



MUSCULOSKELETAL IMAGING

Learning objectives:

1. To learn how to distinguish between various types of arthropathies based on specific radiological findings.
2. To get an understanding of the most prevalent bone cancers, their unique radiological findings, and the most essential differential features.
3. To define the word "osteonecrosis," as well as the various forms and radiological presentations of the condition.
4. To distinguish between osteoporosis, osteomalacia, and rickets based on radiological findings.
5. To emphasize the importance of x-rays in skeletal trauma.

ARTHRITIS

The changes within an articulation can occur from direct injury to the joint, systemic inflammatory processes, or from metabolic abnormalities resulting in deposition of products within and surrounding the joint.

CLASSIFICATION OF ARTHRITIS

DEGENERATIVE JOINT DISEASE

OSTEOARTHRITIS

Definition: is a non-inflammatory process of synovial joints, resulting from mechanical joint destruction and repair.

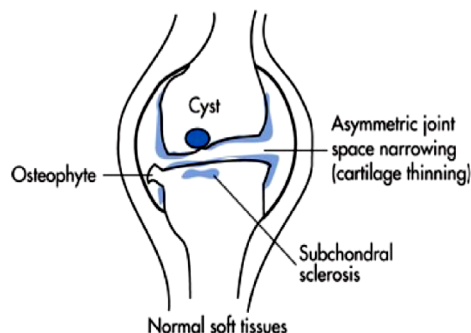
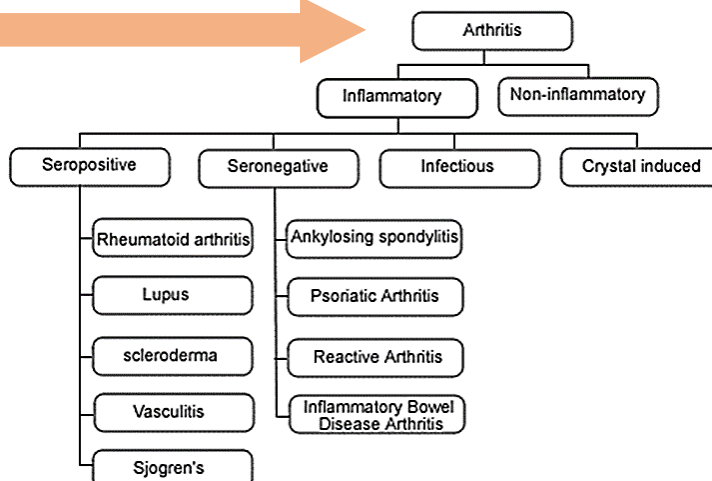
Types:

- **Primary:** when abnormal forces applied to a normal joint lead to joint disruption.
- **Secondary:** when normal forces applied to an abnormal joint lead to disruptive changes.

Radiographic features:

- Narrowing of joint space
- Subchondral sclerosis.
- Subchondral cysts.
- Osteophytes.
- Lack of osteoporosis and erosion

Common sites of involvement: Knee>spine>hips> hands.



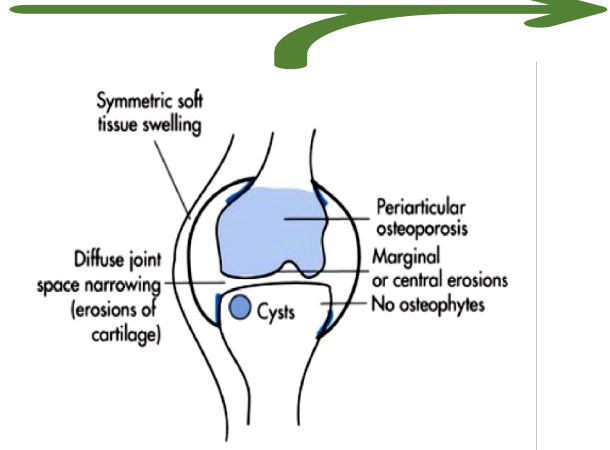
INFLAMMATORY ARTHRITIS

SEROPOSITIVE ARTHRITIS

RHEUMATOID ARTHRITIS

Definition: chronic polyarthritis due to inflammation and proliferation of synovium (pannus) leading to bone erosion with cartilage destruction. It affects female > male.

