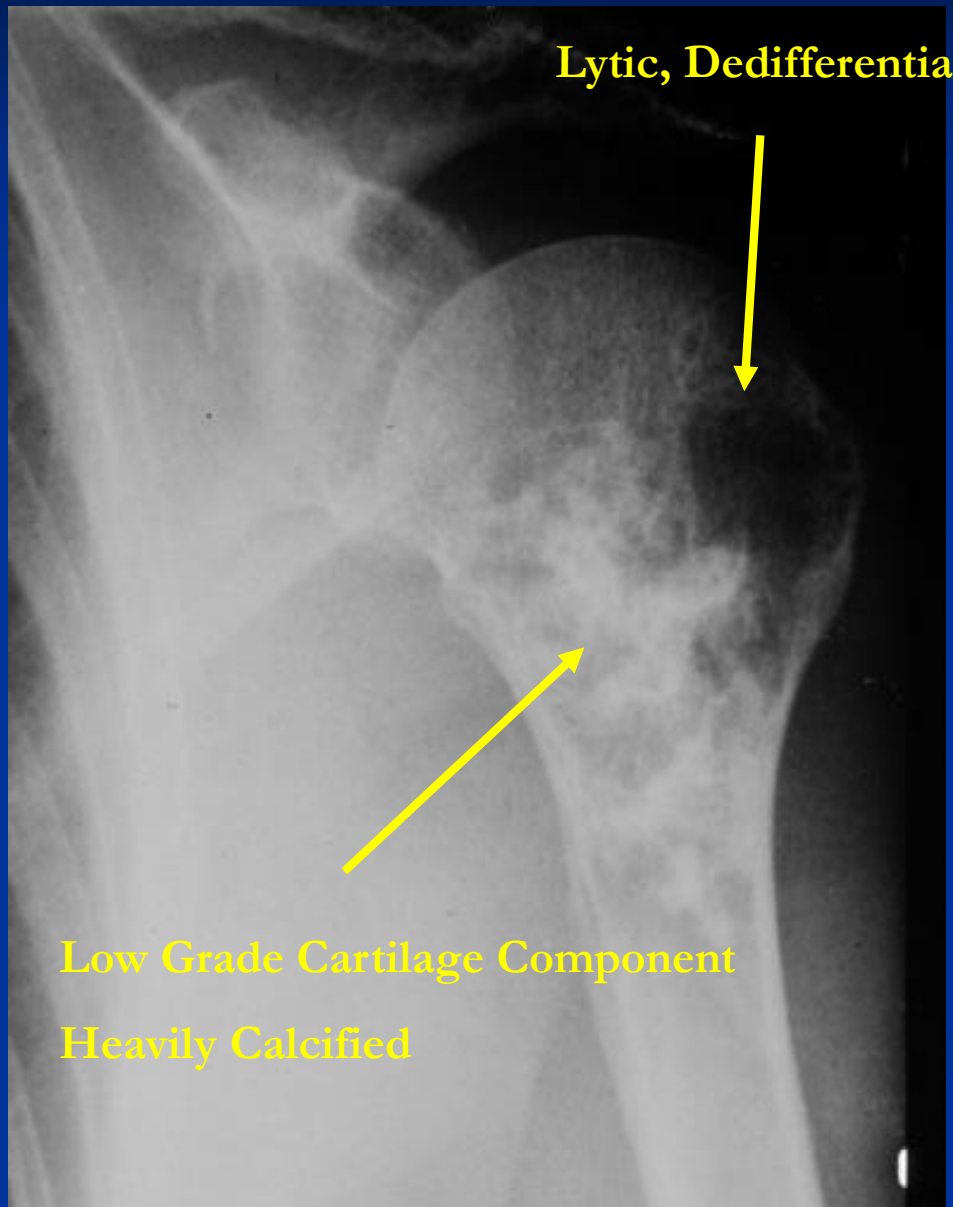
Stippled Calcifications

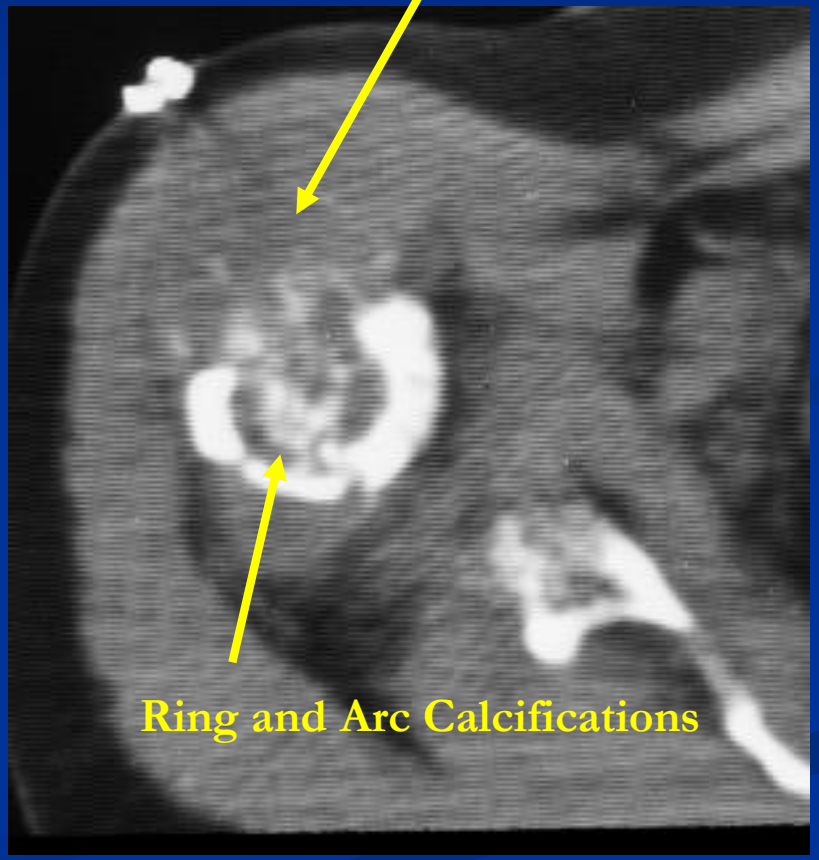
Aggressive Dedifferentiated Sarcomatous Component

Lysis, Cortical Destruction

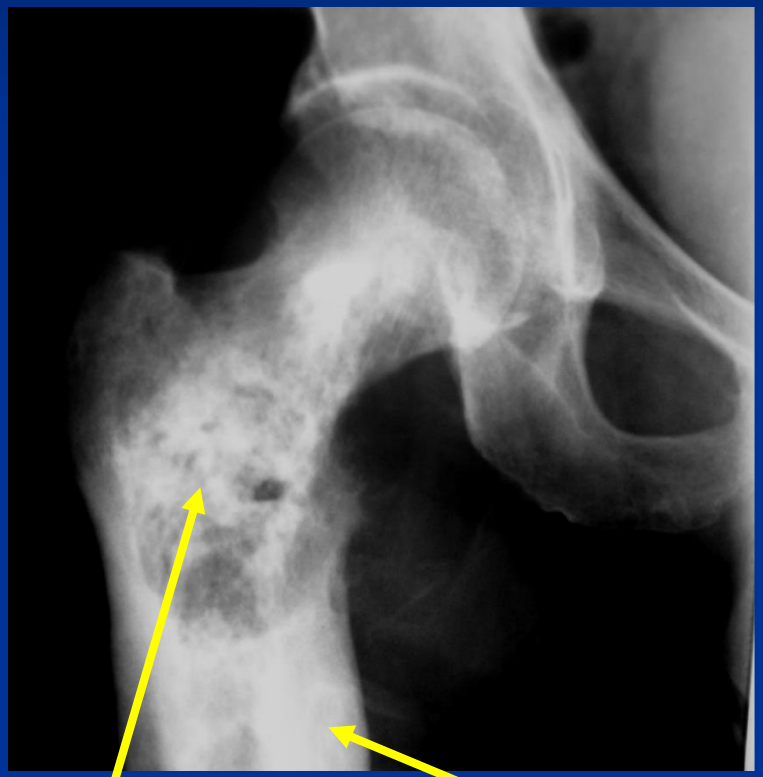
Soft Tissue Mass without Calcification

Plain X-ray/CT: Dedifferentiated Chondrosarcoma of Proximal Humerus





Plain X-ray: Dedifferentiated Chondrosarcoma of Proximal Femur



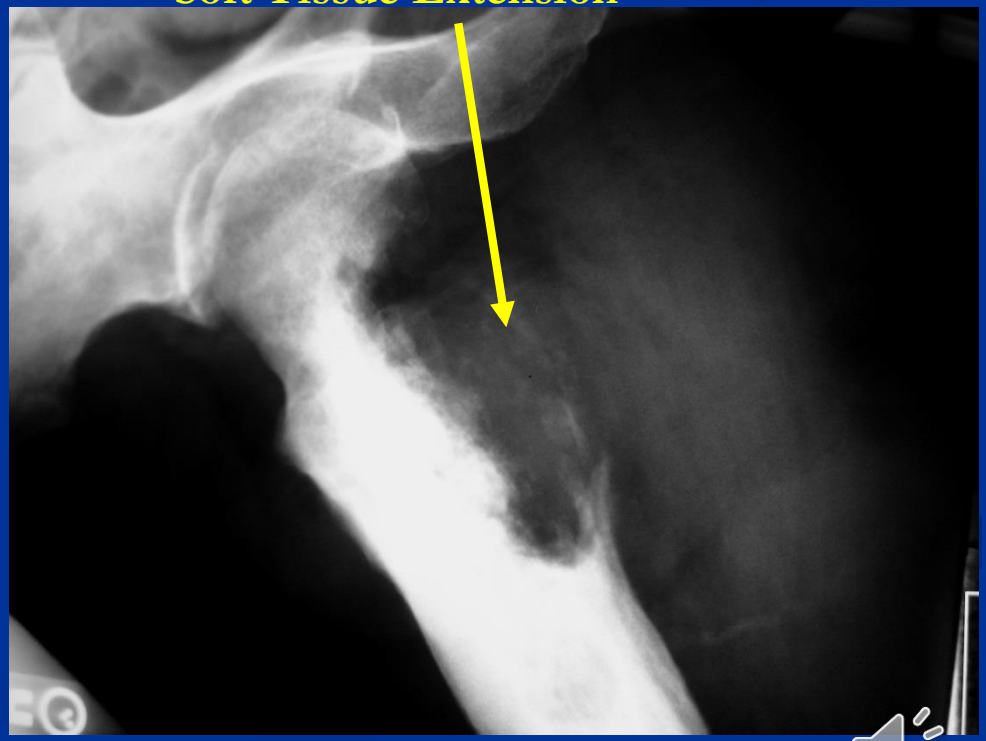
Heavily Mineralized Low Grade Cartilage Component

Cortical Thickening

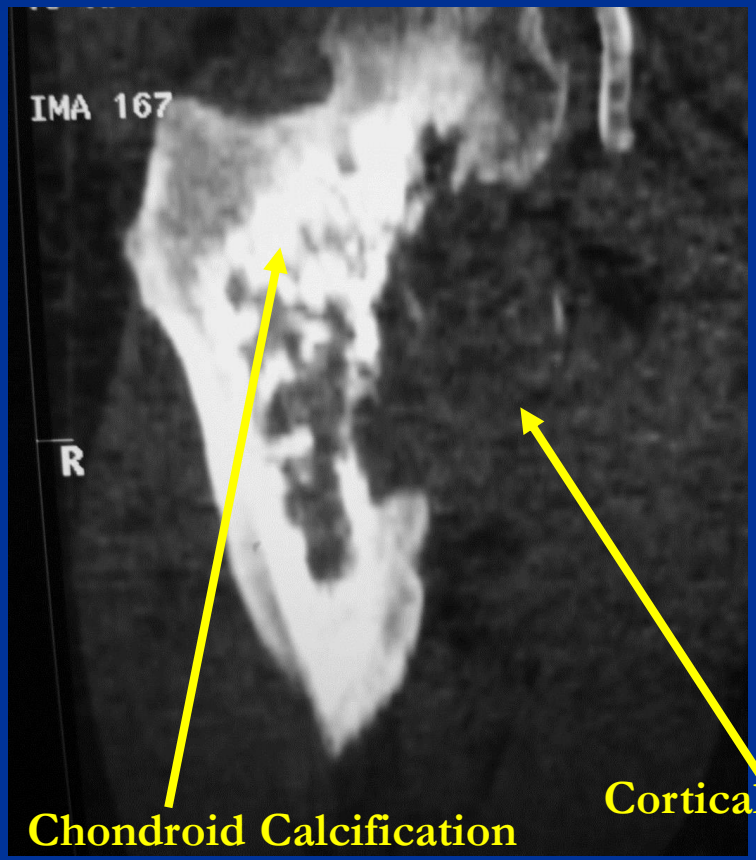
High Grade, Lytic Dedifferentiated Sarcoma Component

