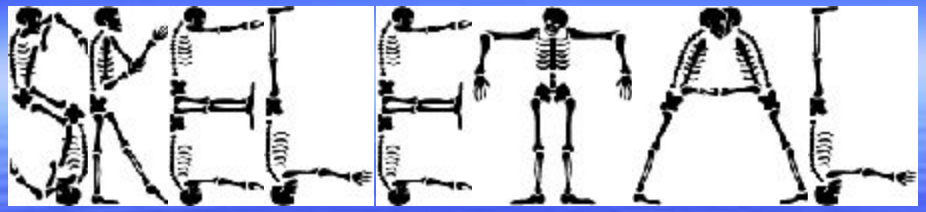

SKELETAL


SYSTEM

Plain films

- Plain films still remain the mainstay of radiological investigation of the skeletal system. Views should always be obtained in two projections.

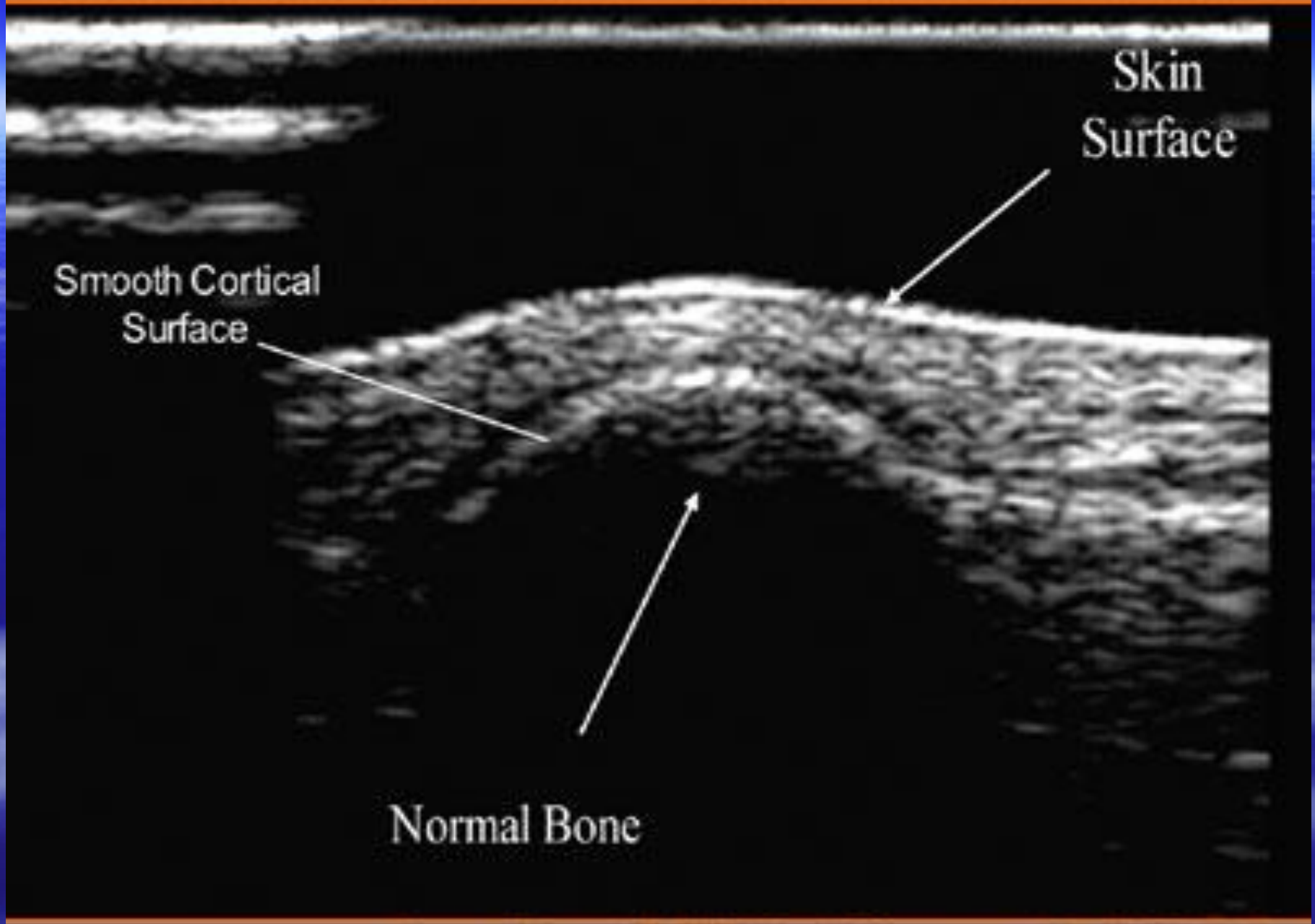
Figure 1

Figure 2

Ultrasound

Ultrasound is utilized for the evaluation of:

- neonatal hip for congenital dislocation
- soft-tissue lesions, abscesses and masses
- joint effusion

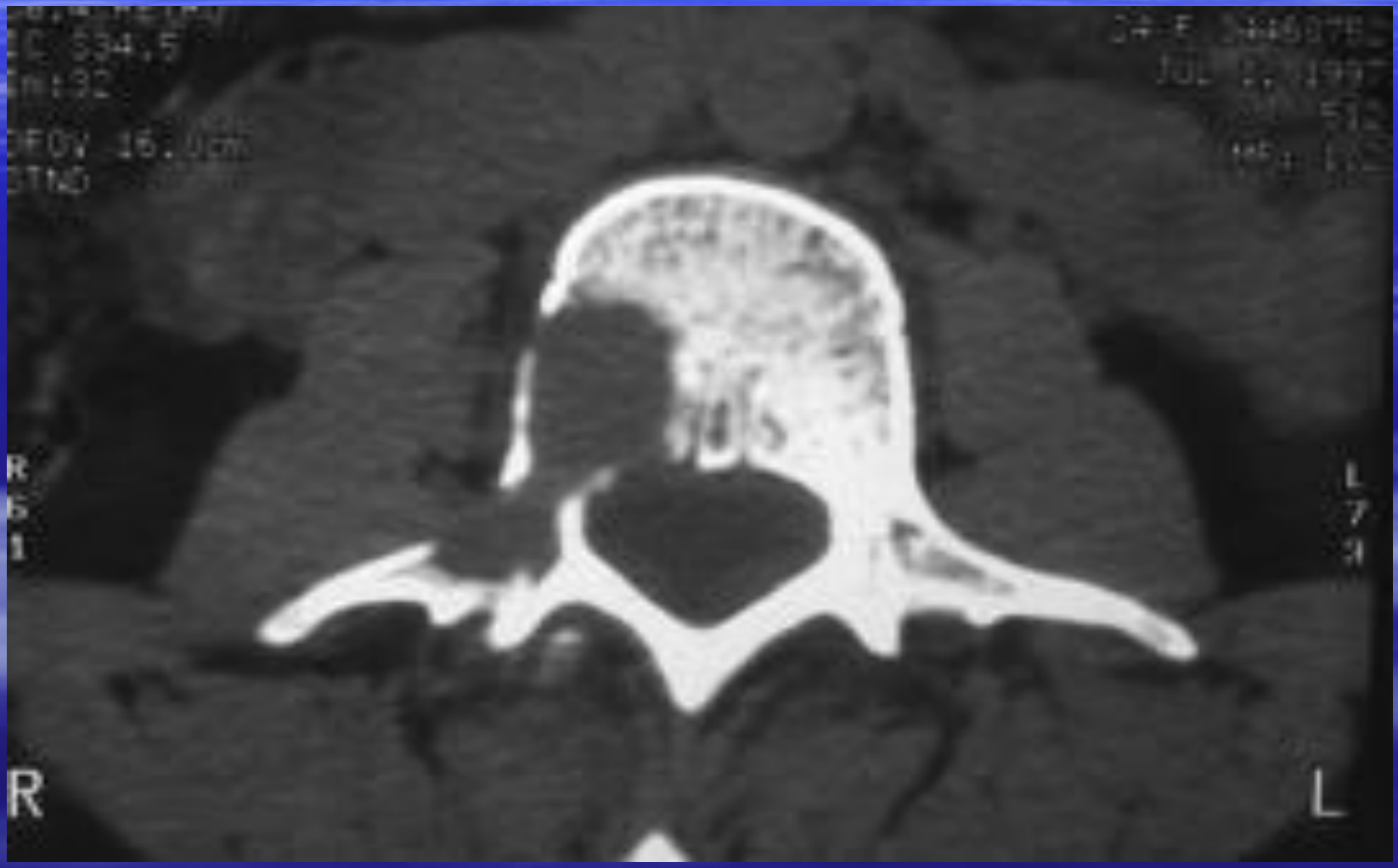


CT scan

CT aids:

- assessment of bone tumors prior to surgery
- evaluation of certain fractures, such as the acetabulum and subtalar joint
- study of the spinal column

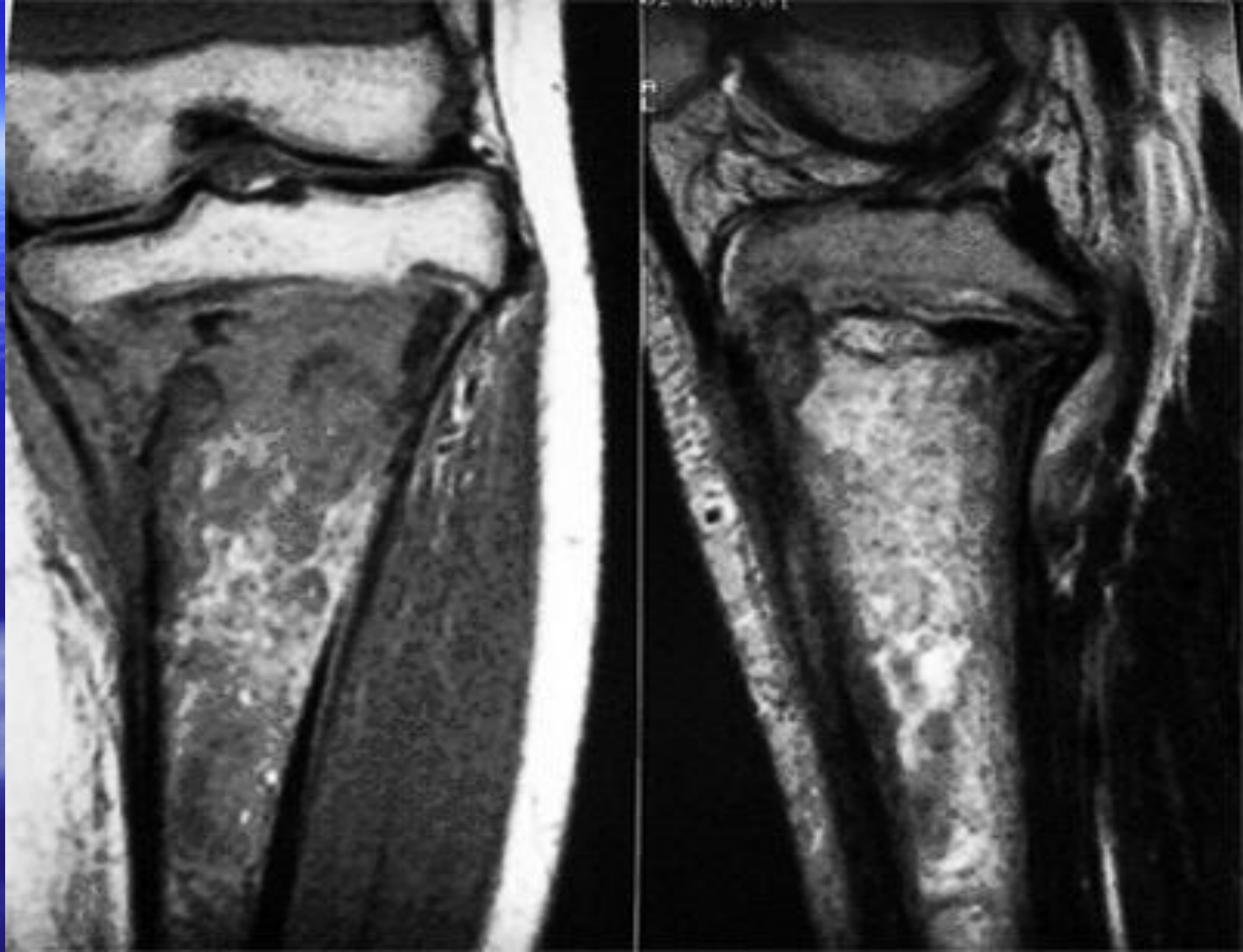
Aneurysmal **bone** cyst



MRI

MRI assists the:

- investigation of bone tumor
- soft tissue masses
- the spinal column and joints



Isotopes scan

Technetium 99 phosphonate compounds accumulate in bone several hours after intravenous injection of the isotope; principally used for:

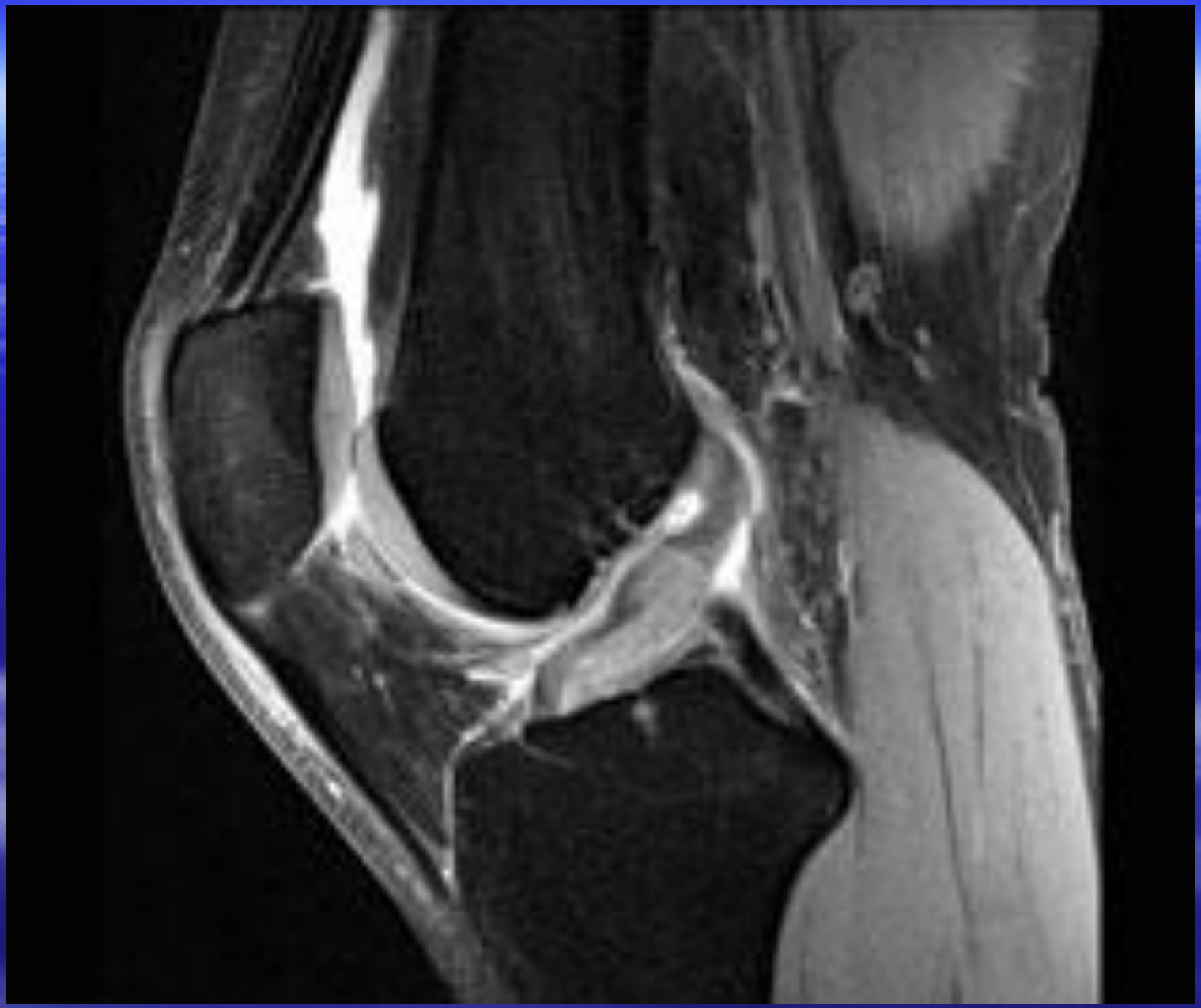
- detection of osteomyelitis and other musculoskeletal soft-tissue inflammatory changes
- metastatic bone lesions: changes are seen much earlier than plain films
- staging tumors such as breast carcinoma or bronchial carcinoma
- functional bone abnormality: Paget's disease

An isotope bone scan showing hot spots in the left foot and in the ribs, suggestive of metastases.

Arthrography

In this procedure, contrast and air are injected into joints such as the knee, hip, elbow, shoulder, wrist and temporomandibular joints to diagnose

- loose bodies
- ligamentous abnormalities
- cartilaginous abnormalities



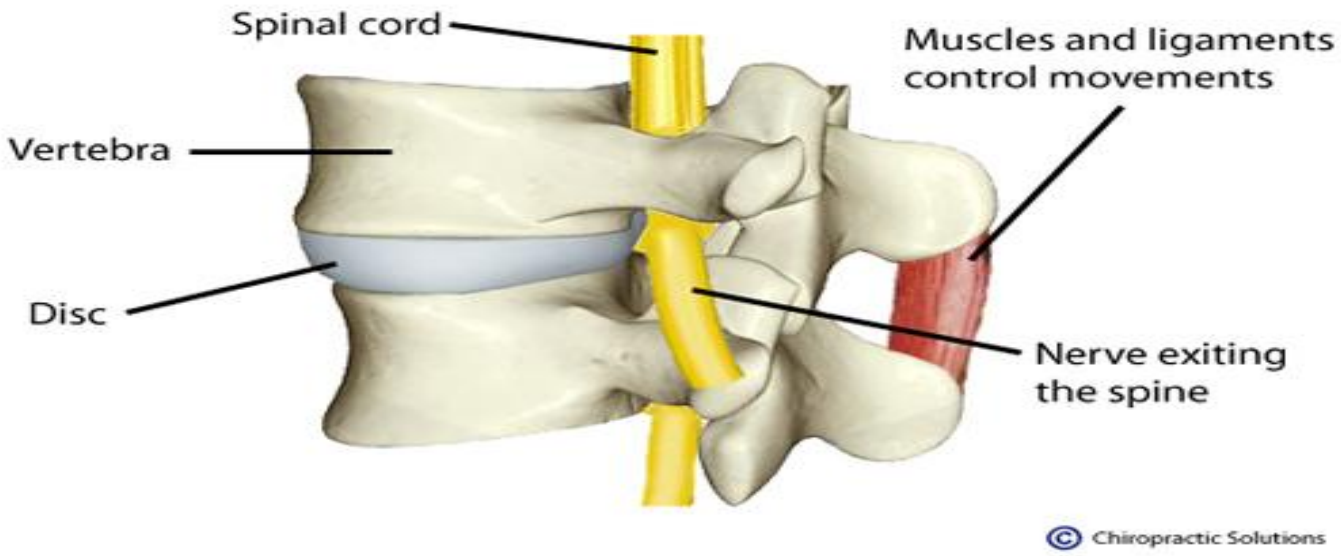
the left shoulder in external rotation

Skeletal trauma

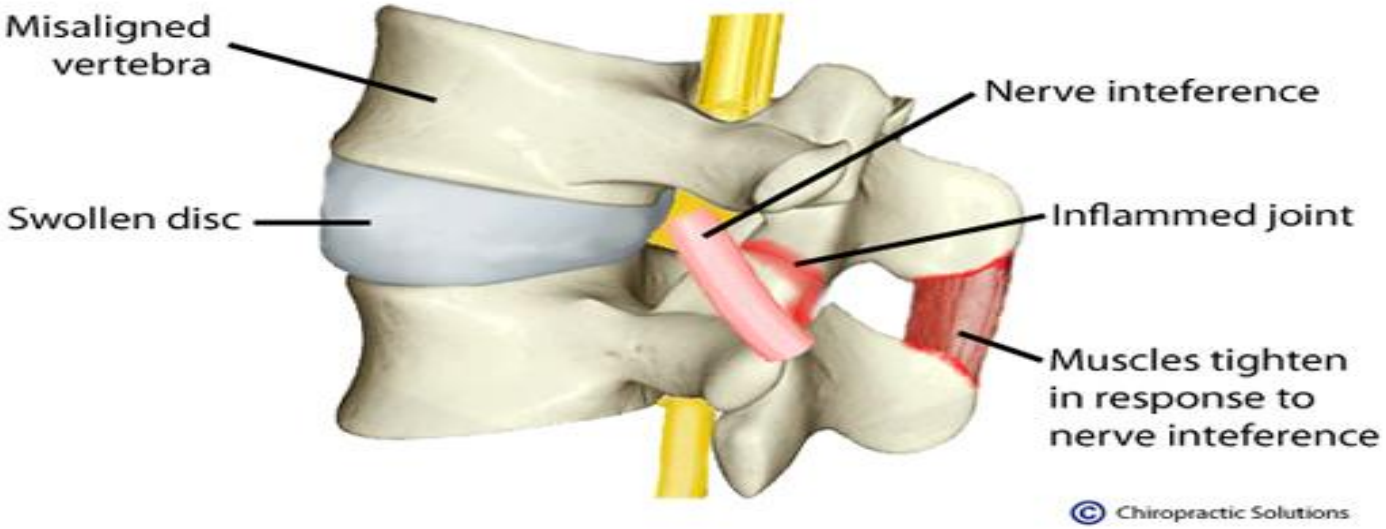
- **Fracture**
- Fracture is defined as complete or incomplete disruption in the continuity of bone.
- **Dislocation**
- Dislocation is defined as the complete disruption of the alignment of the articular surfaces of the joint.
- **Subluxation**
- Subluxation is defined as the incomplete disruption of the a ligament of articular surfaces.