Radiographic features:



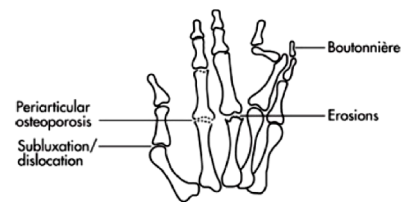
- Early changes**
- Periarticular soft tissue swelling
 - Juxta-articular osteoporosis
 - Joint space widening

- Late changes**
- Joint space narrowing
 - Marginal/ central erosions
 - Erosions of the ulnar styloid and triquetrum
 - Subchondral cyst formation
 - Subluxations
 - Carpal instability
 - Fibrous ankylosis is a late finding.
 - Generalized osteopenia (disuse)

Common sites of involvement:

Hands > feet > spine

- ✓ **MCP ulnar deviation.**
- ✓ **Boutonnière deformity:** hyperextension of DIP, flexion of PIP
- ✓ **Swan-neck deformity:** hyperextension of PIP, flexion of DIP
- ✓ **Hitchhiker's thumb**
- ✓ **Telescope fingers:** shortening of phalanges because of dislocations



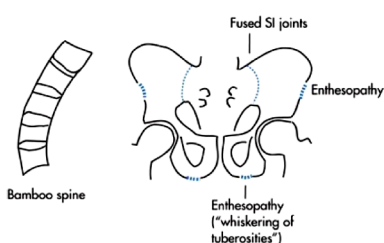
SERONEGATIVE ARTHRITIS

ANKYLOSING SPONDYLITIS

Definition: seronegative spondyloarthropathy, affects young males > females. +HLA-B27 in 95%.

Radiographic Features:

Sacroiliac joint involvement	Spine involvement
<ul style="list-style-type: none"> • It's the initial site of involvement. • Bilateral symmetric involvement. • Stages: <ul style="list-style-type: none"> ✓ Erosions: early ✓ Sclerosis: intermediate ✓ Ankylosis: late 	<ul style="list-style-type: none"> • Vertebral body squaring. • Syndesmophytes • Bamboo spine: fusion and ligamentous ossification • Romanus lesion: earliest MR sign, bright T2 signal in superior & inferior anterior corners of vertebra. • Dagger sign: dense lines along spine because of ossification of paraspinal ligaments. • Spine fracture with pseudoarthrosis. • enthesopathy



PSORIATIC ARTHRITIS

Definition: seronegative spondyloarthropathy, associated with psoriasis (20%), +HLA-B27 in 50%.

Radiographic Features: combination of productive and erosive changes, affects hands > feet

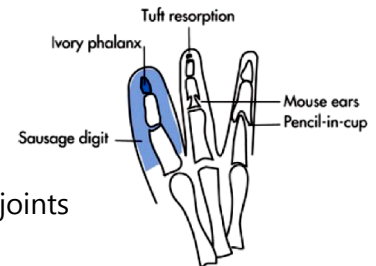
Bone production

- **Mouse ears:** bone production adjacent to erosions
- **Ivory phalanx:** sclerosis of distal phalanx

Bone erosion

- **Pencil-in-cup deformity.**
- **Resorption of terminal tuft**

- ✓ Soft tissue swelling of entire digit: **sausage digit**
- ✓ Severe joint space narrowing
- ✓ **Sacroiliitis** is usually bilateral asymmetrical.
- ✓ Periostitis and enthesopathy common (not seen in RA)
- ✓ **Commonest site:** Hand involvement: DIP + PIP joints, less so MTP joints



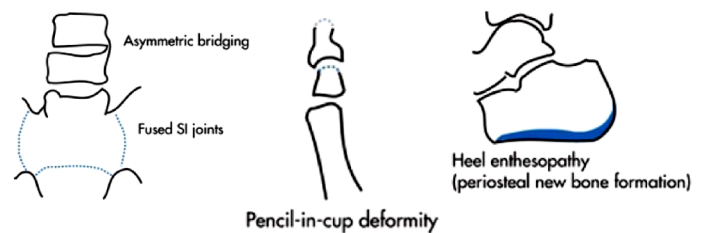
REACTIVE ARTHRITIS (REITER SYNDROME)

Definition: seronegative spondyloarthropathy, affects males > females, +HLA-B27 in 80%.