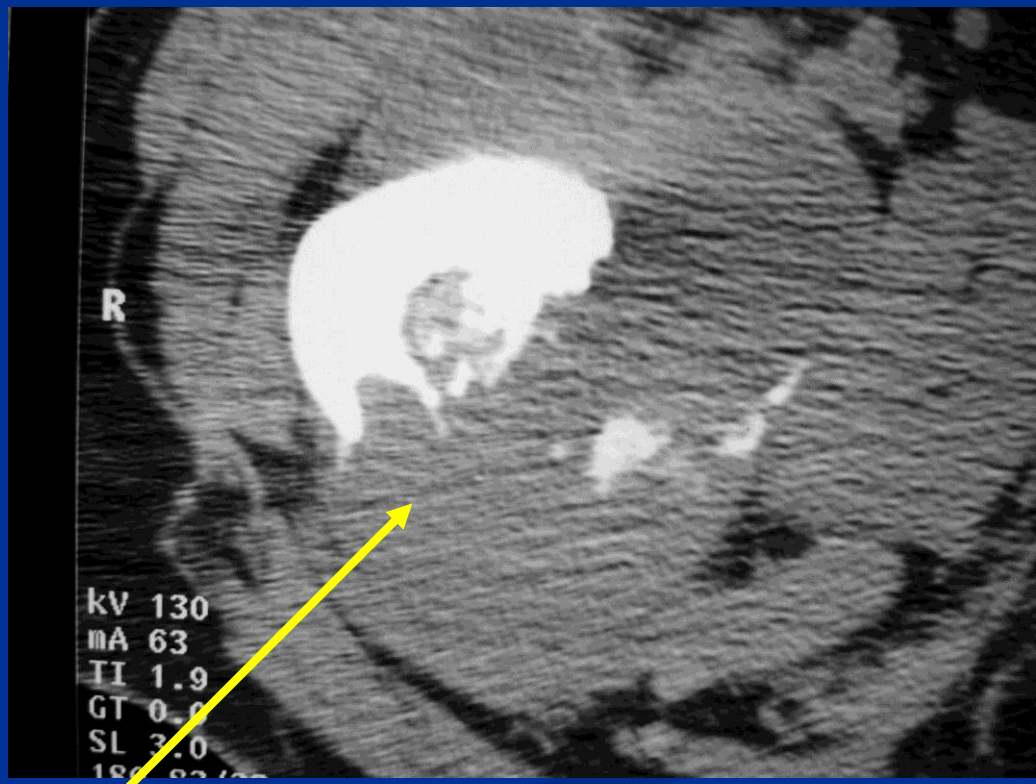
Cortical Destruction

Soft Tissue Extension



CT Scan: Dedifferentiated Chondrosarcoma of Proximal Femur



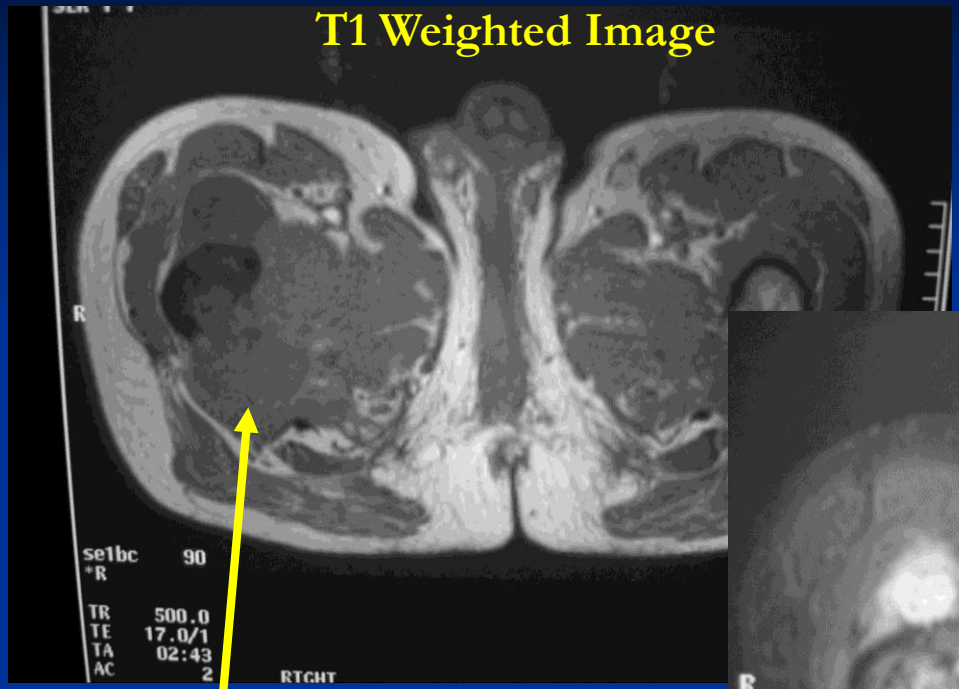


Chondroid Calcification

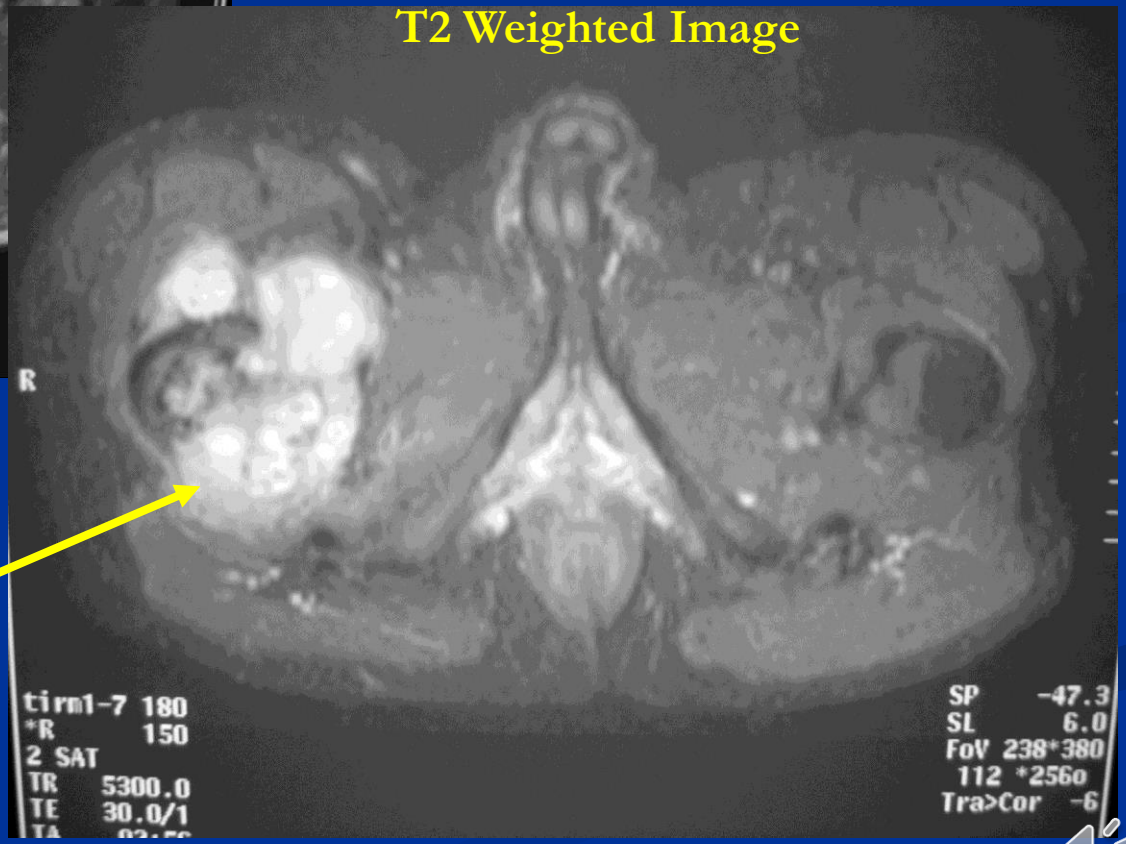
Cortical Destruction and Soft Tissue Extension

MRI: Dedifferentiated Chondrosarcoma of Proximal Femur

T1 Weighted Image



T2 Weighted Image



Cortical Destruction and Soft Tissue Extension

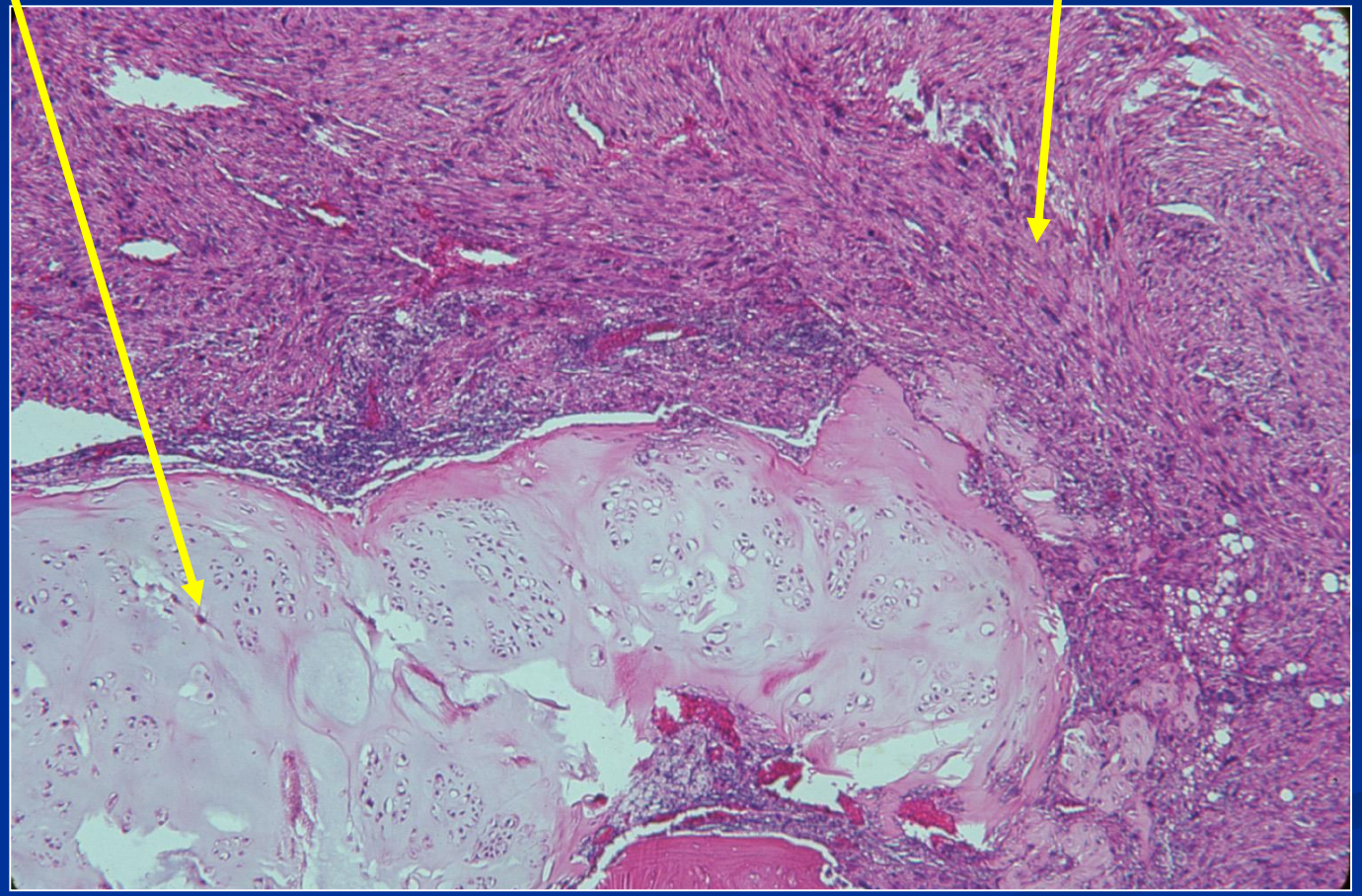
Microscopic Pathology

- Chondrosarcoma component is often grade I (Low Grade Hyaline Type Cartilage)
- Dedifferentiated component: high grade spindle cell sarcoma
- Sharp and distinct junction. There are no dedifferentiated areas admixed in the middle of the cartilaginous areas