R

Normal



Subluxated



Evaluation of fracture

- Complete radiographic evaluation of fracture should include:
- site and extent of the fracture
- type of fracture
- alignment of the fractured fragment
- direction of fracture line
- dislocation or Subluxation of the adjacent joint
- associated abnormalities

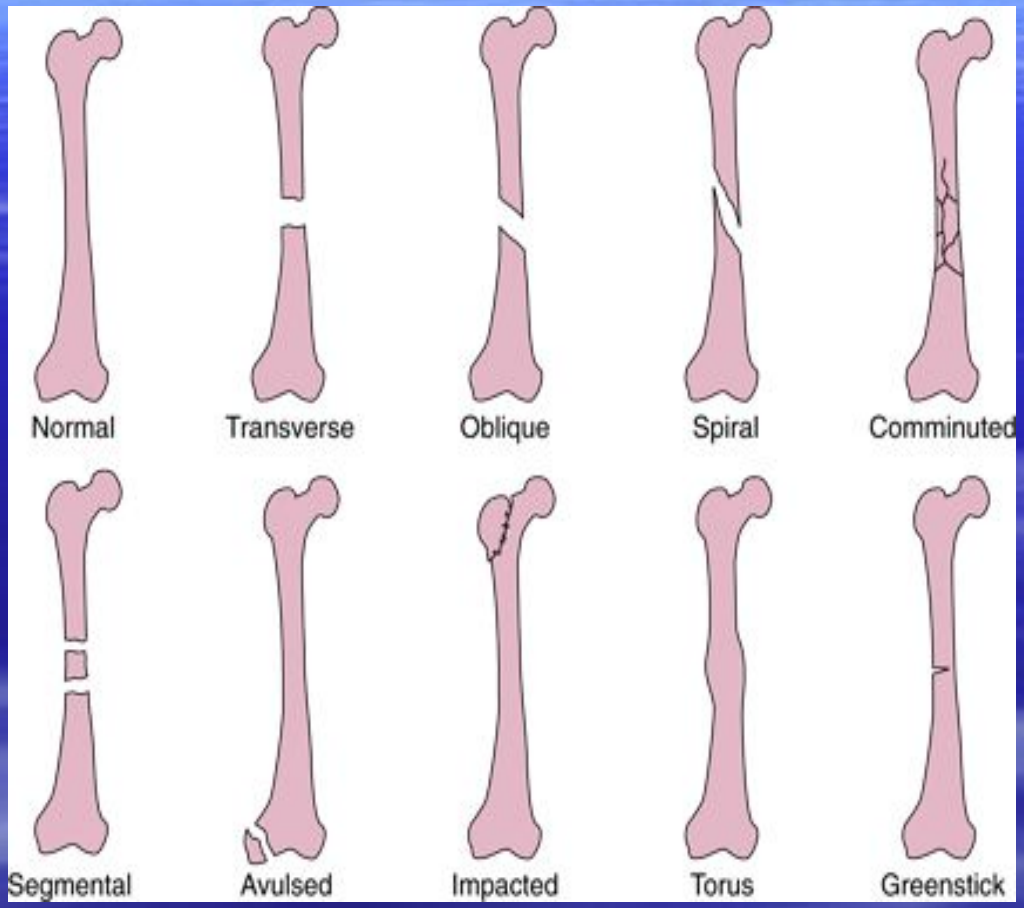
Types of fractures

- based on the fracture line and the number of fractured fragments fractures are classified into:
  - *simple fracture:* here single fracture line is seen with two fracture fragments
  - *comminuted fractures:* here multiple fracture fragments are seen
- based on whether the fracture is exposed to the external surface or not, the fractures can be classified into:
  - *closed fractures:* here there is no communication of the fracture with the exterior
  - *open fractures:* here the fractured fragments are exposed to the exterior trough a skin wound

- based on the etiology of the fracture, they can be further subdivided into:
  - *pathological fracture:* they are secondary to an underlying bone pathology
  - *fractures involving growth plate:* based on the pattern of involvement of the growth plate further classification is done by Salter and Harris
  - *greenstick and torus fractures:* these are the incomplete fractures of the cortex seen in children

Types of fracture lines

- horizontal
- oblique
- spiral
- vertical


Normal
Transverse
Oblique
Spiral
Comminuted
Segmental
Avulsed
Impacted
Torus
Greenstick

Simple fracture

Comminuted fracture

Open fracture

Fracture types

Greenstick (incomplete)