Clinical triad: urethritis, arthritis and iritis.

Radiographic Features

- Feet > hands
- Pencil in cup deformity [articular erosion].
- Retrocalcaneal bursitis and enthesopathy
- Bilateral sacroiliitis: 30%
- Spinal osteophytes and syndesmophytes



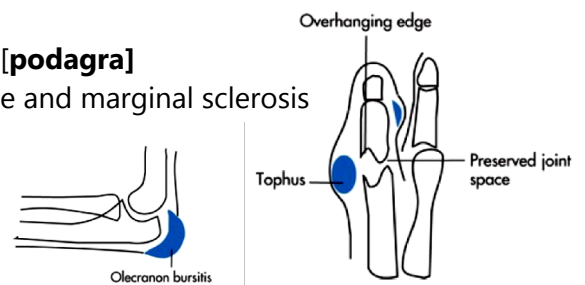
CRYSTALS INDUCED ARTHRITIS

GOUT

Definition: arthritis secondary to deposition of sodium urate crystals in the joints [male > female]

Radiographic features:

- Lower limb > upper limb; big toe is most common site [**podagra**]
- Marginal, para-articular erosions with overhanging edge and marginal sclerosis
- Joint space is preserved.
- **Tophi:** juxta-articular, helix of ear
- **Bursitis:** olecranon, prepatellar
- Chondrocalcinosis



INFECTIOUS ARTHRITIS

It results from hematogenous spread to synovium and subsequent spread into the joint.

Radiographic Features:

- ✓ **Plain radiograph:** Joint effusion + Juxta-articular osteoporosis + articular surface destruction
- ✓ **Bone scan:** useful if underlying osteomyelitis is suspected
- ✓ **MRI:** Joint effusion [Sensitive in detecting early cartilage damage]

BONE TUMORS

CLASSIFICATION OF BONE TUMORS

OSTEIOD LESIONS

OSTEOMA

A benign tumor that contains only compact osseous tissue. Commonly seen in the skull and sinuses. **X-ray finding:** round, well defined dense bone mass, it can be associated with Gardner syndrome.

OSTEIOD OSTEOMA

It occurs in young male. The classic history is that of night pain relieved with aspirin. The most common location is in the diaphysis of long bones. **X-ray finding:** small circular lucent area (nidus) under the cortex surrounded by thickened reactive bone [< 15 mm in diameter].

OSTEOBLASTOMA

It's rare tumor occurs in the posterior elements of the spine in 40% of the cases. **Radiographic findings:** osteolytic lesion with expansion, cortical thinning, or mild destruction [> 1.5 cm in diameter] and associated with soft tissue mass.

OSTEOSARCOMA

The second most common primary malignant tumor between the ages of 10 and 25, mostly appear around the knee joint. **The classical radiographic findings:** Irregular medullary destruction, Periosteal reaction, cortical destruction, soft tissue mass and new bone formation.

CHONDRROID LESIONS

OSTEOCHONDROMA (EXOSTOSIS)

The commonest benign tumor, most frequent site being the metaphyseal region of the lower femur and upper tibia. malignant transformation is less than 1-10%. The multiple for called Hereditary multiple osteochondromas (diaphyseal aclasis). **X-ray finding:** cortical bone projections directed away from the nearby joint.

ENCHONDROMA

One of the most common benign tumors of bone. **X-ray finding:** appears as a well- defined lytic lesion, often expanded, with small flecks of calcification. The hands and feet are most frequently affected. If multiple called **Ollier's disease** and multiple enchondroma with soft tissue hemangiomas. called **Maffucci syndrome** → increased risk of malignant transformation to chondrosarcomas.

CHONDROBLASTOMA

It is an epiphyseal lesion of children or young adults. **Radiographic findings:** well-marginated epiphyseal lesion, often centrally located. Presence of chondroid matrix

CHONDROSARCOMA

A slow-growing malignant tumor, **Central type:** usually arise from a tubular bone, is lytic and situated in the region of the metaphysis. **Peripheral type:** probably originate from the periosteum or evolve from a previous benign osteochondroma.