Microscopic Pathology: Dedifferentiated Chondrosarcoma

Low Grade Cartilage Component

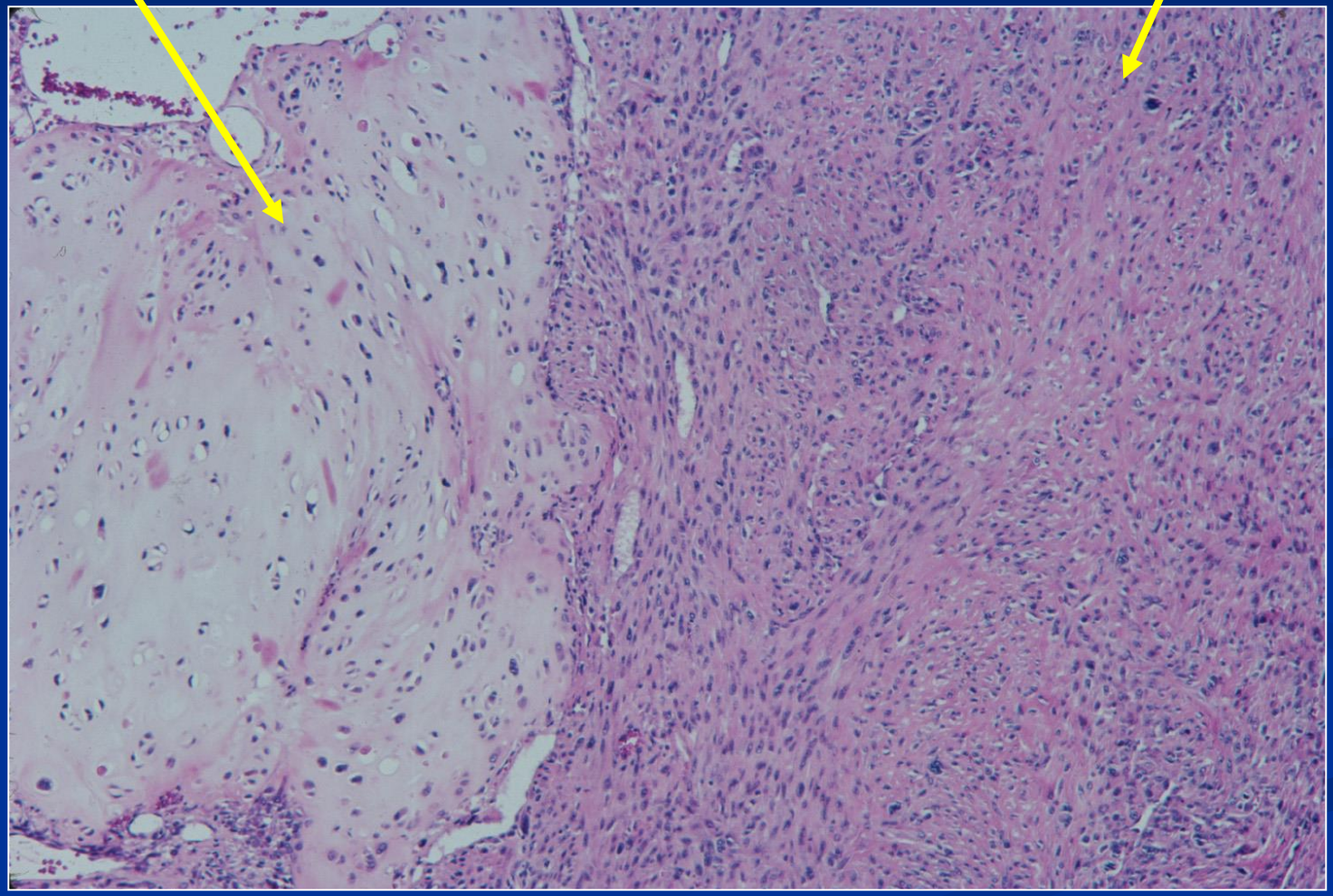
High Grade Malignant
Spindle Cell Component



Microscopic Pathology: Dedifferentiated Chondrosarcoma

Low Grade Cartilage Component

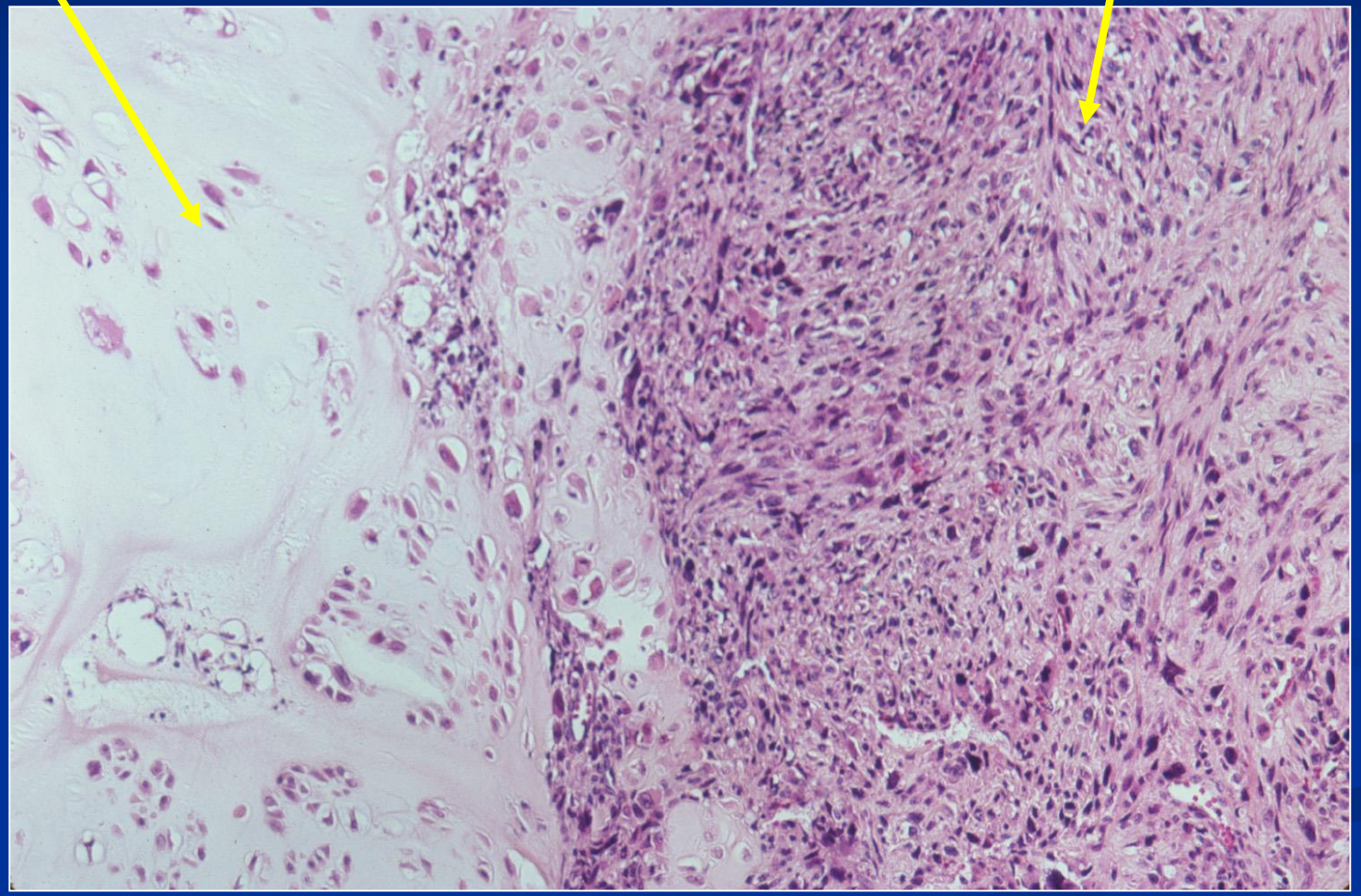
Dedifferentiated Component



Microscopic Pathology: Dedifferentiated Chondrosarcoma

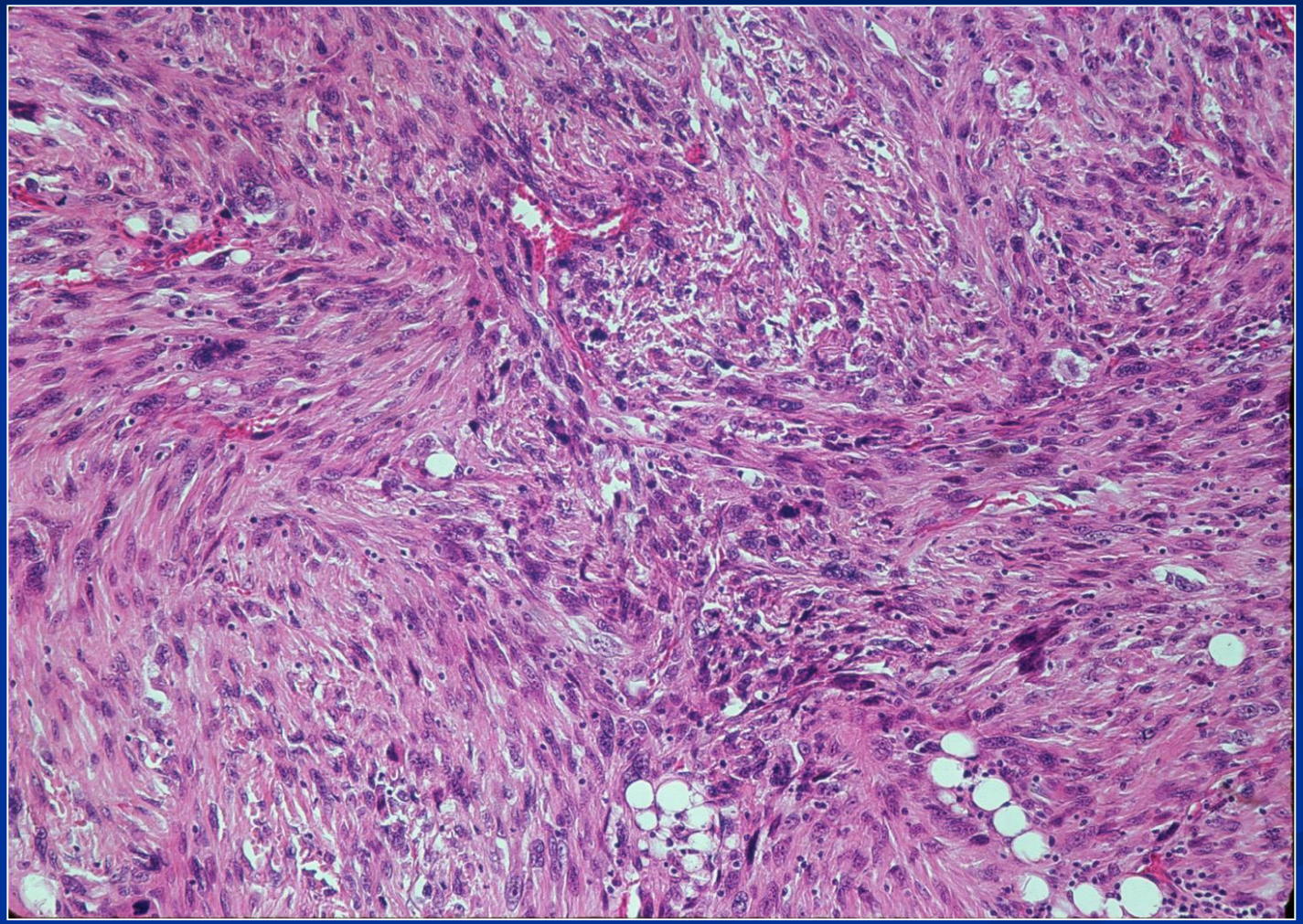
Low Grade Cartilage Component

Dedifferentiated Component



Dedifferentiated Chondrosarcoma: High Power View of Dedifferentiated High Grade Pleomorphic Spindle Cell Component

Malignant Fibrous Histiocytoma with Storiform Pattern



Treatment & Prognosis

- Wide/Radical limb sparing resection whenever feasible
- Amputation may be necessary for large tumors
- Chemotherapy may be considered for high grade dedifferentiated component but is controversial and no clear cut benefit has ever been demonstrated
- 90% of patients are dead of metastatic disease within 2 years

Clear Cell Chondrosarcoma

General Information

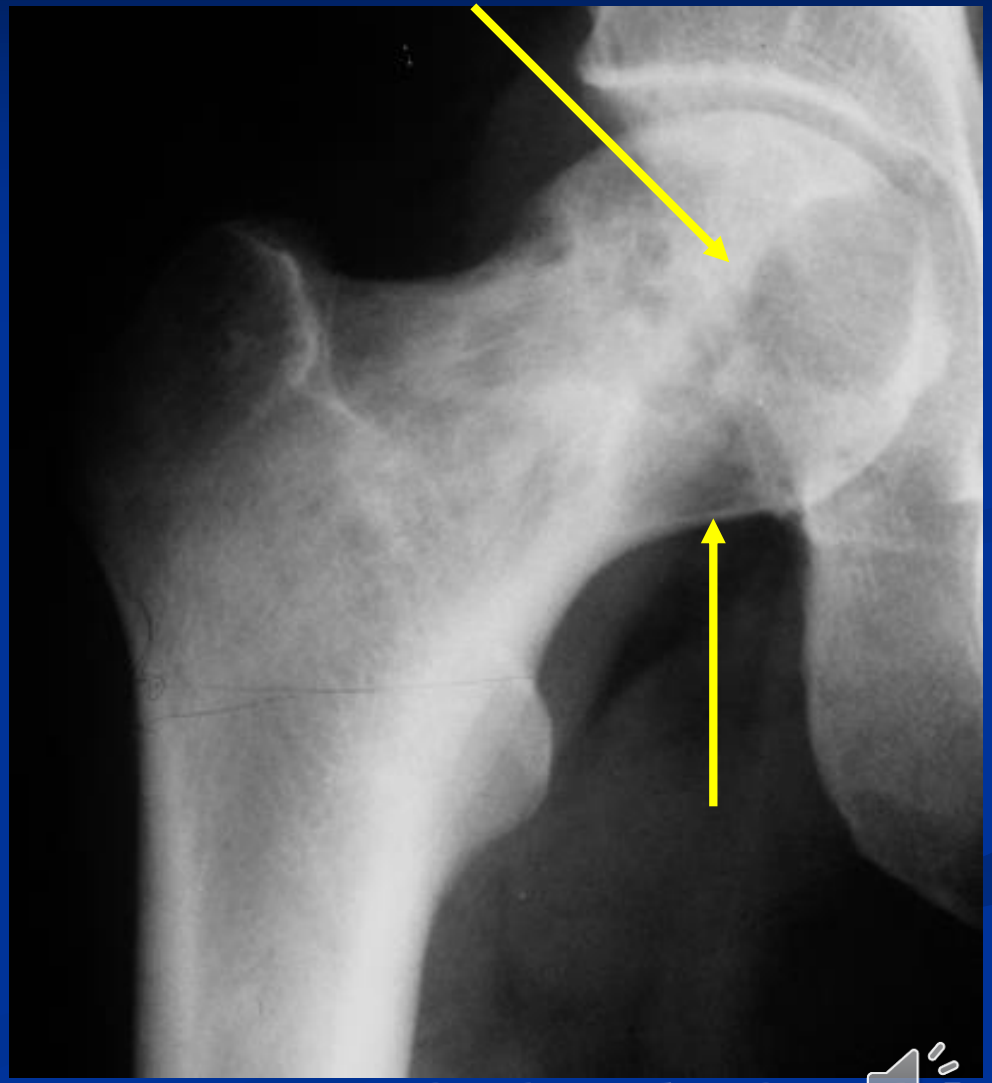
- Malignant low to intermediate grade tumor
- Comprised of neoplastic chondrocytes
  - Abundant, clear cytoplasm
  - Little intervening matrix
- Foci of conventional chondrosarcoma may be present
- Approximately 15% rate of metastases primarily to the lungs