Transverse

Simple

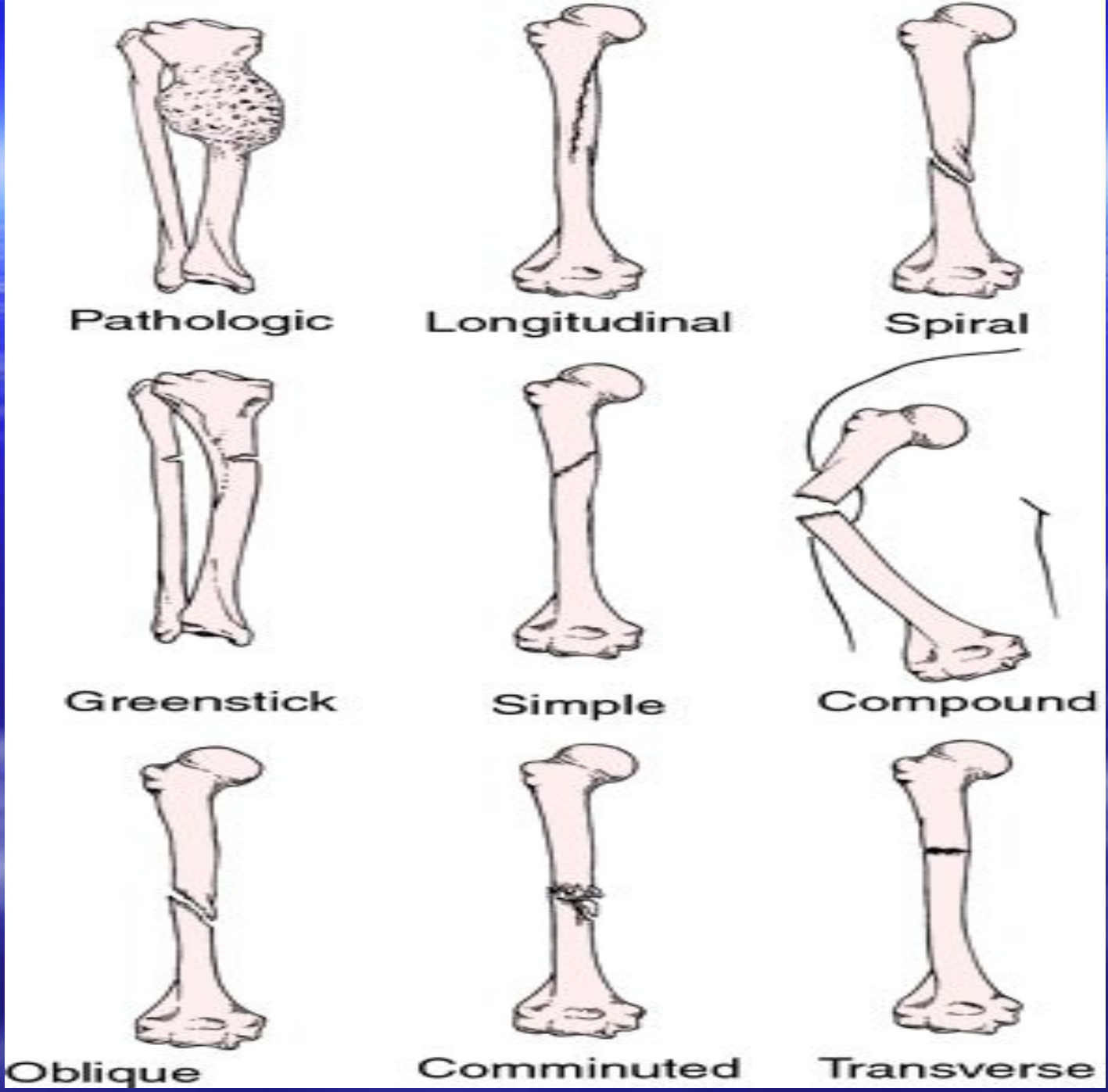
Fracture types

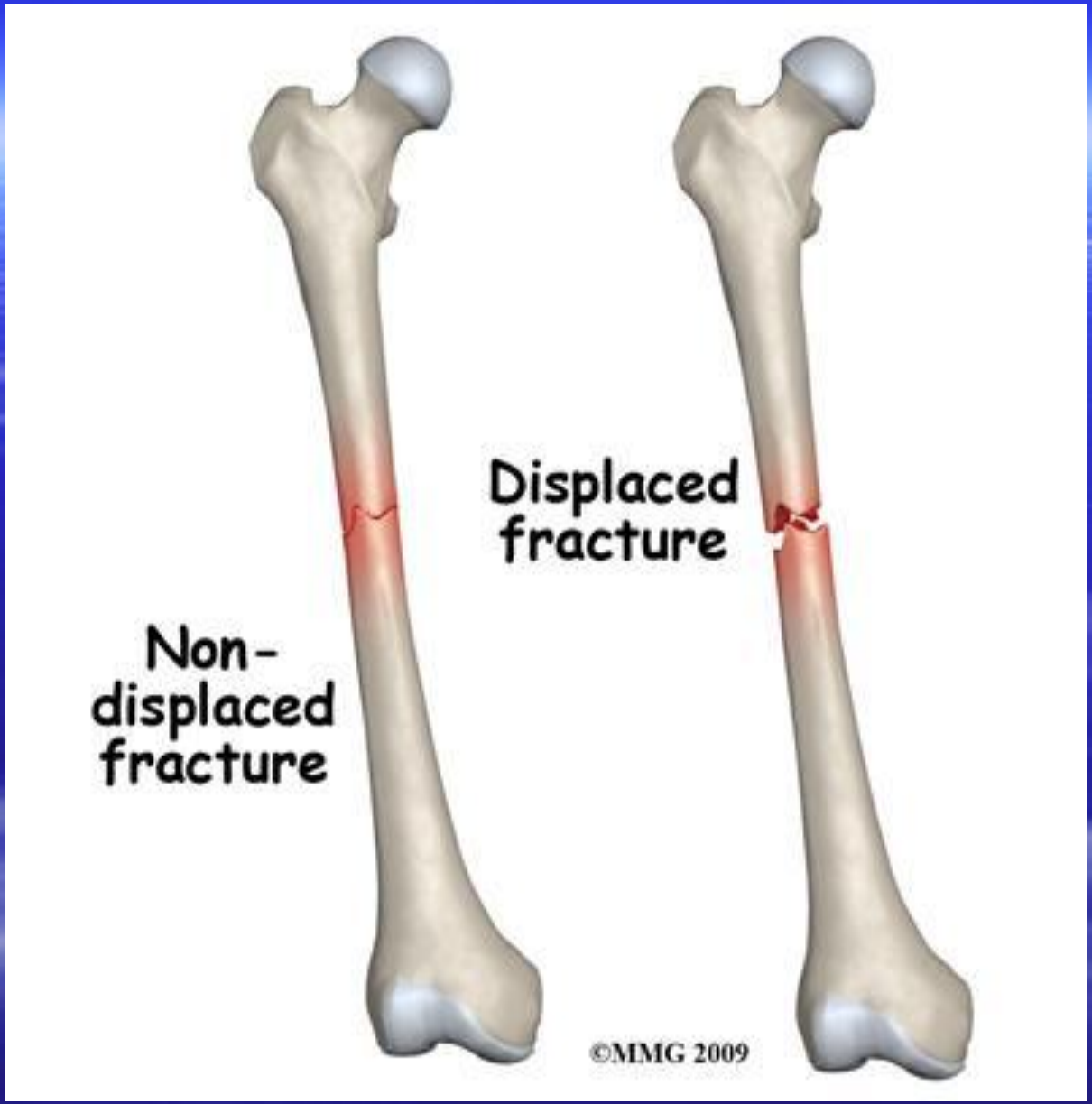
Oblique

Comminuted

Spiral

Compound

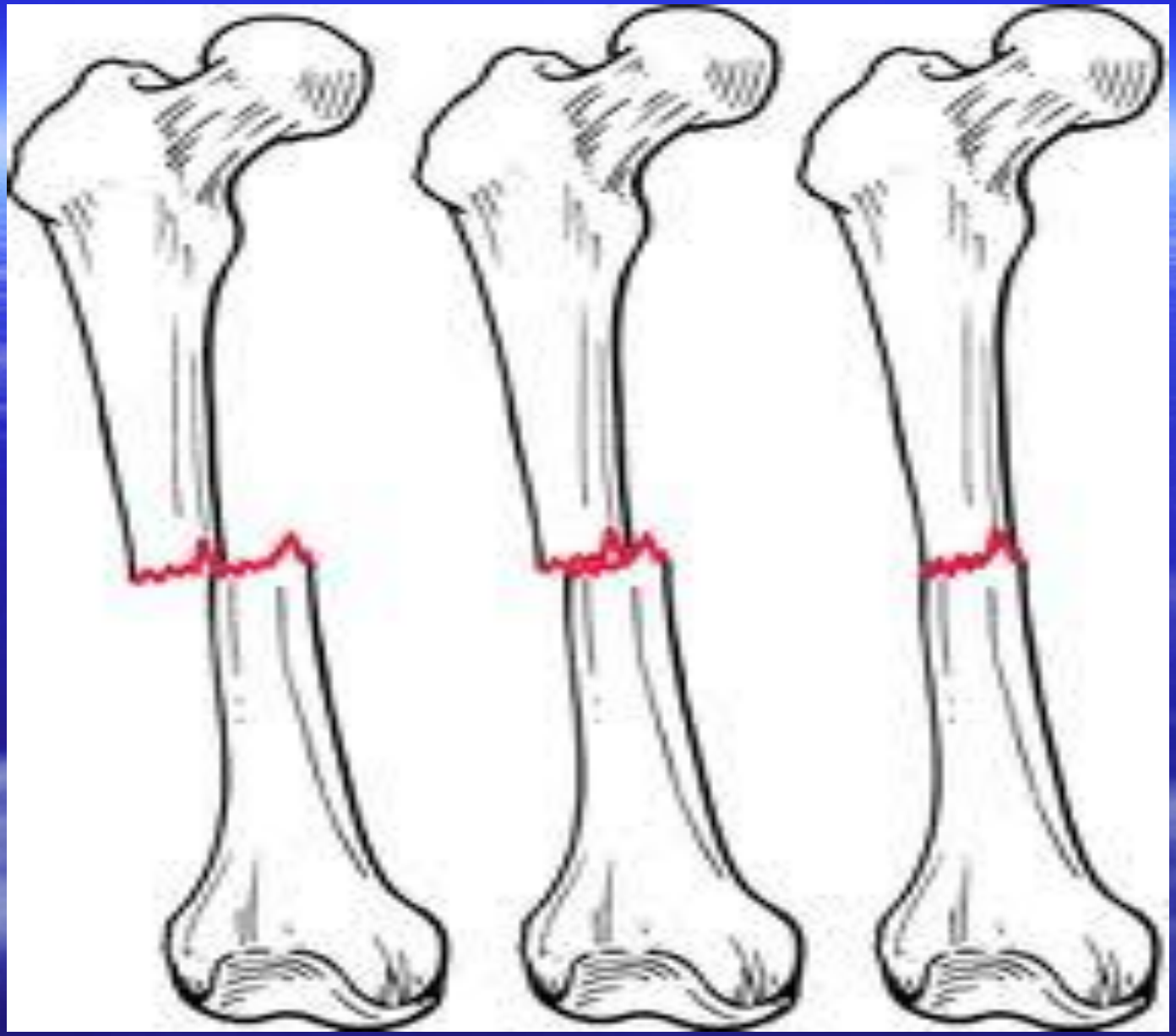

Pathologic
Longitudinal
Spiral
Greenstick
Simple
Compound
Oblique
Comminuted
Transverse


Displaced fracture
Non-displaced fracture
©MMG 2009

Oblique **fractures** of the radius and ulna.

Types of displacement of fractured fragments

- medial displacement
- lateral displacement
- medial angulation (or lateral angulation of distal fragment-valgus configuration)
- lateral angulation (or medial angulation of distal fragment-varus configuration)
- internal rotation
- external rotation
- overriding with foreshortening (bayonet apposition)
- distraction



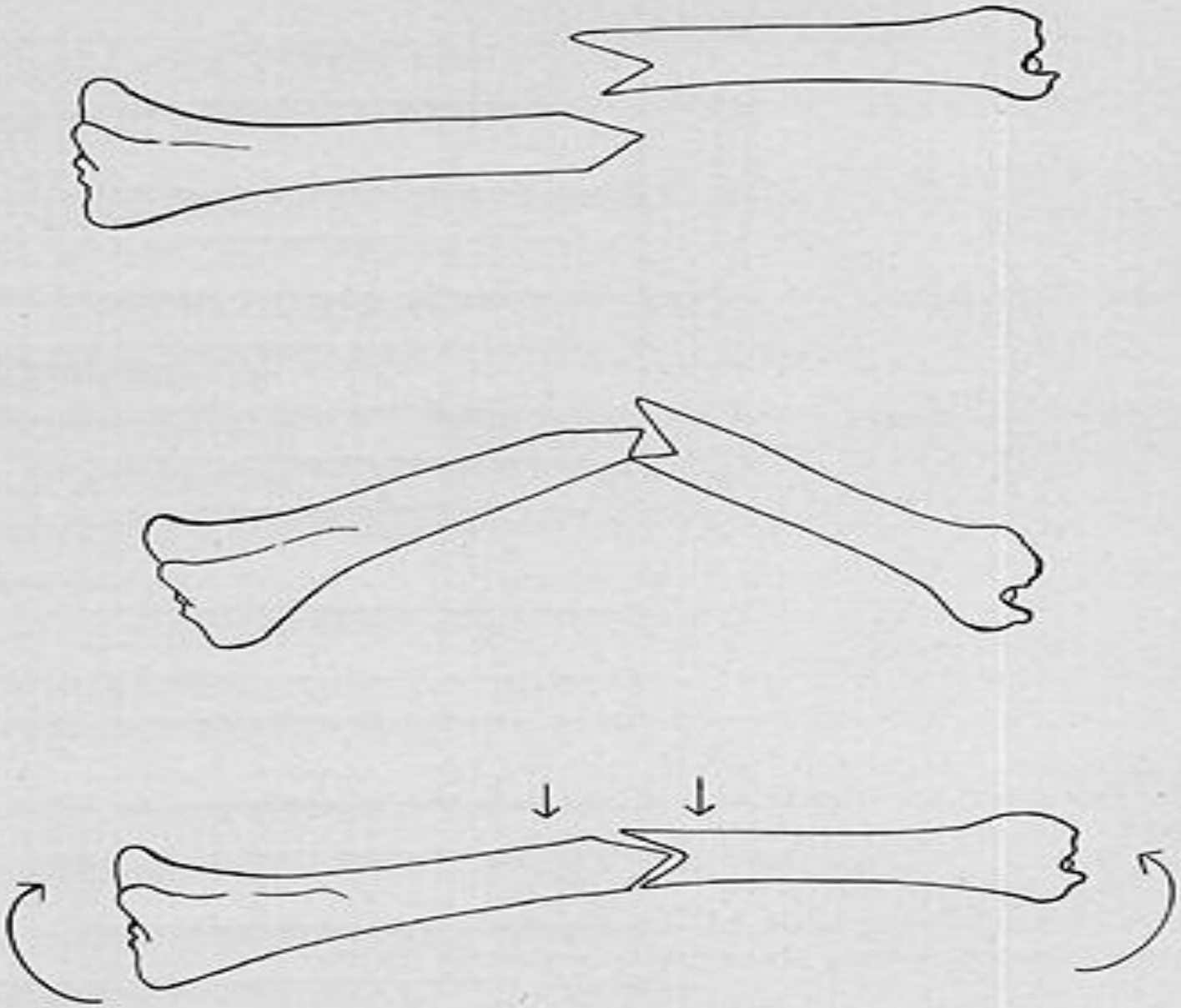
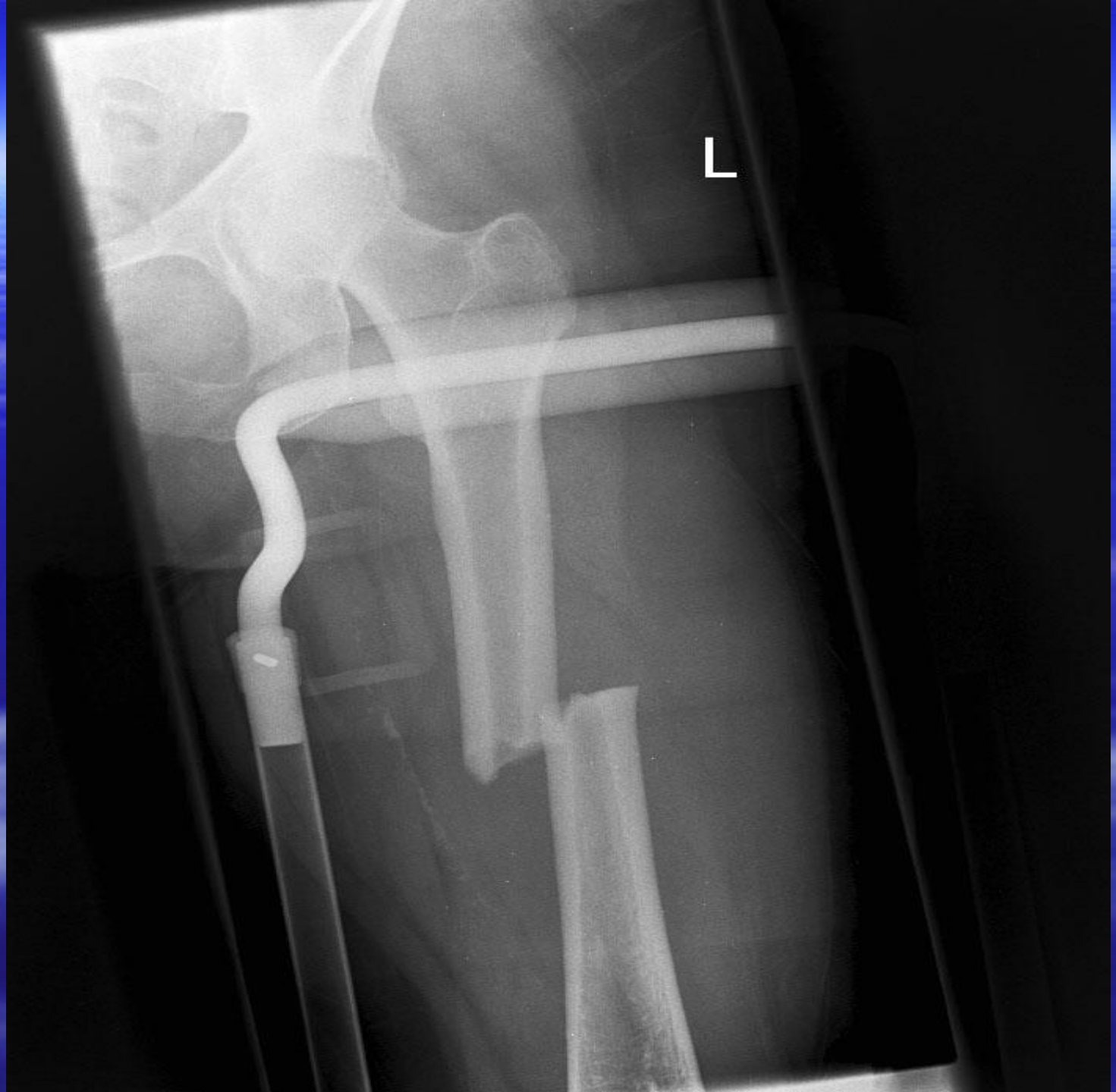


FIG. 12-23 Illustration of the method of "toggling" to achieve fracture reduction. Bone fragments must be placed in correct rotational orientation and angled to provide edge-to-edge cortical contact. Gradual straightening of the bone is accomplished by digital pressure applied away from sharp fracture ends.