FIBROUS LESIONS

FIBROUS DYSPLASIA

It's a benign condition, commonly located in the femur, tibia, calvarium/facial bones, and ribs.

Radiographic appearance: expansile, lytic with ground-glass matrix and a sclerotic rind.

FIBROUS CORTICAL DEFECT/ NON-OSSIFYING FIBROMA

It is a benign, self-limited, very common pediatric lesion. The term fibrous cortical defect is used when the lesion is small (1–2 cm) and confined to the cortex. Non-ossifying fibroma (NOF) extends into the medullary canal. **Radiographic findings** include a lucent lesion within the cortex of the metaphysis, often with a rim of sclerosis. It can be mildly expansile, but there is no associated soft tissue mass or aggressive periosteal reaction.

CHONDROMYXOID FIBROMA

Rare, benign cartilaginous tumor, x-ray findings: eccentric, lobulated, lucent lesion at the cortex and medulla of the proximal third of the tibia with thick sclerotic margin & mild cortical expansion.

BONE MARROW TUMORS

MULTIPLE MYELOMA

Multiple myeloma is the most common primary malignant tumor, commonly involves skull, spine, pelvis and ribs. **Radiological features:** generalized osteoporosis with scattered, 'punched-out' lytic lesions with well-defined margins and pathological fractures are common.

EWING 'S SARCOMA

A highly malignant tumor originating from bone marrow between the ages of 5 and 15 years. Most common location is diaphysis or metaphysis of long bones. The appearances may mimic an osteomyelitis. **Radiographic findings** typically demonstrate a lytic, permeative lesion with aggressive periosteal reaction (onion-peel appearance) and associated soft-tissue mass.

BONE METASTASES

The most common malignant bone tumors. **Radiographic patterns:** **sclerotic** [breast in female and prostate in male], **lytic** [breast in female & lung cancer in male] and **mixed** as in breast cancer.

MISCELLANEOUS LESIONS:

SOLITARY BONE CYST

- Most commonly occurs in the first and second decades of life, commonest sites are the proximal humerus, central, metaphyseal location, mildly expansile osteolytic lesion with cortical thinning, narrow zone of transition and a fine sclerotic rim. **'Fallen fragment' sign:** a fractured fragment that settles in the dependent portion of the fluid-filled cyst

ANEURYSMAL BONE CYST

- It occurs in patients < 30 years of age predominantly in the vertebrae and long bones. **Imaging features:** **Plain X-ray** → expansile, eccentric lesion in the metaphysis, thin 'egg-shell' cortex, no periosteal reaction, unless a fracture is seen. **MRI** → Fluid–fluid levels.

GIANT CELL TUMOR [OSTEOCLASTOMA]

This adult tumor formed from osteoclast-like giant cells, 10% are malignant. **Radiographic findings:** a lytic, expansile, eccentric epiphyseal/metaphyseal lesion. It occurs almost exclusively after fusion of physal plate. Narrow zone of transition with fading sclerosis.

OSTEONECROSIS [avascular necrosis]

Definition: bone death caused by a vascular insult

Causes: Idiopathic, Trauma, Alcohol intake, steroids, sickle cell disease ...etc

Stages: sclerosis → lucency → flattening & fragmentation → deformity → degenerative arthropathy

Types:

- **Legg-Calve Perthes Disease:** osteonecrosis of femoral head in school-aged children.
- **Kienbock's disease:** osteonecrosis of lunate.
- **Preiser's disease:** osteonecrosis of scaphoid
- **Freiberg's disease:** osteonecrosis of head of 2nd metatarsal.
- **Kohler disease:** osteonecrosis of navicular bone.
- **Blount disease:** osteonecrosis of the medial tibia.

OSTEOPOROSIS

Definition: it is a condition in which there is a reduction of bone mass.

Causes: Disuse, senility, post menopause, steroid therapy, malnutrition ...etc

Radiological investigations

- Plain x-ray films.
- Bone densitometry either by dual energy X - ray absorptiometry (DEXA) or CT (QCT).