Clinical Presentation

- **Age:**
  - 20 years to 40 years of age
- **Sites:**
  - Epiphyses of long bones (rarely metaphysis or diaphysis)
  - Proximal femur, proximal humerus, distal femur, proximal tibia

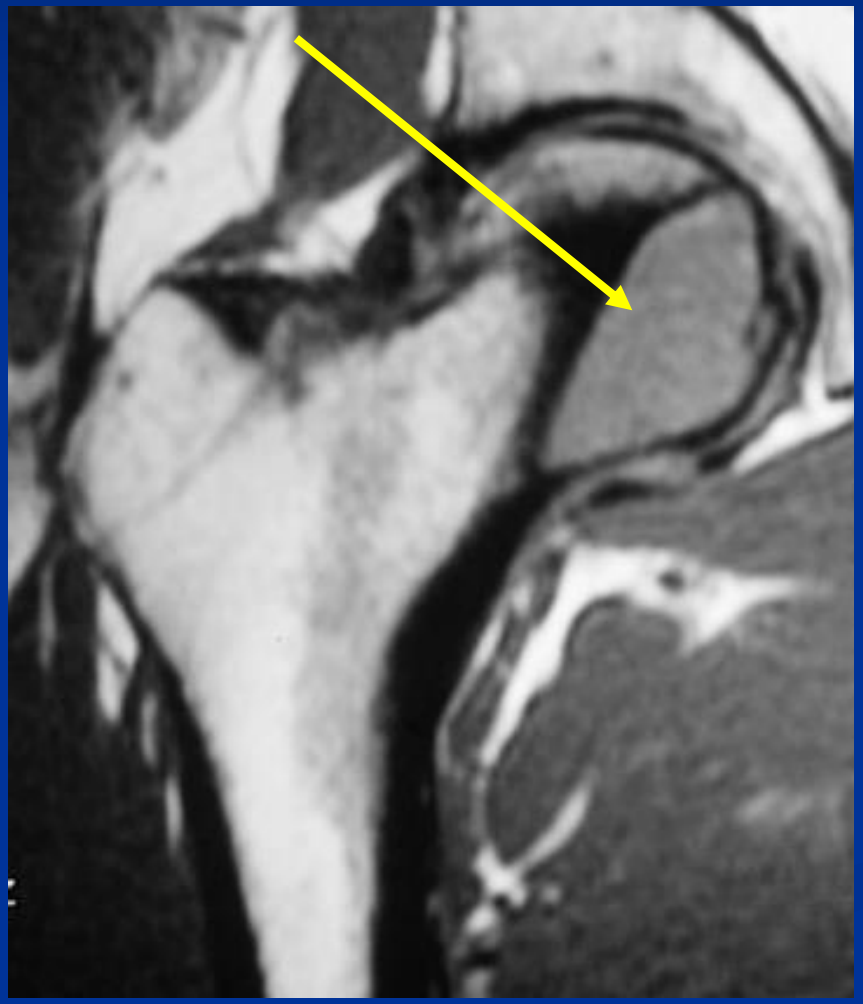
Radiographic Presentation

- Osteolytic, expansile epiphyseal lesion
- May have focal calcifications
- Often a sharp interface between tumor and surrounding bone
  - Sclerotic rim is uncommon
- Overlying cortex is usually thin, but intact
- Rarely an associated soft tissue component