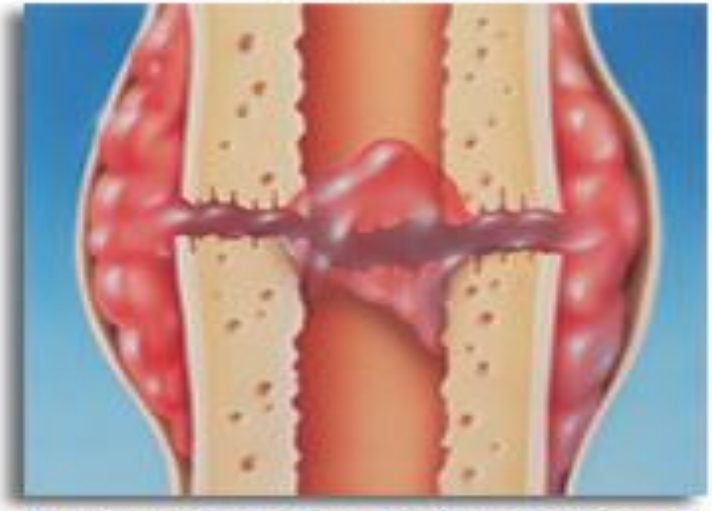

L

Mechanism of fracture healing

- *primary union* – this type of healing is seen in undisplaced and perfectly reduced fractures and the healing occurs by endosteal callus formation
- *secondary union-* this type of healing in displaced fractures and the healing is by periosteal callus formation

Fracture Healing Process

Week 1



Hematoma (or Inflammation)

Weeks 2-3

Soft Callus

Weeks 4-16

Hard Callus

Weeks 17 & Beyond

Remodeling

www.bonefixator.com

Stage 1 : Impact

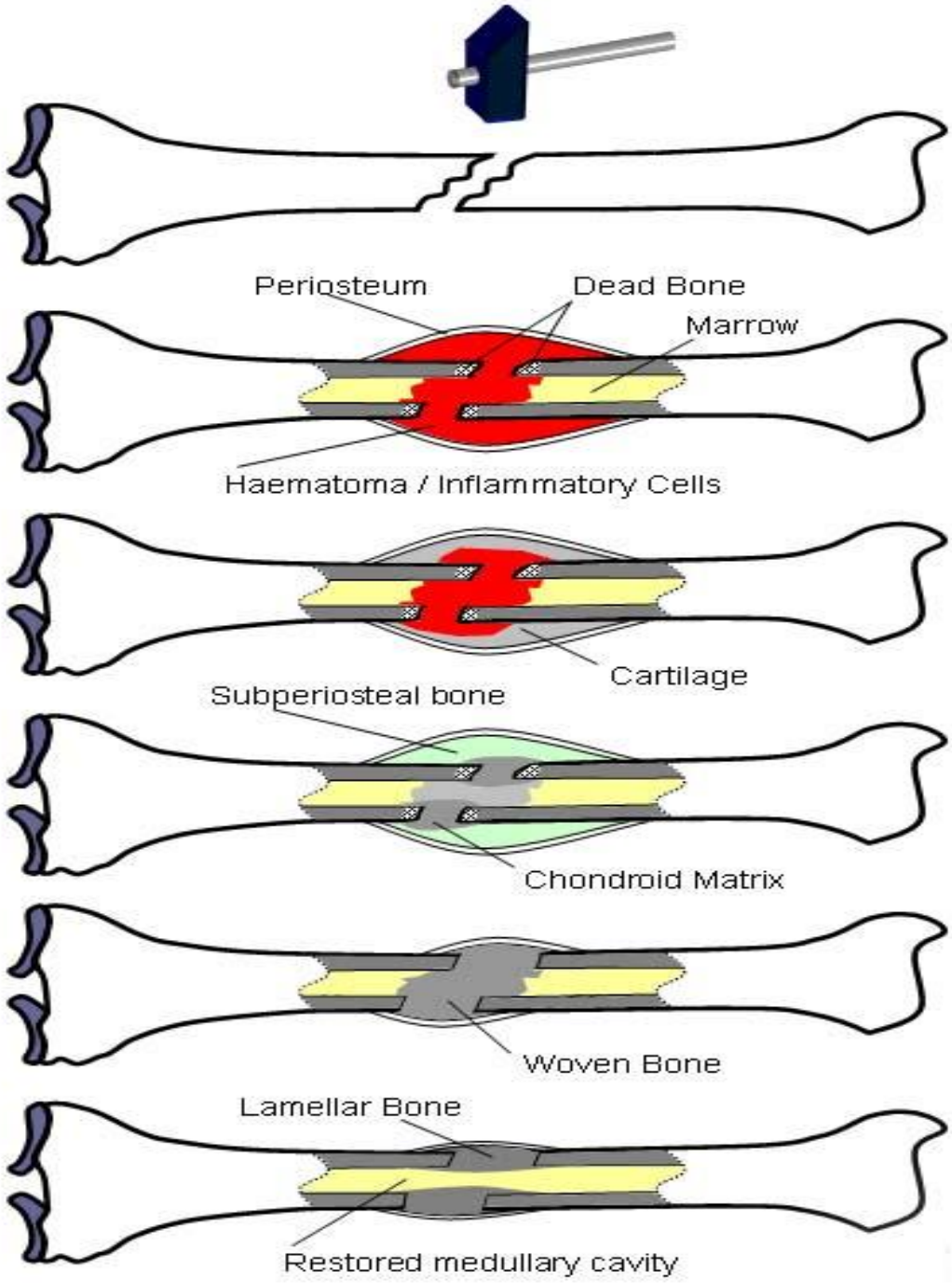
Stage 2 : Induction

Stage 3 : Inflammation

Stage 4 : Soft Callus

Stage 5 : Ossification

Stage 6 : Remodelling




callus


Pre-op
Post-op
7 Weeks
15 Weeks

Complications of bone healing

- *mal-union* – this is the most common complication of fracture healing; here the fracture healing occurs in the mal-aligned fracture fragments
- *delayed union-* the fracture healing is delayed for 16-18 wks due to underlying infection or improper immobilization
- *non union* – no healing will be noted in the fractured fragments and the margins are sclerosed
- *disuse osteoporosis and reflex sympathetic dystrophy syndrome*

- *myositis ossificans:* due to prolonged immobilization and soft tissue ossification mainly around the hip region
- *osteonecrosis:* interruption of the vascular supply leads to avascular necrosis; this complication is common with fracture of scaphoid and fracture neck of femur
- *injury to major blood vessels*
- *growth disturbance*
- *post traumatic arthritis*

Glenohumeral dislocations

- ***Anterior dislocation***
- This is the most common type of gleno-humeral dislocation.
- Humeral head is dislocated anterior to glenoid fossa.
- Force which predisposes to anterior dislocation is the combination of abduction, extension and external rotation.
- The bone lesions associated with recurrent anterior dislocations of the shoulder

- ***Posterior dislocation***

- less common
- force predisposing to the posterior dislocation is – adduction, flexion and internal rotation
- humeral head is displaced posterior to glenoid fossa

Osteoporosis

- Osteoporosis is a condition in which there is a reduction of bone mass.
- ***Presentation***
- asymptomatic
- bone pain
- skeletal fractures
- vertebral compression fractures

Radiological investigations

- plain films
- CT scan
- Radioisotope scan

Radiological features

- decrease in the number of trabeculae
- coarse striations
- the vertebral bodies appear lucent with thin cortical lines
- biconcave appearance (“cod fish” vertebrae)
- vertebral wedging and collapse
- kyphosis
- fractures of the peripheral skeleton, including femoral neck fractures, commonly occur even after minor trauma

Causes of generalized osteoporosis

- senile osteoporosis
- postmenopausal
- steroid therapy
- immobility (prolonged bed rest)
- endocrine (Cushing's disease)
- multiple myeloma
- nutritional deficiency syndrome(scurvy, malnutrition, chronic liver disease, malabsorption syndrome)


R

Ankylosing spondylitis

- Ankylosing spondylitis, a progressive inflammatory disease, usually affects young adult males, often with a family history of the disease.

- ***Presentation***
- repeated attacks of backache and stiffness
- anorexia and weight loss

Radiological features

- On plain films the following features may be seen:
- *sacroiliac joints:* the earliest changes begin in the sacroiliac joints with symmetrical blurring and poor definition of joint margins; later, erosion and bony sclerosis lead to tendency for complete sacroiliac joint fusion; both joints are commonly affected

- *spinal changes:* the entire spine may be involved but changes usually commence in the lumbar region and progress upwards to involve the thoracic and cervical spine; the features most commonly noted are: squaring of the vertebral bodies due to new bone formation in the anterior vertebral bodies, and filling in of the normal anterior concavity by longitudinal ligamentous calcification; calcification of the lateral and anterior spinal ligaments to produce the classical “bamboo spine”
- *peripheral joint involvement:* an erosive arthropathy may accompany ankylosing spondylitis, the hips being the commonest joints involved

Complications

- upper-lobe fibrosis
- aortic incompetence: from an aortitis of the ascending aorta
- inflammatory bowel disease: a colitis resembling Crohn's disease or ulcerative colitis
- atlanto-axial subluxation
- fractures: spinal rigidity causes increased susceptibility to trauma
- ventilatory failure: due to restrictive chest movements and ankylosis of the costovertebral joints
- iritis

Osteomyelitis

- infection of the bone
- routes of spread may be haematogenous or direct spread from the infected joint or infected wound
- staphylococcus is the most common organism
- in infants the site of predilection is metaphyseal with epiphyseal extension; in children it is metaphyseal while in adults it is epiphyseal

- There are two types of osteomyelitis: acute and chronic.

Acute osteomyelitis

- presents with an acute episode of pain and reduced functioning of the part with the systemic ill-health
- more common in boys

Imaging features

- initial radiographs are normal as bone changes are not visible upto 10-14 days of infection; Tc99 radionuclide scan shows increased uptake after 2-3 days
- MRI also picks up early osteomyelitis where in the normal marrow signal intensity is lost in T1 weighted images due to oedema with soft tissue swelling
- Typically acute osteomyelitis affects metaphysis of long bones, usually femur and tibia
  - features are soft tissue swelling with blurring of fat planes
  - focal osteopenia (rarefaction) of the bones seen in the metaphyses with periosteal reaction

Fig. 3: Roentgenogram of left hand. The proximal phalanx of the fourth digit shows well-organized, periosteal thickening.

Chronic osteomyelitis

- sequelae of acute osteomyelitis
- in chronic osteomyelitis, bone becomes thickened and sclerotic with loss of differentiation between cortex and medulla

Imaging features

- 2-6 weeks after acute infection, there is progressive destruction of cortical and medullary bone with increased endosteal sclerosis, indicating reactive new bone formation and periosteal reaction
- In 6-8 weeks, “sequestra” which are areas of necrotic bone become apparent; they appear more sclerotic (more dense) because of the relative decrease in density in the adjacent bone and lack or remodeling

- They are surrounded by dense involucrum which represents a sheath of periosteal new bone

- Defects in the involucrum which allow the discharge of pus to the skin via the sinus tract are called cloaca