Radiological features

- Detection of osteoporosis on plain films requires a reduction in bone mass of **at least 30%**.
- Reduction of bone density [**osteopenia**]
- **'Picture framing':** cortex is sharp, trabeculae are decreased.
- **'Empty box' sign:** relative increased density of vertebral endplates with resorption of central spongy bone.
- **'Codfish vertebrae':** biconcavity of the vertebral bodies
- **Compression fractures** of vertebrae and subsequently leads to a kyphosis.

RICKETS

Definition: vitamin D deficiency in children.

Causes: malnutrition, malabsorption, chronic renal disease or prolonged anticonvulsant therapy.

Radiological features:

- Osteopenia
- Widening of the growth plate
- Delayed appearance of epiphyses.
- Fraying and indistinct margins of the metaphysis producing a cupped appearance.
- Periosteal reactions, especially during the healing stage.
- Bowing and curvature of bones.
- Greenstick fractures are common.
- Bulbous enlargement of the anterior ends of the ribs producing a **'rickety rosary'**

OSTEOMALACIA

Definition: vitamin D deficiency in the mature skeleton.

Radiological features

- Osteopenia.
- **Looser 's zones** (pseudo fractures) are narrow translucent bands, at the cortical margins, and are diagnostic of osteomalacia. They are seen most frequently in the ribs, scapulae, pubic rami and medial aspects of the proximal femora.
- Biconcave vertebrae (**'cod fish' vertebrae**).
- Bone softening leading to **triradiate pelvis**.

OSTEOMYELITIS

Definition: it is an infection of bone.

Causes: Staphylococcus aureus in the majority of cases

Radiological features of ACUTE osteomyelitis:

- **X-ray:** may be normal for up to 10 days but the earliest sign is soft tissue swelling with periosteal reaction and eventually bone destruction.
- **Isotope scan:** uses technetium, gallium or labelled white cells, non-specific increased uptake.
- **MRI:** a sensitive technique in detecting infection [bone marrow edema is first sign].

Radiological features of CHRONIC osteomyelitis:

- **Cloaca:** a canal formed in the cortex of a bone due to formation of a draining sinus tract.
- **Sequestrum:** death of cortical bone secondary to occlusion of nutrient arteries
- **Involucrum:** lesion in which new bone is laid down around a sequestrum.
- **Brodie's abscess:** reactive bone from the periosteum and endosteum surrounding and containing an infection.

Complications

- ✓ Soft tissue abscess.
- ✓ Fistulae.
- ✓ Premature fusion of epiphyses.
- ✓ Deformity.
- ✓ Pyogenic arthritis leading to bony ankylosis (e.g. hip fusion).

FRACTURE

Typical features of a fracture: fracture line, soft tissue swelling and cortical irregularity

Essential information in fracture radiograph:

1. Anatomical site.
2. Fracture pattern.
3. Alignment
4. Associated soft tissue injuries.

Types of fracture:

- **Greenstick:** bending of bone on one side with a break of the cortex on the other side.
- **Comminuted:** a fracture with multiple fragments.
- **Avulsion:** a fragment of bone detached from the site of a ligamentous or tendon insertion.
- **Pathological:** a fracture through diseased bone.

- **Stress or fatigue fracture:** results from chronic repetitive minor trauma.
- **Impacted fracture:** the fragments are compressed into each other without visible fracture line.
- **Epiphyseal plate fractures** in children under the age of 16. These can be classified into types 1 to 5 using the **Salter Harris classification**.

Complications of fractures

- **Nonunion**
- **Malunion.**
- **Avascular necrosis**
- **Osteoarthritis**
- **Osteoporosis**
- **Myositis ossificans:** post-traumatic heterotopic bone formation in a chronic hematoma within the muscle appears as peripheral calcification with a radiolucent center.

Dislocation: total loss of congruity between articular surfaces of a joint.

Subluxation: anything less than total loss of congruity between articular surfaces.

Further readings:

Diagnostic imaging, seventh edition

Andrea Rockall

Andrew Hatrick

Peter Armstrong

Martin Wastie