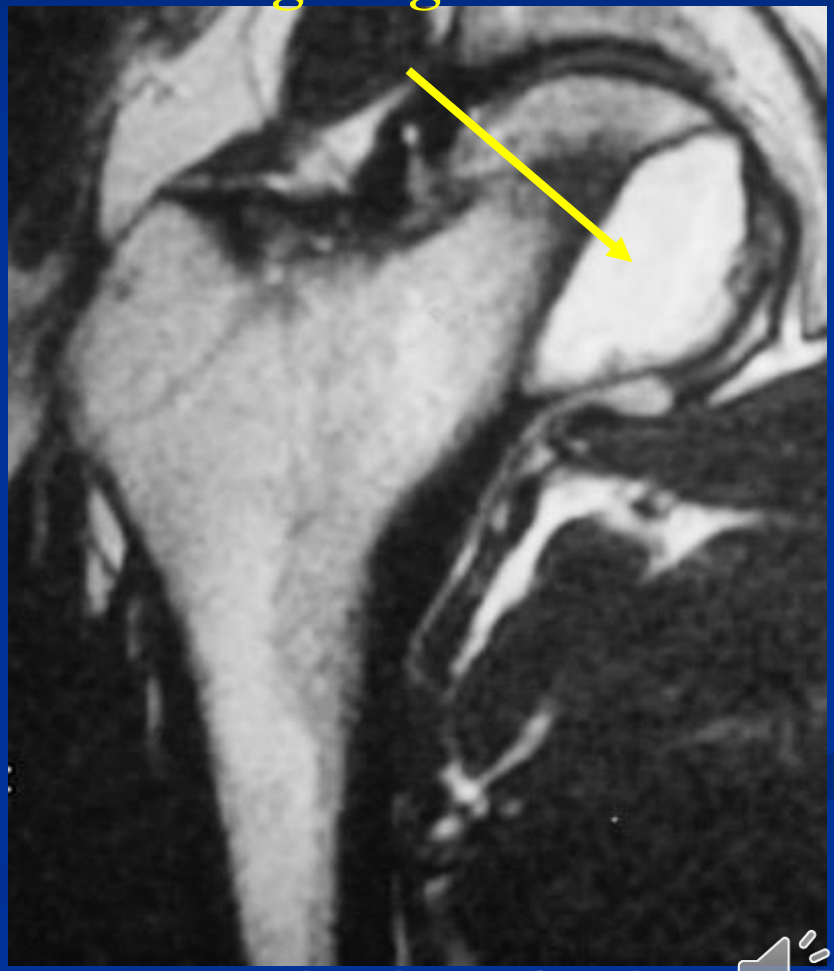


MRI: Clear Cell Chondrosarcoma of Proximal Femur

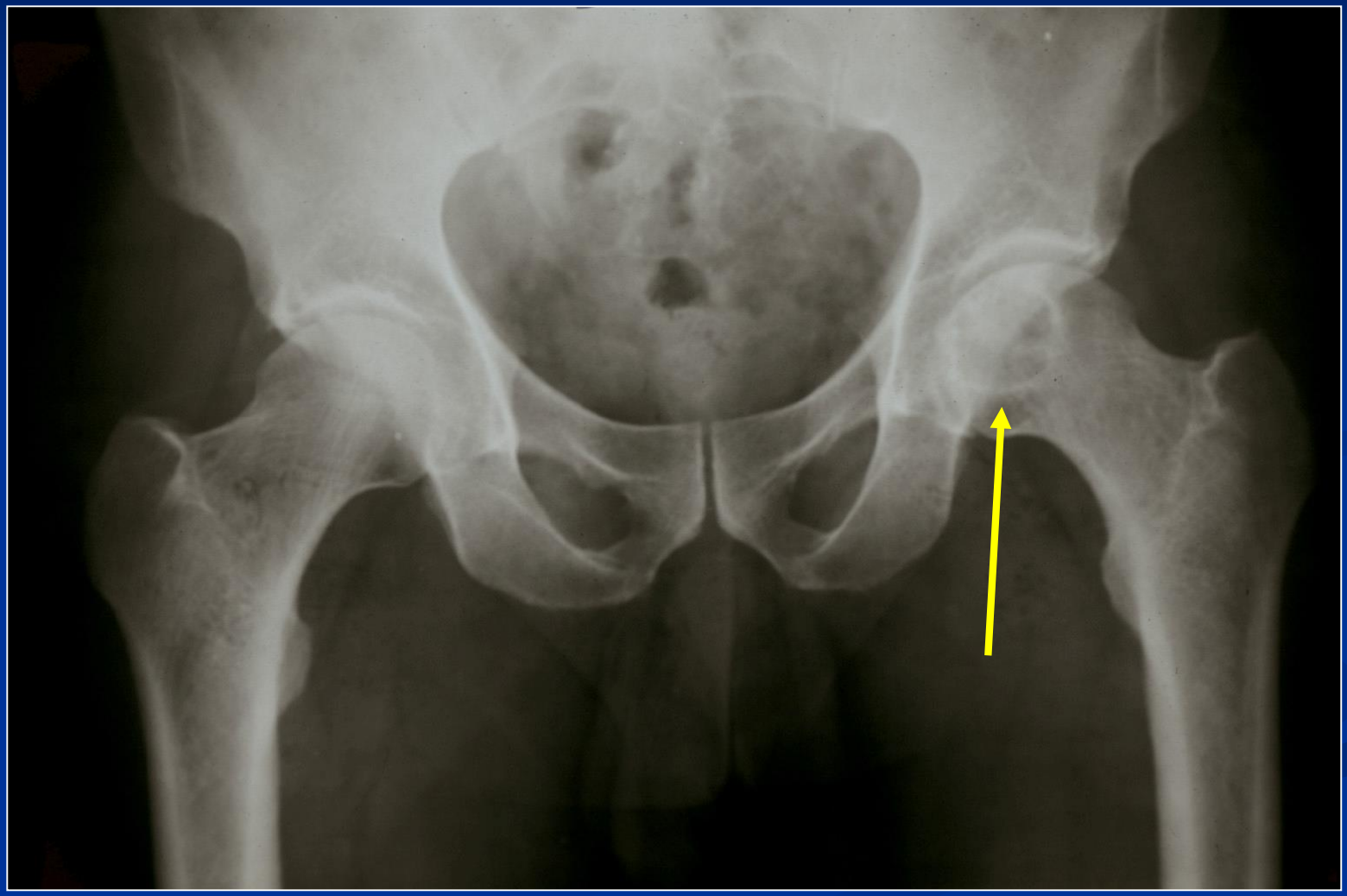
T1: Intermediate Signal



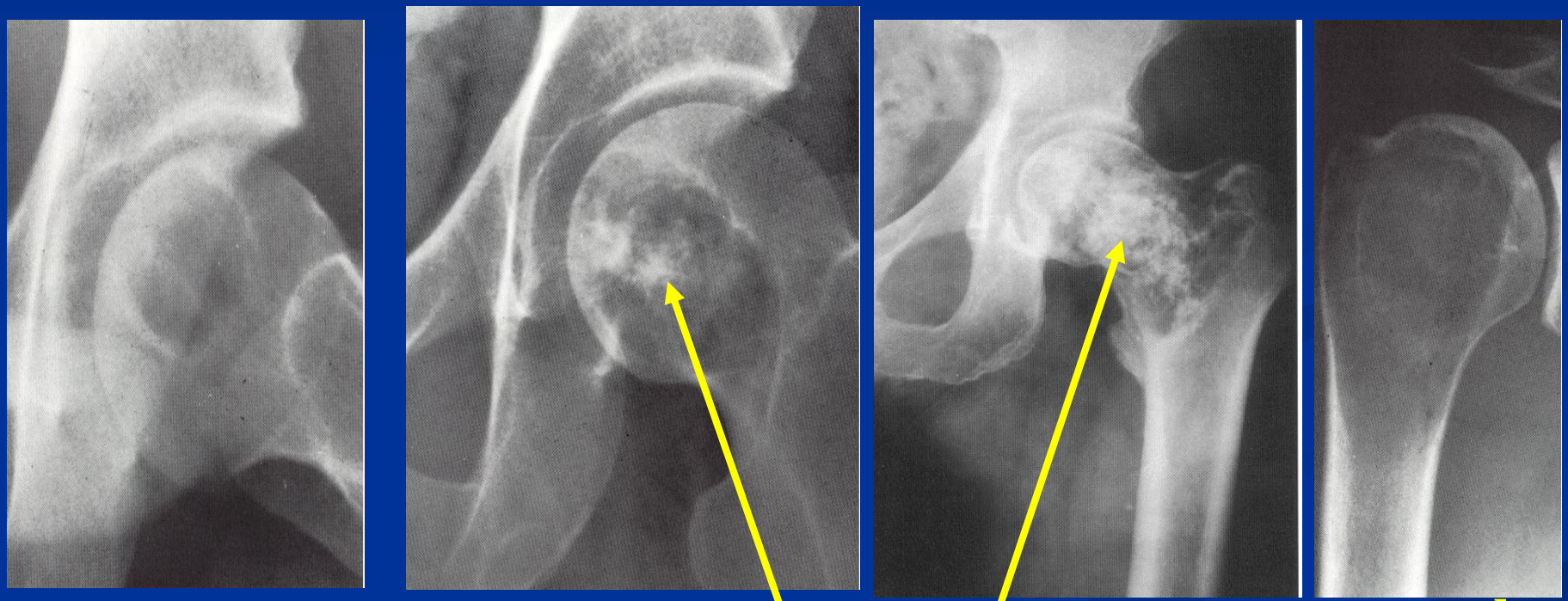
T2: High Signal



Plain X-ray: Clear Cell Chondrosarcoma of Proximal Femur



Clear Cell Chondrosarcoma Radiography



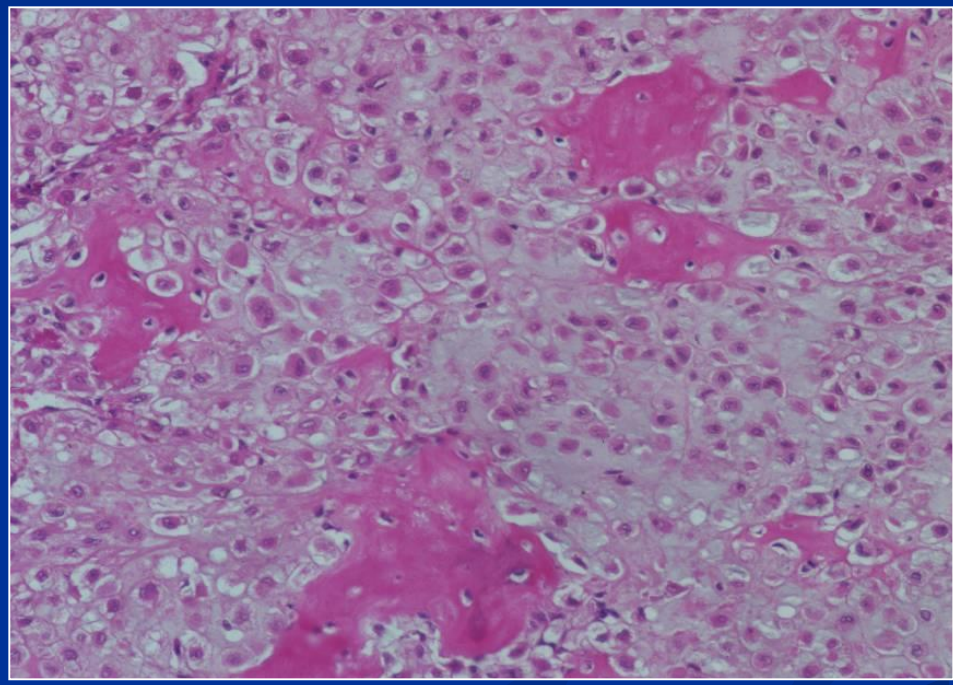
Fine marginal sclerosis

Calcified matrix

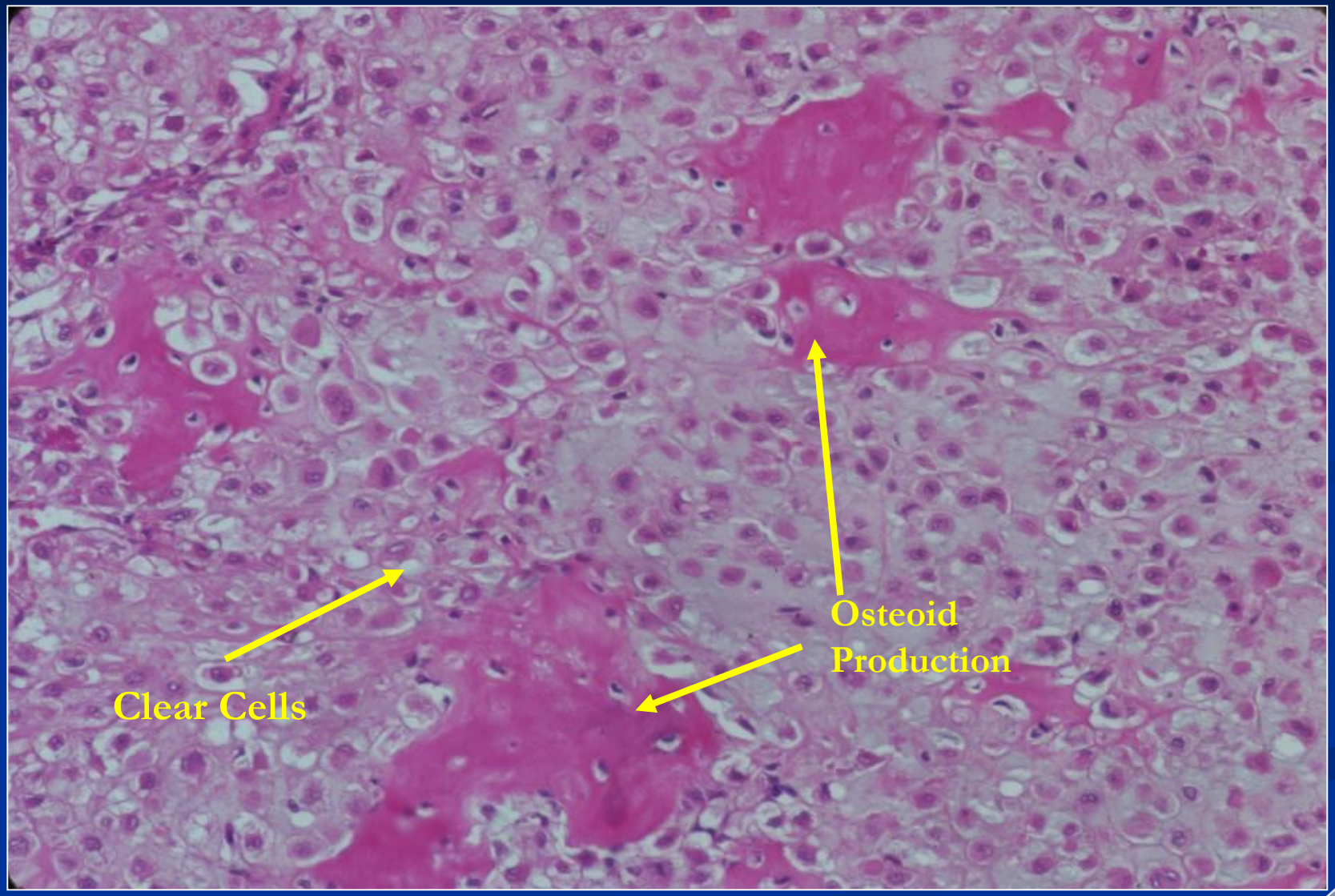
Purely Lytic

Microscopic Pathology

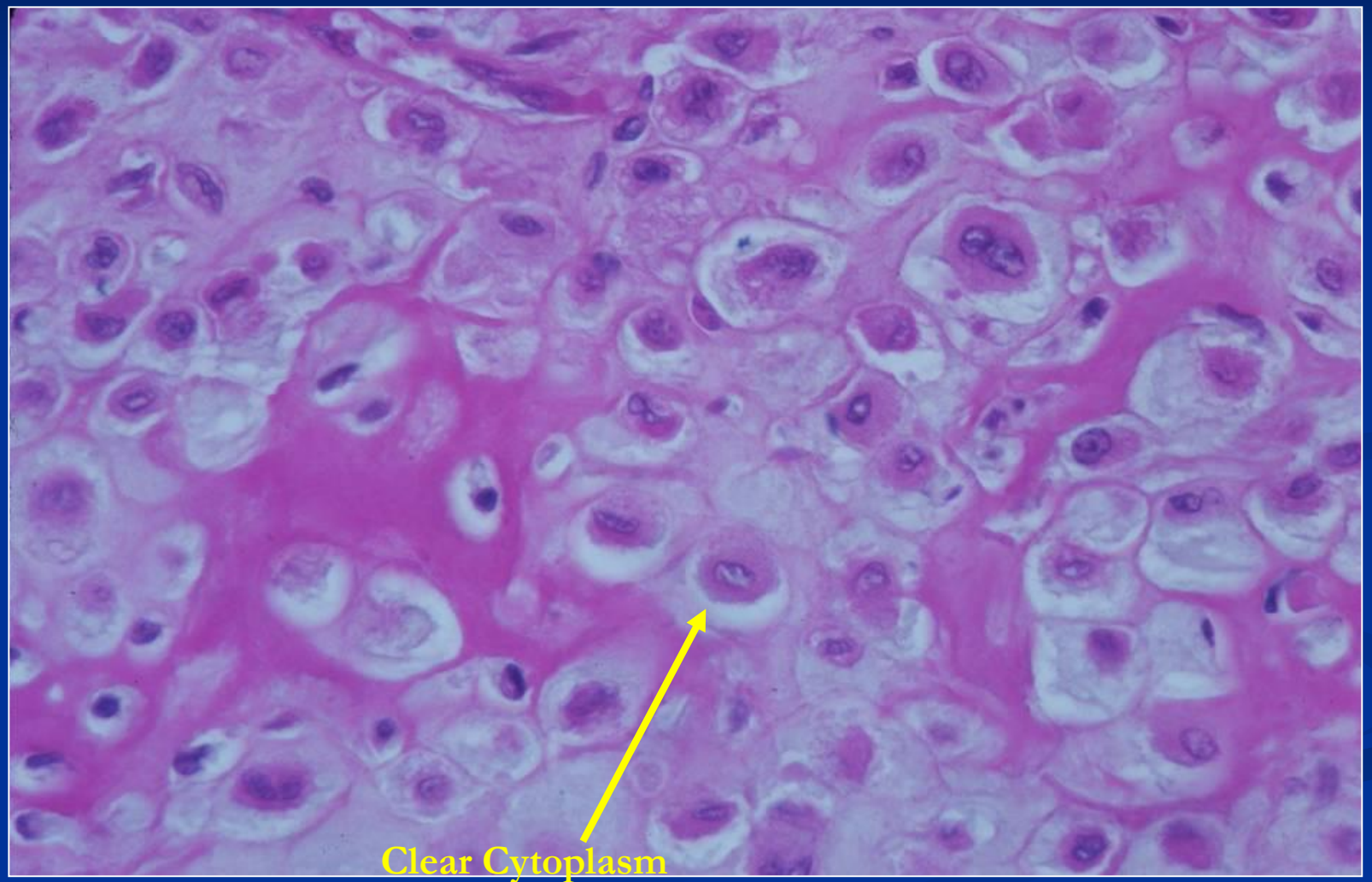
- Large clear cells with abundant cytoplasm, sharp cell border
- Nuclei are more pleomorphic than chondroblastoma (less uniform compared to chondroblastoma)
- Special stains- S-100-positive, P.A.S-positive
- Heavy glycogen production accounts for the clear appearance of the cytoplasm
- May have small deposits of uncalcified or calcified osteoid



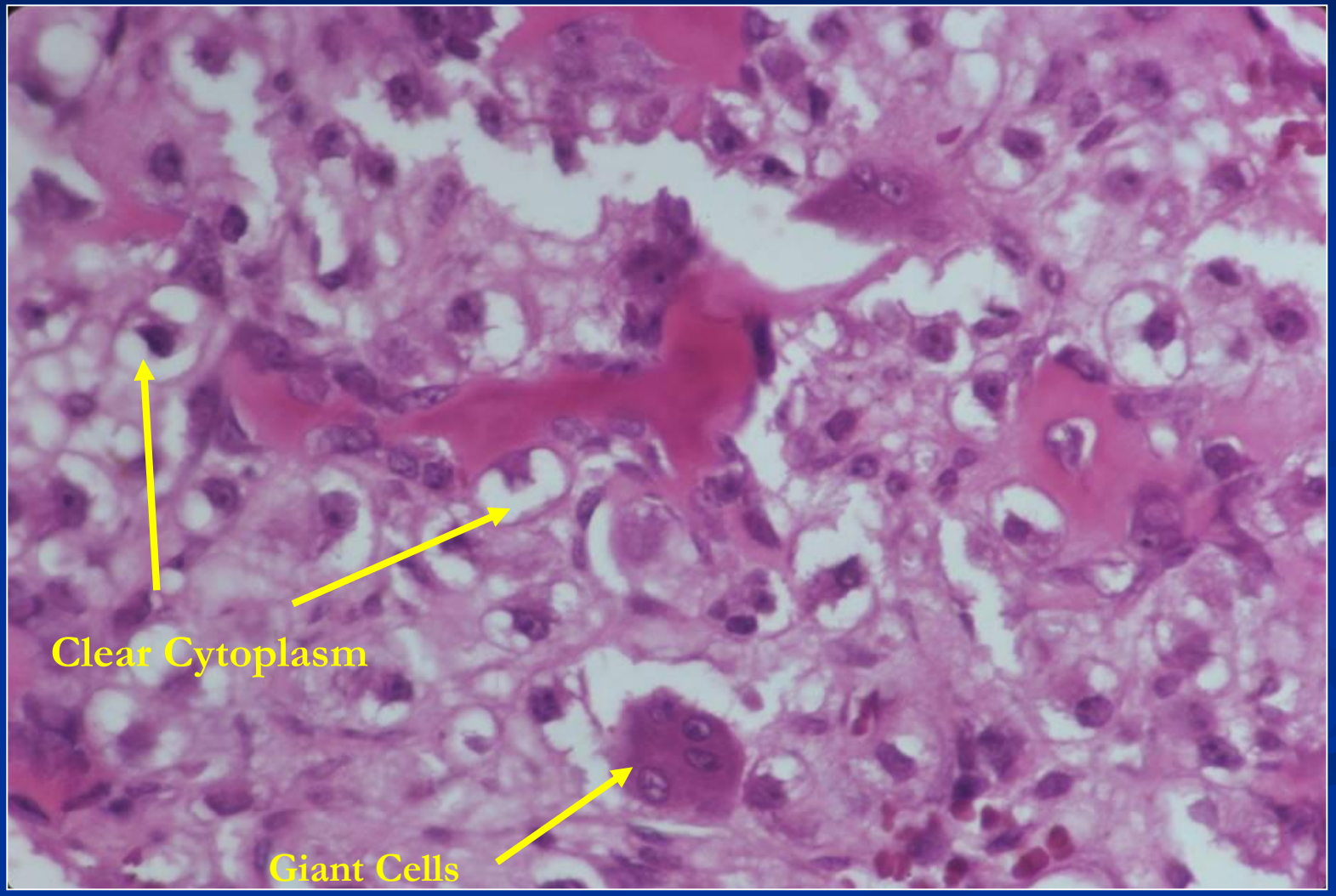
Microscopic Pathology: Clear Cell Chondrosarcoma