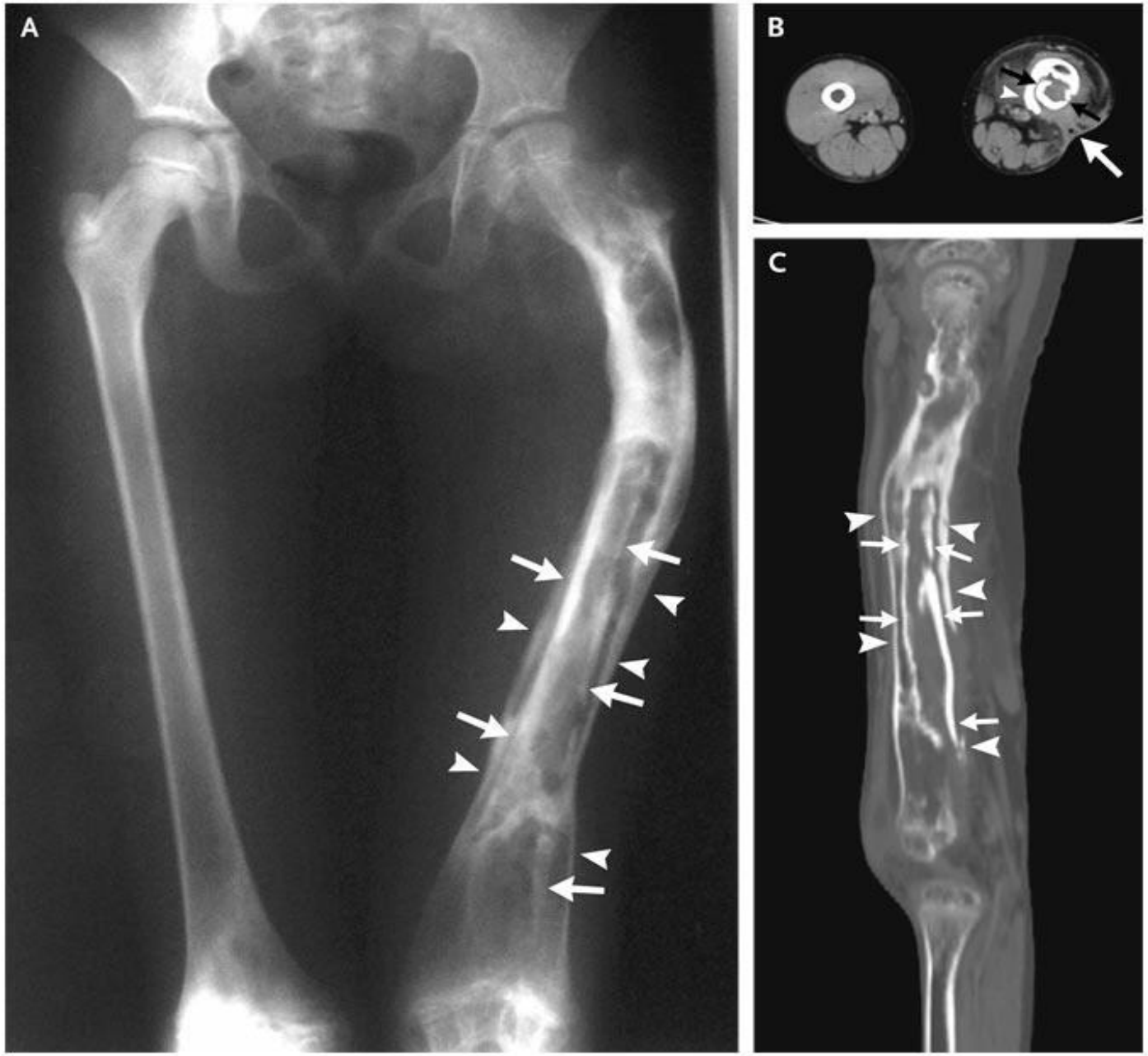
- In later stages, there is sclerosis resulting in loss of corticomedullary differentiation

CT scan:

- it demonstrates changes in subacute or chronic osteomyelitis well, especially those related to cortical bone or periosteum
- sequestra, as on conventional films, are shown as areas of dense or right attenuation spicules of bone lying in areas of osteolysis
- cloacae, periostitis and local soft tissue masses are shown

MRI

- demonstrates osteomyelitis as early as isotopic scanning and when available is the modality of choice in the diagnosis of musculoskeletal infection
- demonstrates soft tissue edema
- ischemia
- destruction of cortex or marrow can be seen at early stage
- soft tissue extension of pus through cloacae and para-osseous abscesses may be seen


A
B
C

Special forms of osteomyelitis

- ***Sclerosing osteomyelitis of Garre***

- manifested by the gross sclerosis in the absence of apparent bone destruction
- bone appears thickened due to periosteal new bone formation and loss of corticomedullary differentiation

Brodie's abscess

- sub acute infection
- usually seen in the cancellous tissue near the end of long bone
- well-circumscribed areas of bone destruction, which is surrounded by intense sclerosis

Multiple myeloma

- Multiple myeloma is primary malignant tumor of bone marrow, in which there is infiltration of the marrow-producing areas of skeleton by a malignant proliferation of plasma cells.

- The skull, spine, pelvis ribs, scapulae and the proximal axial skeleton are primary involved with destruction of marrow and erosion of bony trabeculae; the distal skeleton is rarely involved.

- The disease may occur in a dissemination form, or as a localized solitary enlarging mass. Multiple myeloma is the most common primary tumor of bone and tends to be confined to the skeletal system.

Presentation

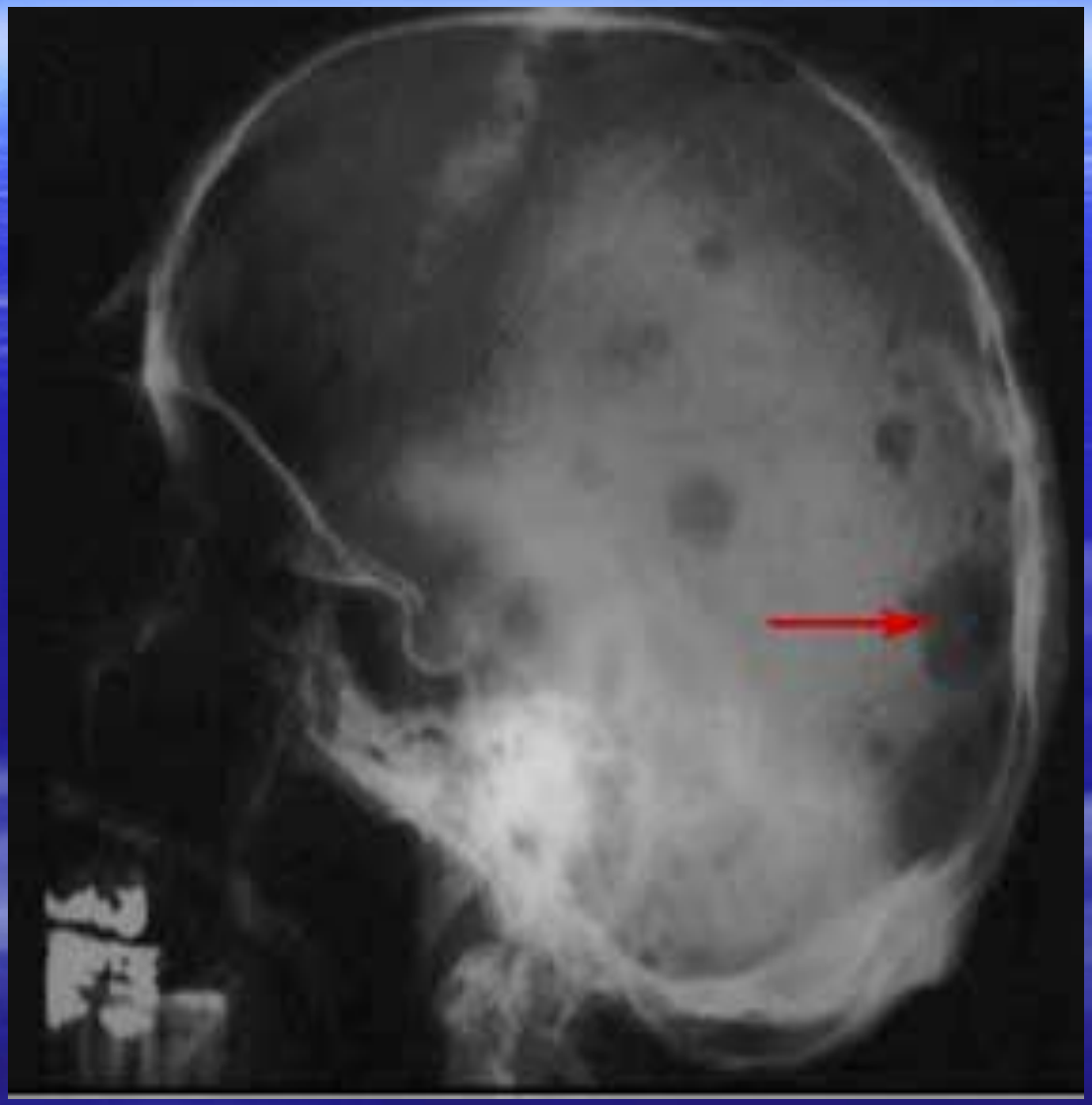
- a male predominance, usually in the over-40 age group
- bone pain
- backache
- vertebral body collapse
- pathological fracture
- Bence-Jones proteinuria

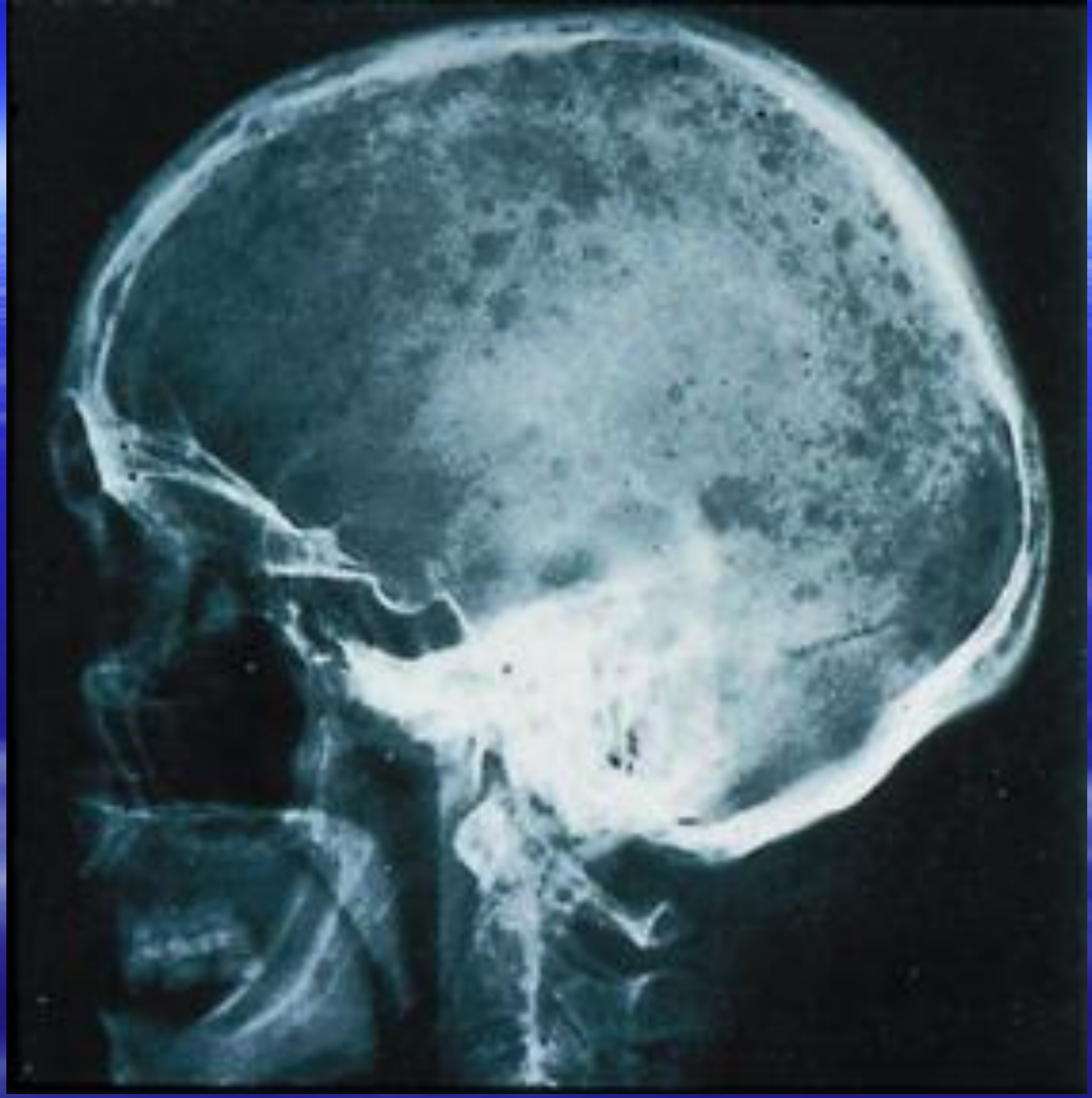
Radiological features

- generalized osteoporosis with a prominence of the bony trabecular pattern, especially in the spine, resulting from marrow involvement with myeloma
- pathological fractures are common
- compression fractures of the vertebral bodies, indistinguishable from those of senile osteoporosis
- scattered “punched-out” lytic lesions with well-defined margins, those lying near the cortex produce internal scalloping
- bone expansion with extension through the cortex, producing soft-tissue masses

Complications

- pathological fractures that heal with abundant callus
- hypercalcaemia secondary to excessive bone destruction
- renal failure may result from a combination of amyloid deposition, hypercalcaemia and tubular precipitation of abnormal proteins
- increased incidence of infections such as pneumonia
- hyperuricaemia and secondary gout





Bone metastases

- Bone metastases are the most common malignant bone tumors. Metastases disseminate mainly to marrow-containing bones, therefore they are more commonly found in the axial skeleton. Generally, spread distal to the knee and elbow is less likely than the proximal skeleton.

- Any primary tumor may metastases to bone, but the most frequent to do so are:

- *breast:* high incidence of bone deposits, usually lytic in nature but may be sclerotic or mixed; the commonest cause of sclerotic deposits in females

- *prostate:* almost always sclerotic, lytic deposits being rare; the commonest cause of sclerotic deposits in a male

- *lung:* lytic deposits; peripheral deposits in the hands and feet are rare, but if present are likely to be form a bronchial carcinoma

- *kidney, thyroid:* lytic and can be highly vascular with bone expansion

- *adrenal gland:* predominantly lytic

Presentation

- bone pain
- pathological fracture
- soft-tissue swelling
- staging or during follow-up of primary tumors

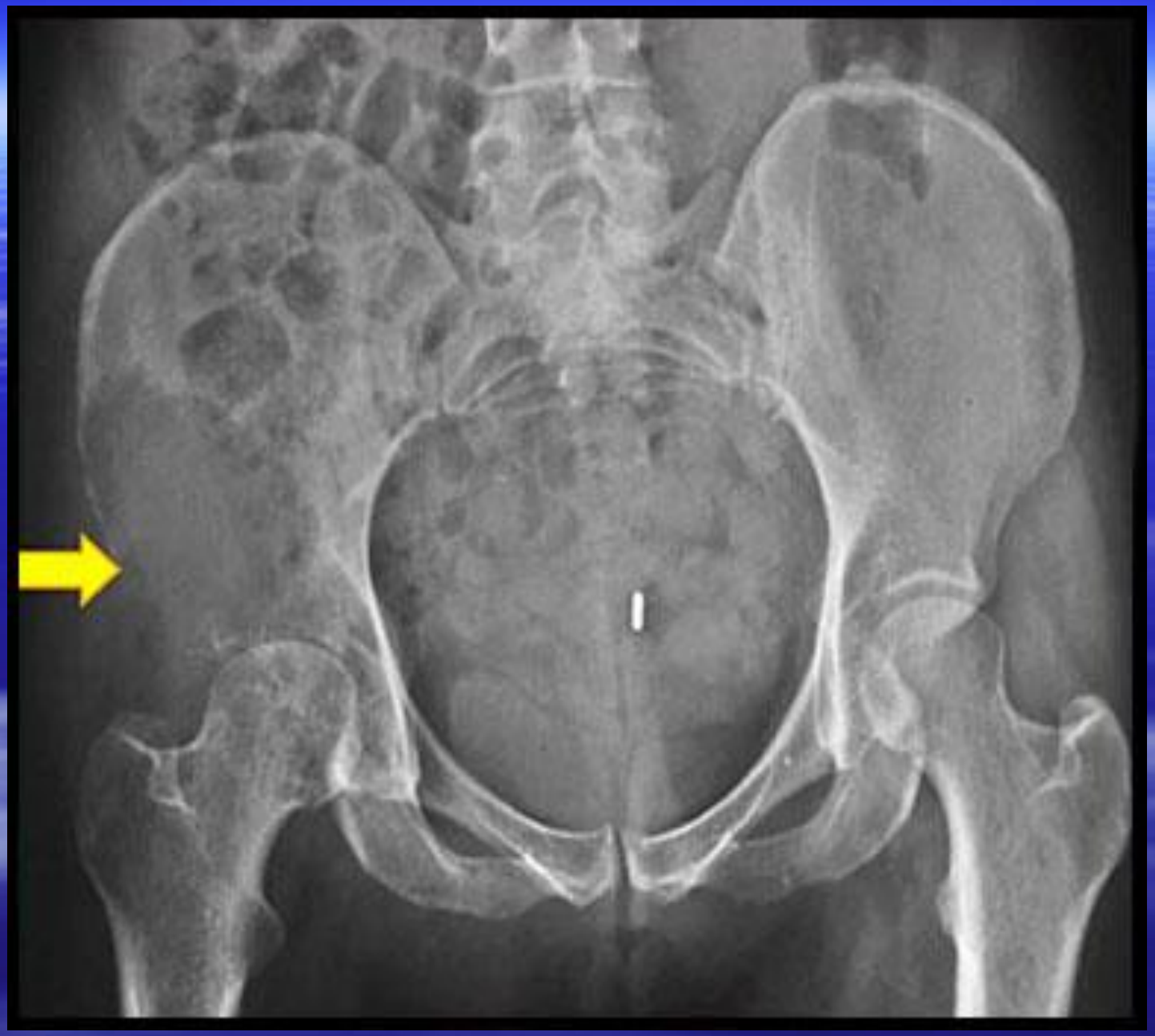
Radiological features

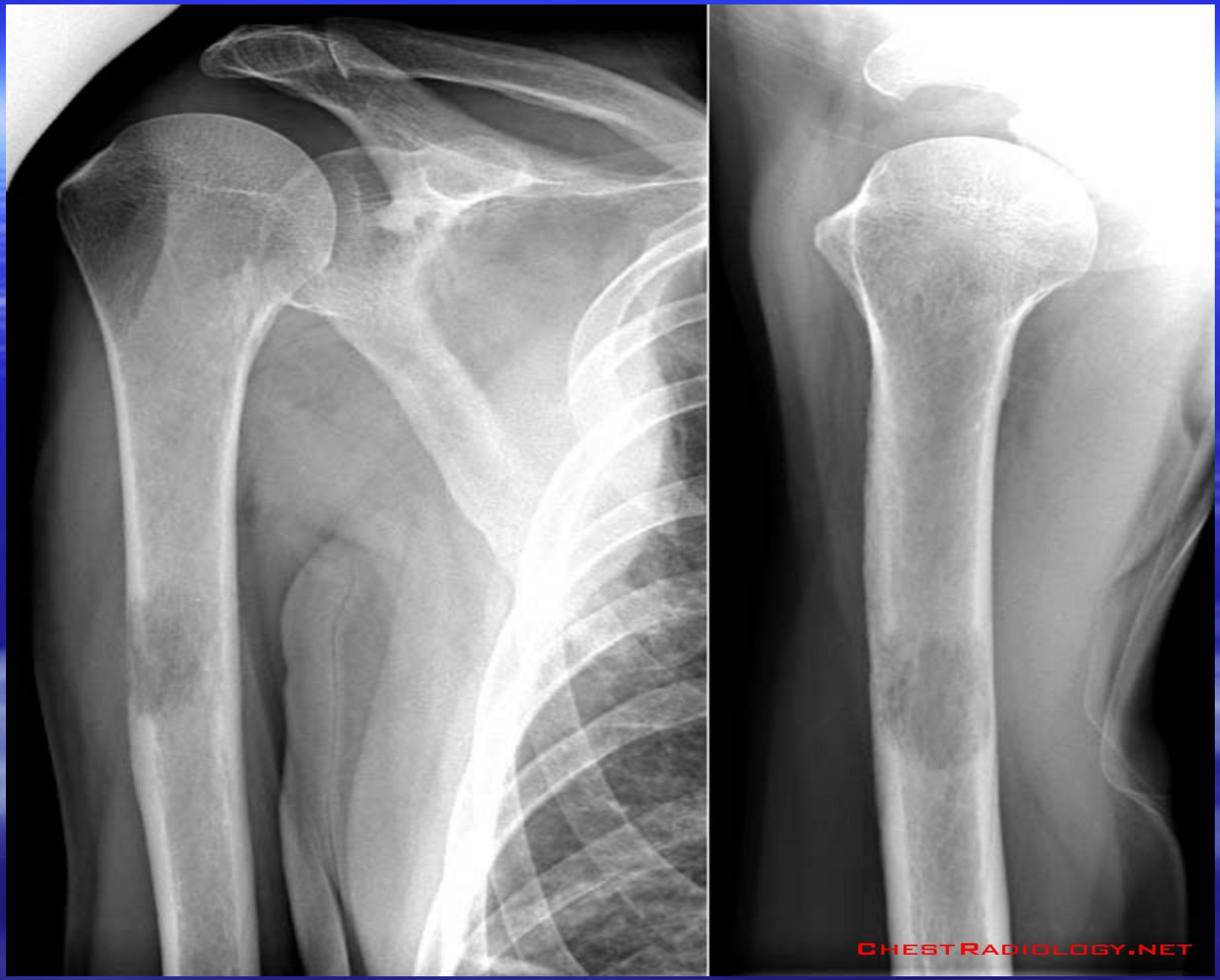
- *Lytic deposits*
- Destruction of bone detail with poor definition of margins and associated pathological fractures are the principal features. Periosteal reactions are rare compared to primary malignant tumors.