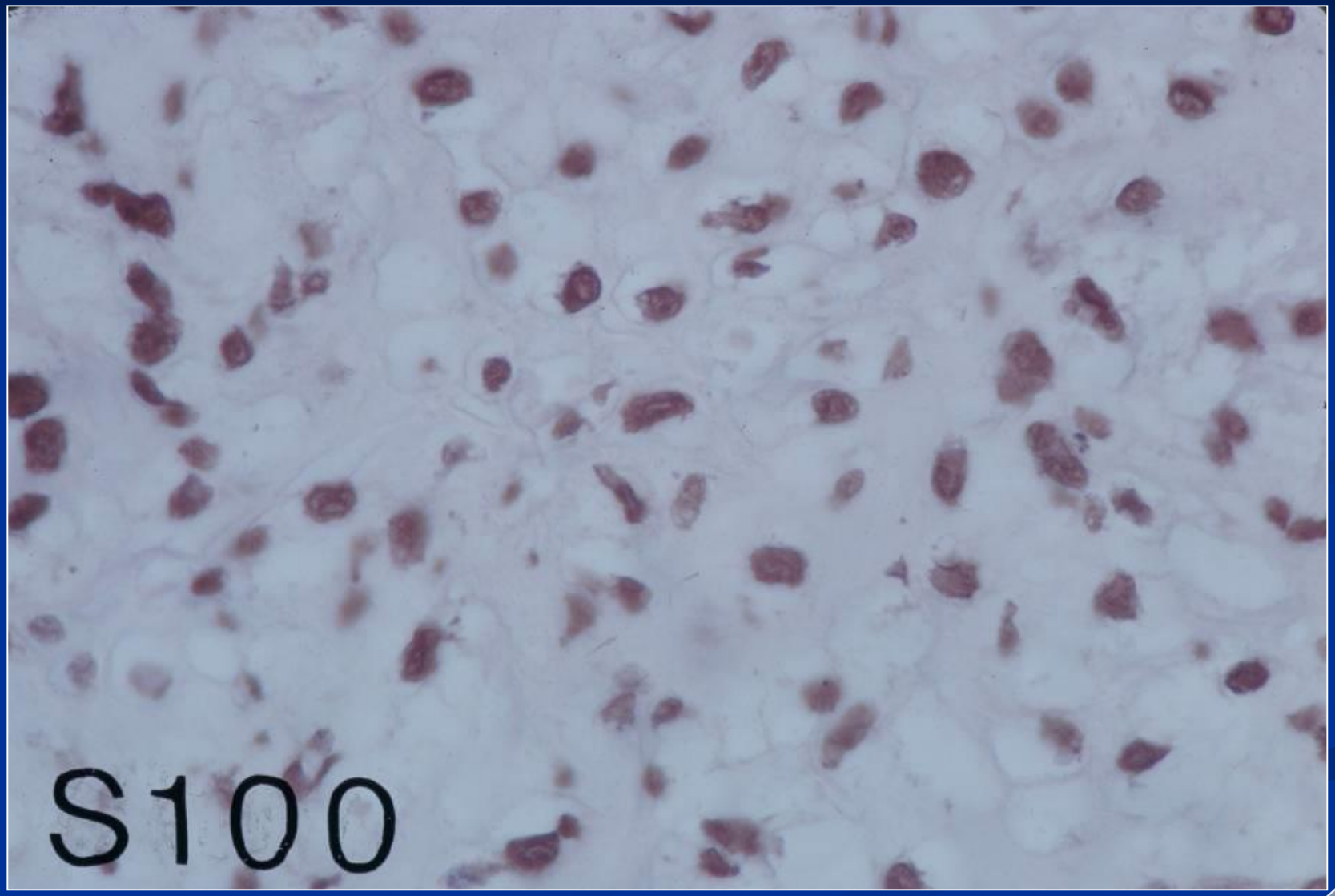
Microscopic Pathology: Clear Cell Chondrosarcoma



Microscopic Pathology: Clear Cell Chondrosarcoma



Microscopic Pathology: Clear Cell Chondrosarcoma



Treatment & Prognosis

- Wide resection
- Simple excision or curettage
  - 80% risk of local recurrence
- Amputation always a possible back up
- No chemo or radiation

Mesenchymal Chondrosarcoma

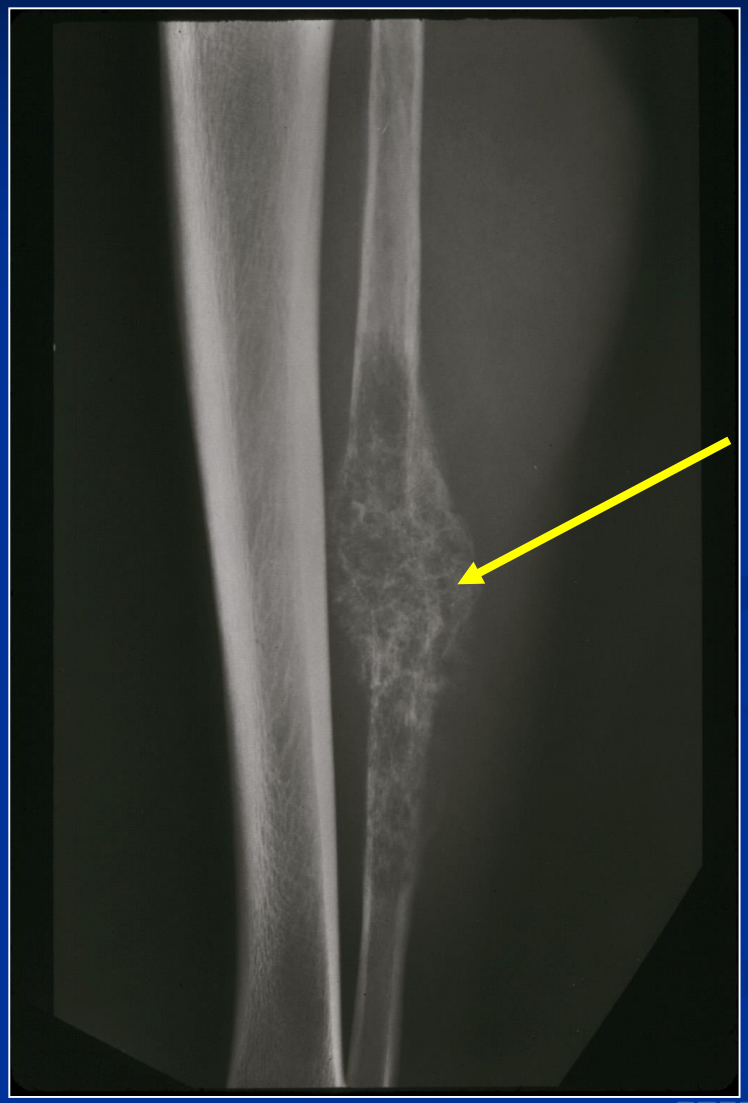
General Information

- High grade malignant, cartilage-forming tumor
- Noncartilaginous small, round, oval, or spindle shaped cells with islands of malignant cartilage dispersed throughout noncartilaginous component of tumor
- Tumor frequently has a hemangiopericytoma-like appearance
- Metastasizes to the lungs and lymph nodes
- May have chondroid matrix calcification

Clinical Presentation

- **Age:**
  - 10 to 40
- **Sites:**
  - Arises in bone and soft tissue (1/3 of cases arise from soft tissue)
  - Femur, ribs, spine, maxilla, mandible, and pelvis

Plain X-ray: Mesenchymal Chondrosarcoma of Fibula Shaft



Permeative Lesion

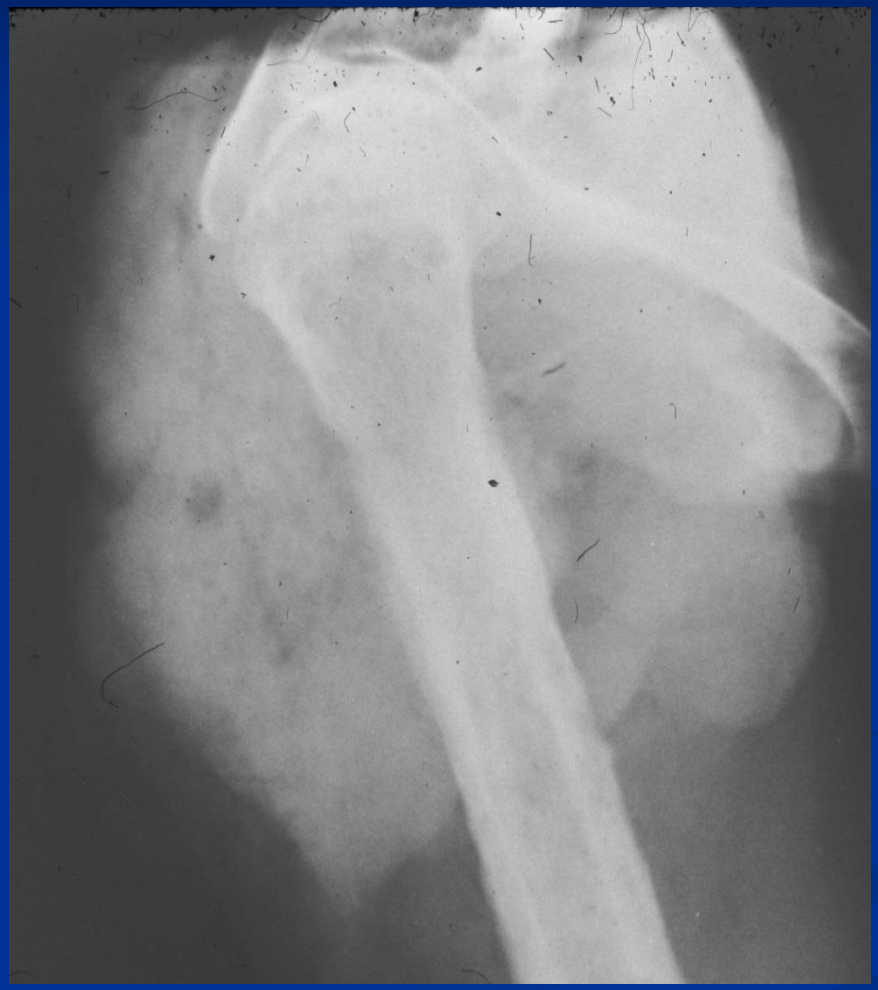
Indistinct Border

Cortical destruction

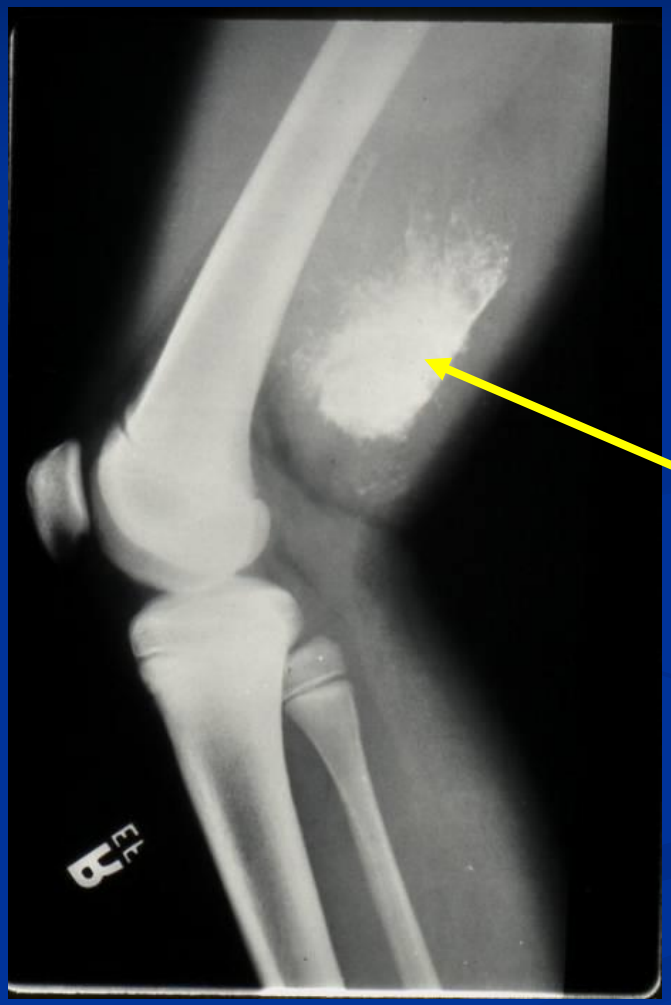
Soft Tissue Extension

Stippled Calcifications

Plain X-ray: Mesenchymal Chondrosarcoma from Proximal Humerus



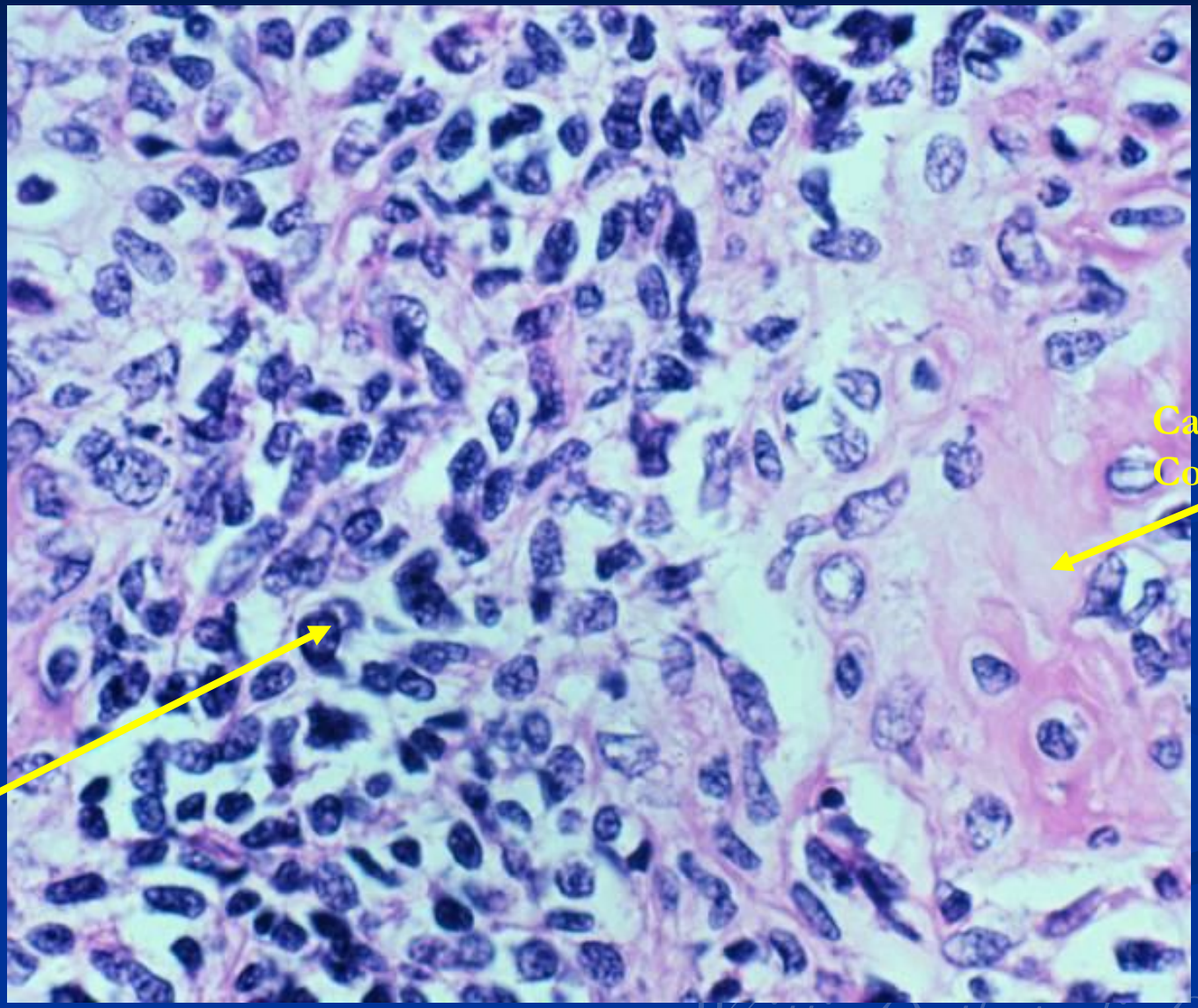
Plain Radiograph of an Extraskeletal Mesenchymal Chondrosarcoma



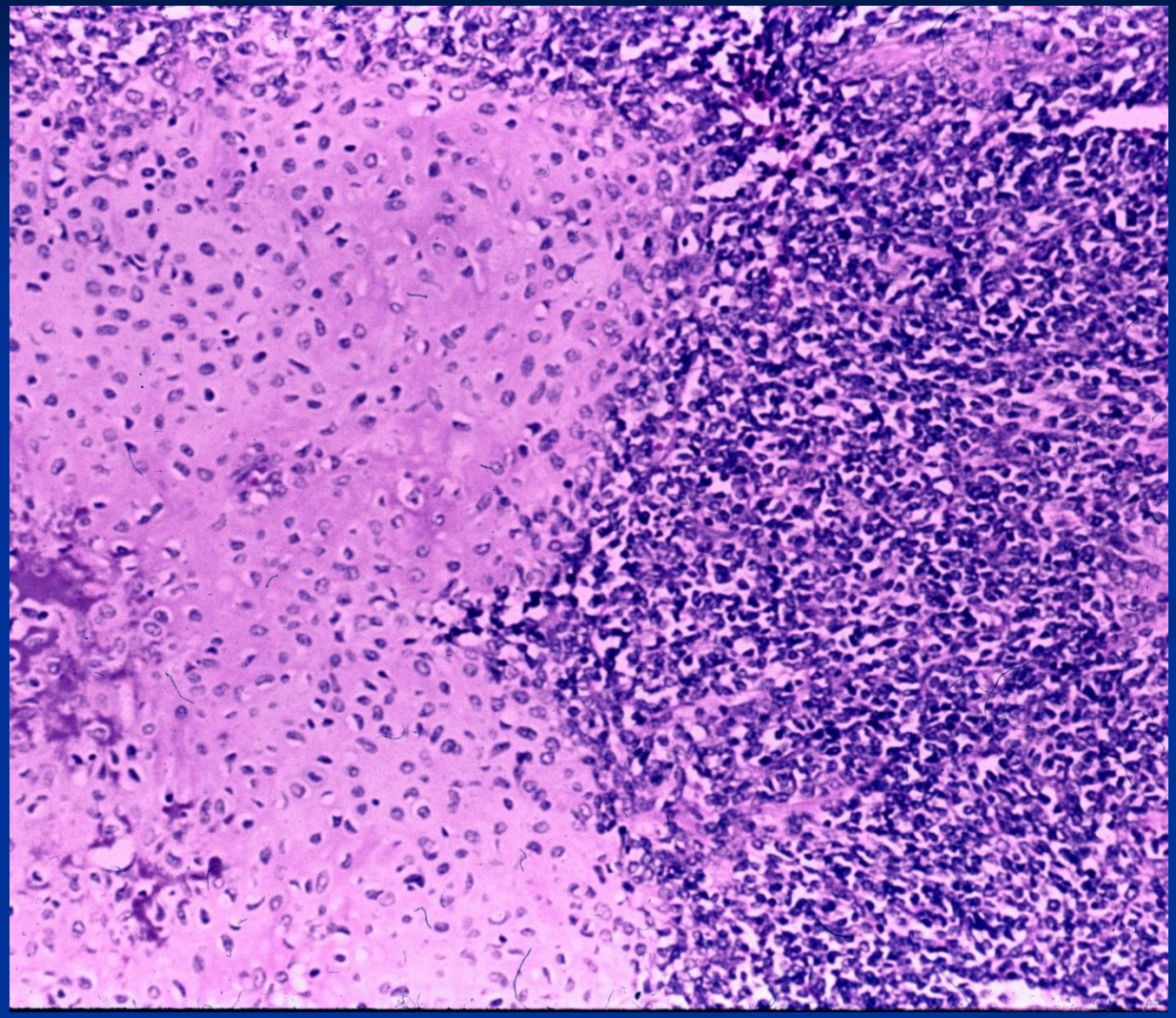
Microscopic Pathology

- Neoplastic cells may be small, round, oval, or spindle shaped
  - Undifferentiated mesenchymal cells similar to Ewing sarcoma
- Low grade islands of cartilage scattered throughout the mesenchymal cells
    - Usually only a small part of lesion
- Lesions are vascular and often have large, anastomosing vessels that impart hemangiopericytoma-like pattern
- Similar chromosomal translocation as Ewing sarcoma t(11;22)

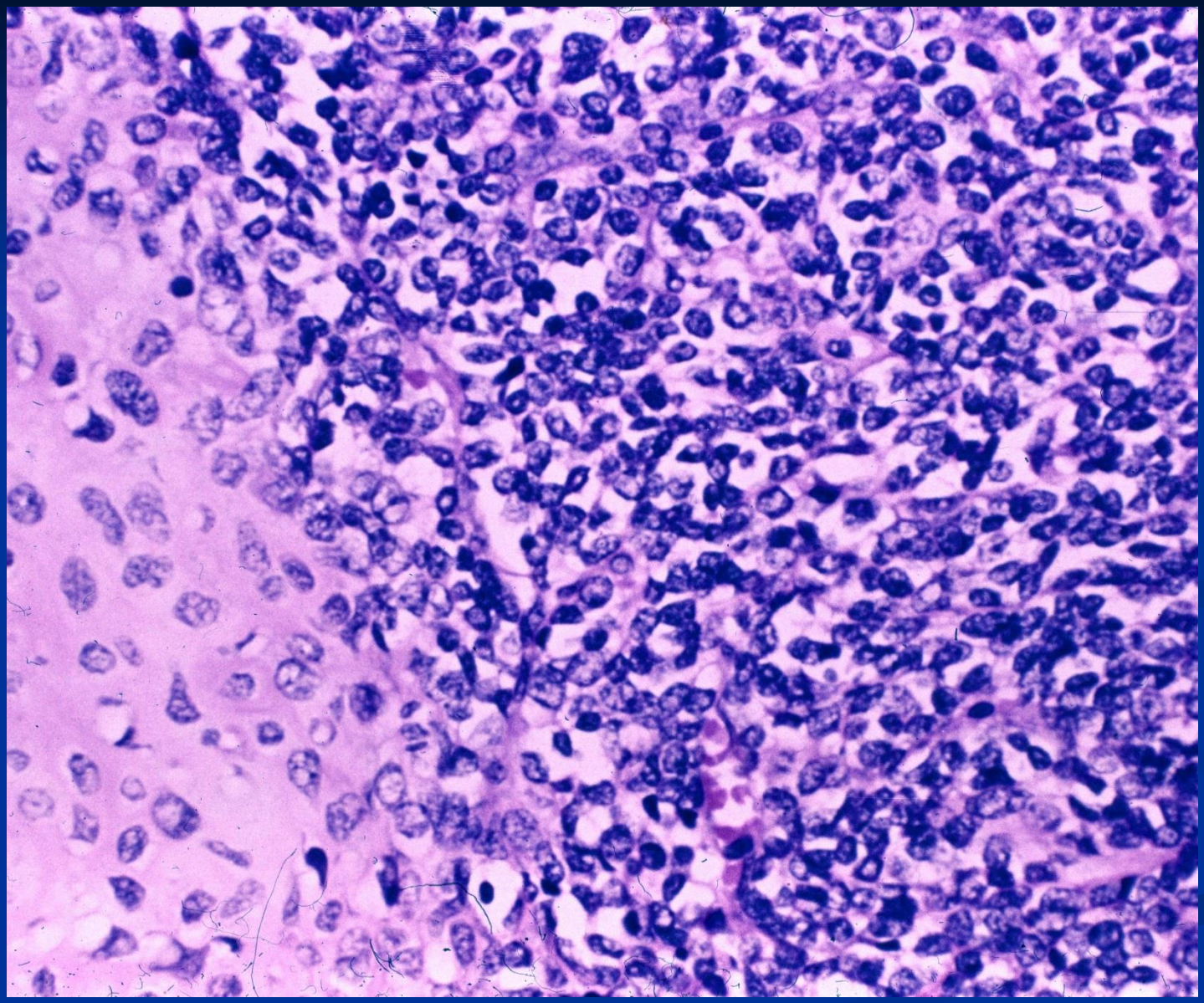
Microscopic Pathology: Mesenchymal Chondrosarcoma



Microscopic Pathology: Mesenchymal Chondrosarcoma



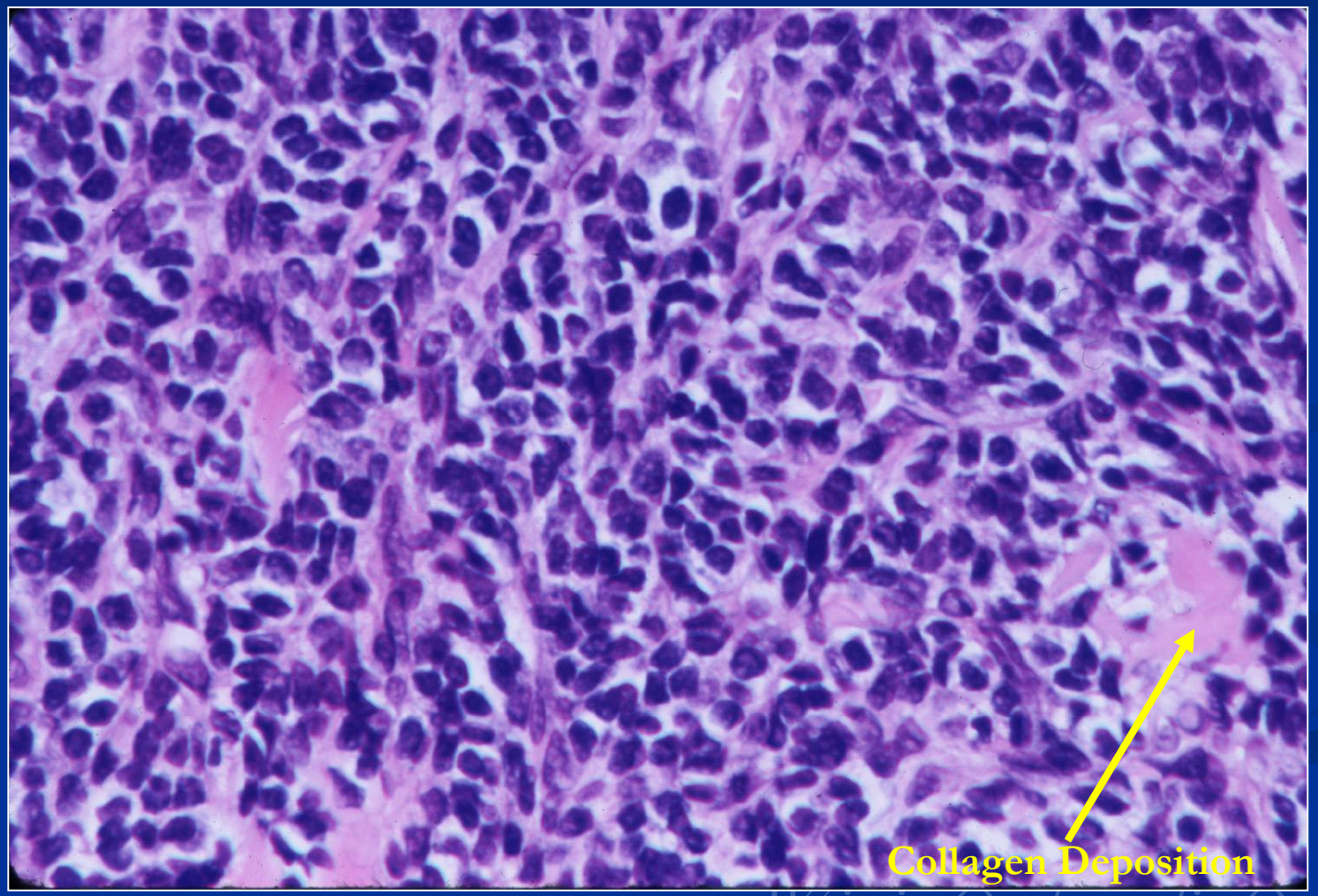
Microscopic Pathology: Mesenchymal Chondrosarcoma



Microscopic Pathology: Mesenchymal Chondrosarcoma

Mesenchymal (Small Round Blue Cell) Component

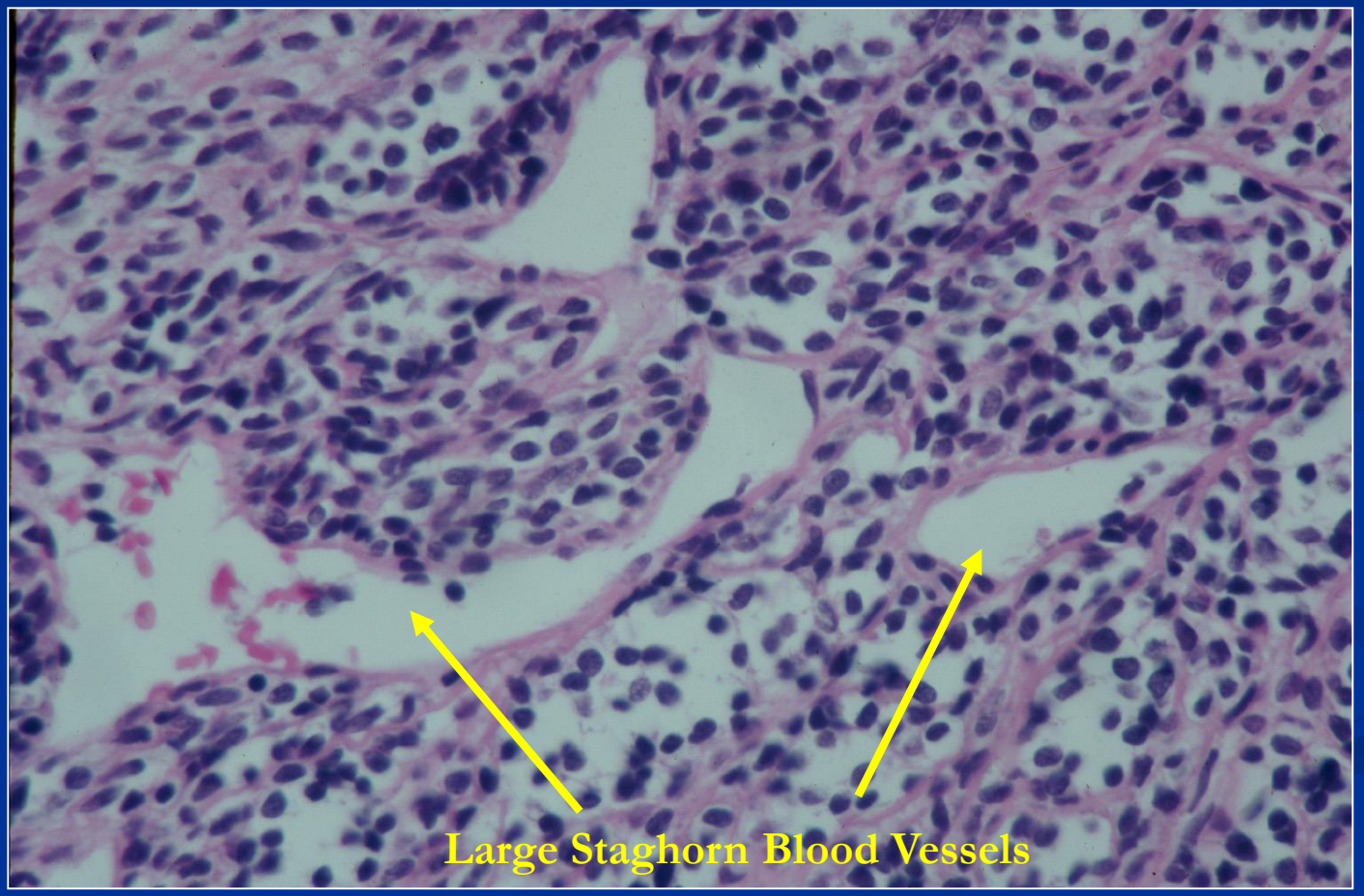
Large Nuclei; No Cytoplasm; No Matrix



Microscopic Pathology: Mesenchymal Chondrosarcoma

Mesenchymal (Small Round Blue Cell) Component

Hemagiopericytoma-like Pattern of Blood Vessels



Differential Diagnosis

- Ewing Sarcoma
- Small Cell Osteosarcoma
- Dedifferentiated Chondrosarcoma

Biological Behavior

- High metastatic and local recurrence rates
  - Metastasizes primarily to lungs, other bones, lymph nodes and viscera
  - 70% mortality

Treatment & Prognosis

- Surgery and chemotherapy. Radiation is used in selected cases, particularly extraskeletal mesenchymal chondrosarcomas

Juxtacortical (Periosteal) Chondrosarcoma

Juxtacortical Chondrosarcoma

- Definition: A malignant, subperiosteal cartilaginous tumor that lacks osteoid production and erodes the underlying cortical bone (periosteal chondrosarcoma)
- Age: 80% are >20 years old vs periosteal osteosarcoma and periosteal chondroma
- Clinical: Painless, mass or swelling; 1/3 of patients have pain (pain rarely exceeds swelling)

Juxtacortical/Periosteal

- Similar to juxtacortical chondroma except larger and grows aggressively
- Periosteal lesion – cortical erosion
- Chondroid matrix calcification
- Similar to periosteal osteosarcoma however no hair on end periosteal reaction
- Larger soft tissue mass/size (>3-4cm)
- Intramedullary canal spared

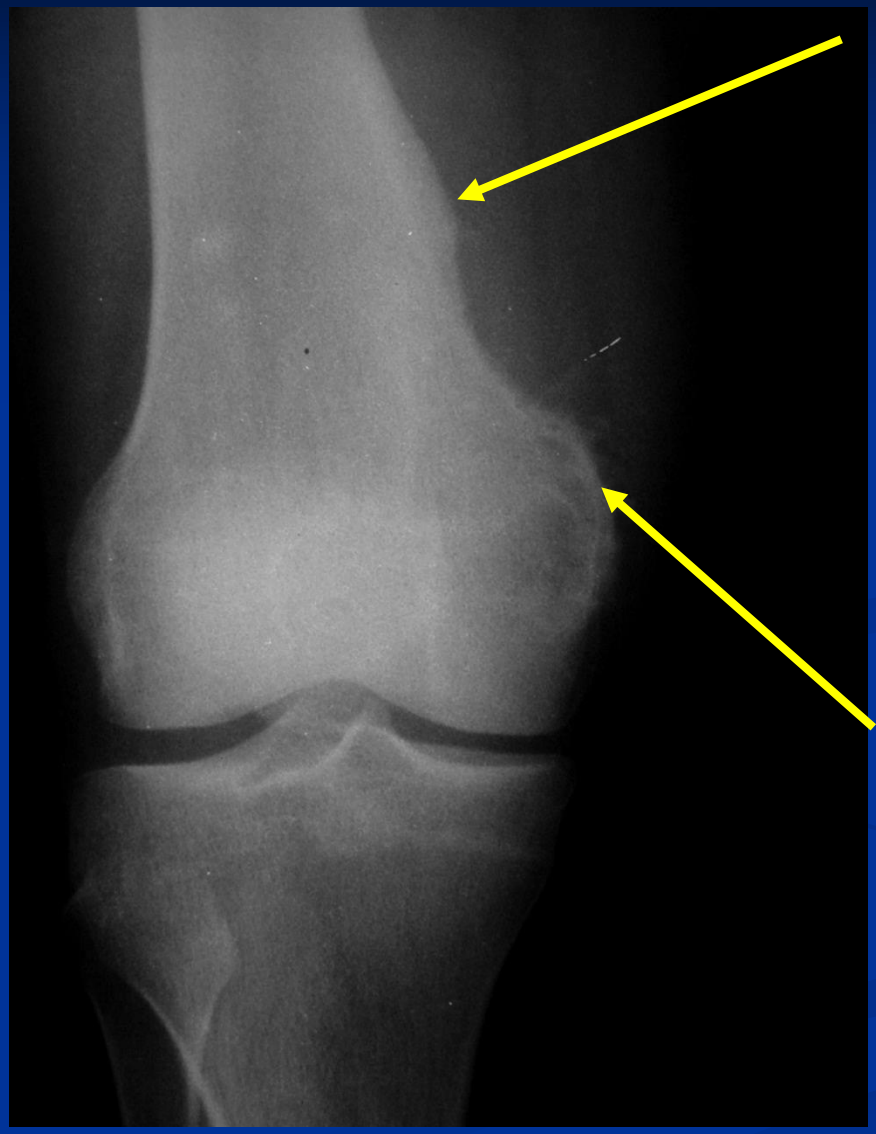
Juxtacortical Chondrosarcoma

- Most Commona Locations:
  - Femur
  - Humerus
  - Pelvis
  - Rib or foot

Radiographic Presentation

- **Radiology:**
  - Metaphyseal
  - Cortical erosion with sclerotic underlying cortex (saucer shaped defect)
  - Matrix calcification
  - Triangular sclerotic spur at margin of tumor
  - >5cm in diameter; average size: 11 cm (vs periosteal chondroma that is usually <5cm)
  - No hair on end periosteal reaction (vs. chondroblastic osteosarcoma)
  - Intramedullary canal is spared

Plain X-ray: Periosteal Chondrosarcoma of Distal Femur



Cortical Thickening at Periphery of Lesion

Erosion of Outer Cortex

Juxtacortical Chondrosarcoma

- Prognosis:
  - 80-90% long term survival
- Treatment:
  - Wide Limb Sparing Resection whenever feasible
  - No Chemotherapy and radiation

Thank You!