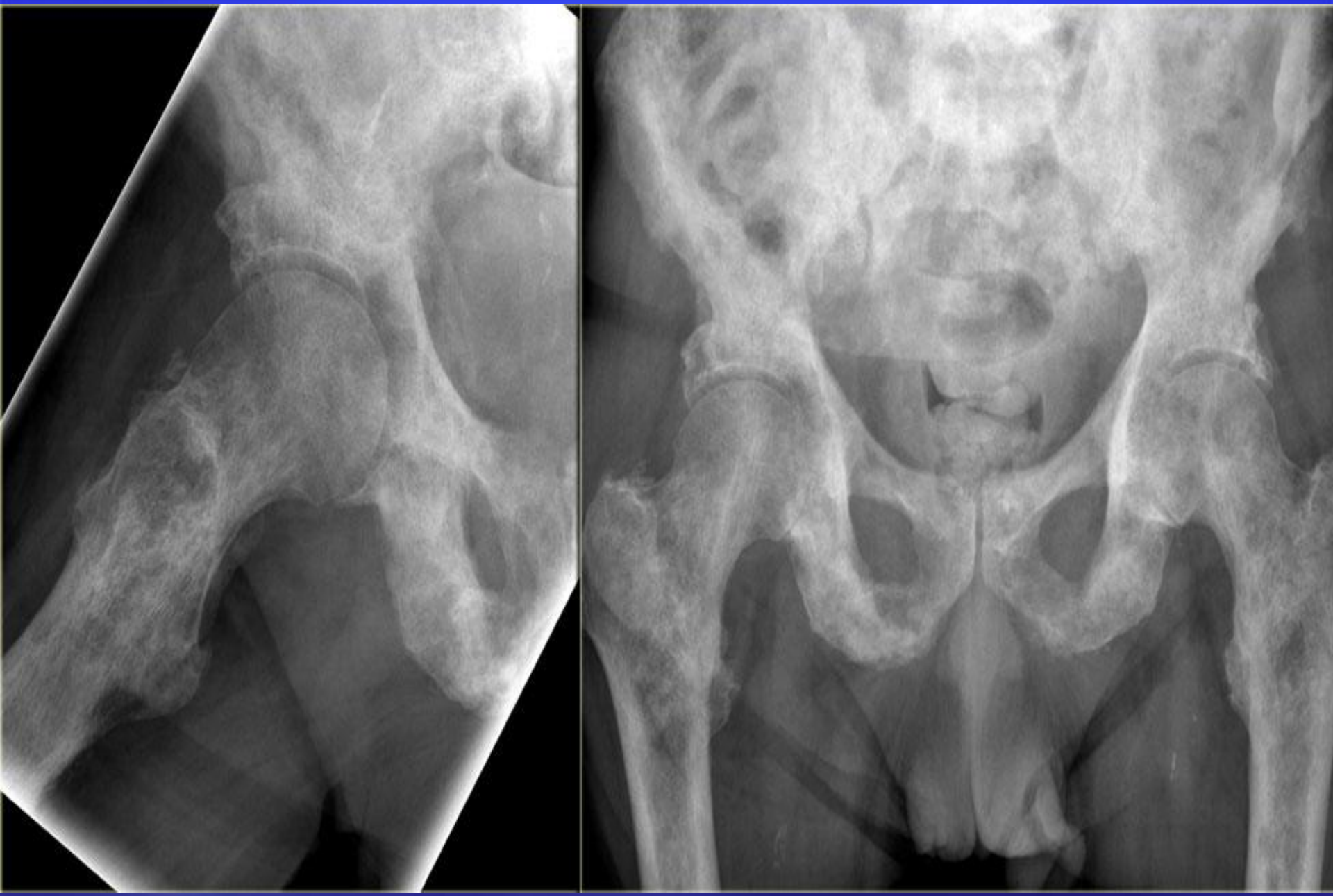
- *Sclerotic deposits*
- Show as an area of ill-defined increased density with subsequent loss of bone architecture. Vertebral secondaries may feature sclerotic pedicles. With multiple lesions, a diagnosis of metastases is almost certain. Isotope bone scanning is more sensitive than plain films (localized areas of increased uptake: hot spots).

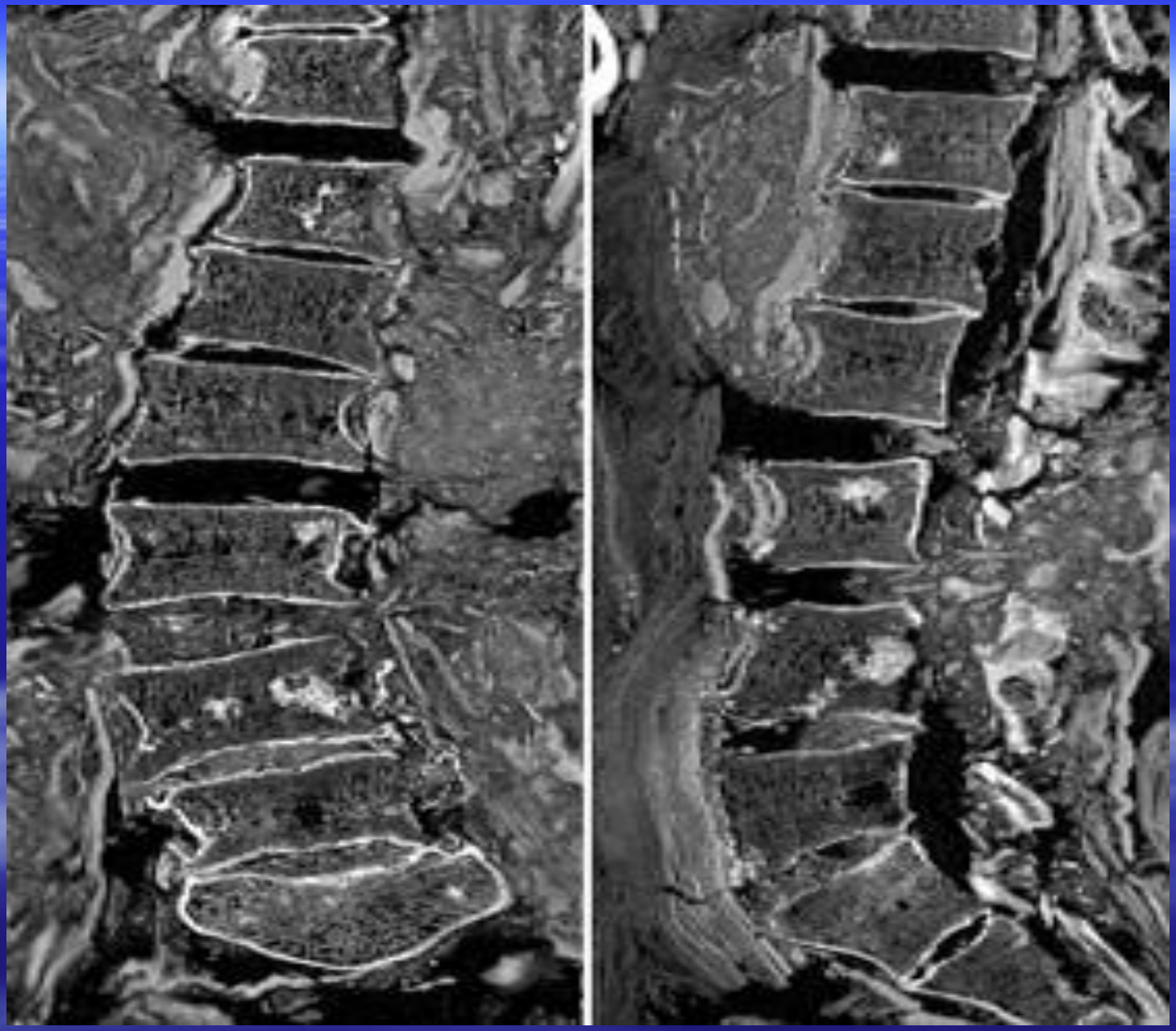
Differential diagnosis

- Paget's disease (sclerotic areas)
- Multiple myeloma (lytic areas)
- Primary tumor
- Infection or osteomyelitis




ChestRadiology.net





osteolytic-**sclerotic bone**

Paget's disease

- Paget's disease is a common disorder of bone architecture, of known aetiology, which occurs with increasing frequency after middle age. It is characterized initially by bone deposition results in bone expansion and abnormal modeling.

Presentation

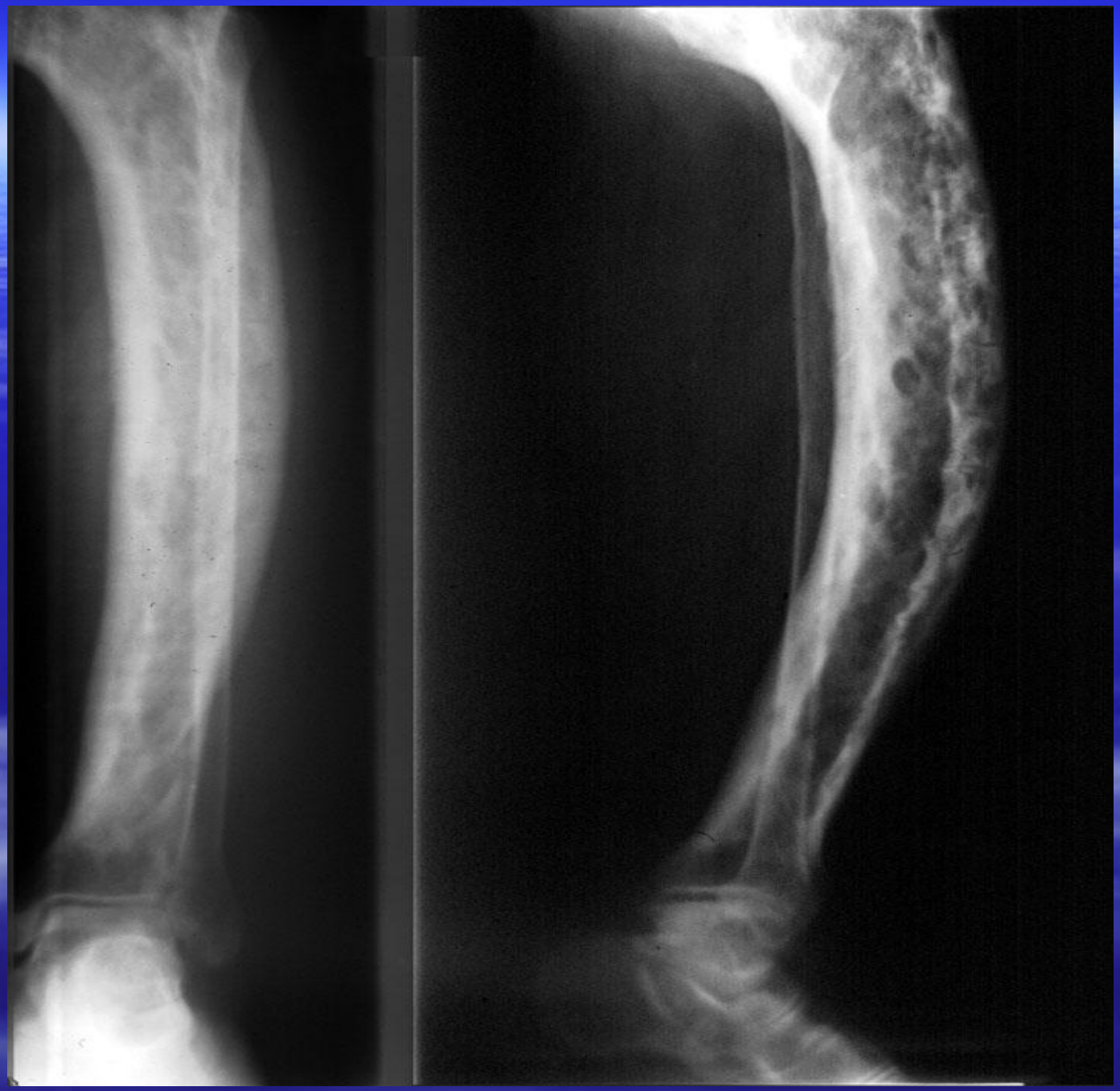
- Any bone may be affected.

- *Skull:* initially a large area of well defined bone loss may be seen; later, generalized sclerosis with diploic thickening produces a characteristic “cotton wool” appearance; they may be an increase in the size of the head

- *Spine:* most commonly involves a single vertebra with sclerosis, altered trabecular pattern and enlargement of the vertebral body
- *Pelvis:* frequently affected with coarsened trabecular pattern, cortical thickening and enlargement of the pubis and ischium
- *Long bones:* widening of bone with deformities, bowing of the tibia and incomplete fractures because of bone softening

Complications

- *pathological fractures*: tend to be sharply transverse
- *pseudofractures*: incomplete fractures found on the convex surfaces of bowed bones
- *malignant degeneration*: in widespread Paget's disease there is an increased incidence of malignant bone tumors, especially osteogenic sarcoma
- *cardiovascular:* increased shunting of blood in involved bone may cause high output failure, although this is rare
- *neurological:* nerve entrapment by bone expansion

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Osteoid osteoma

- ***Age:*** 2nd and 3rd decay

- ***Site:*** More common in the long bones in metaphyses or diaphysis of tubular bones like femur and tibia. Classical clinical presentation of sever bone pain aggravated in the night and relieved by aspirin.

Radiological appearances:

- round or oval lesion with a sclerotic margin
- the radiolucency consists of a small dense opacity known, as the nidus
- the size of lesion is upto 2.5 cm
- the lesion is surrounded by a varying degree of dense sclerosis


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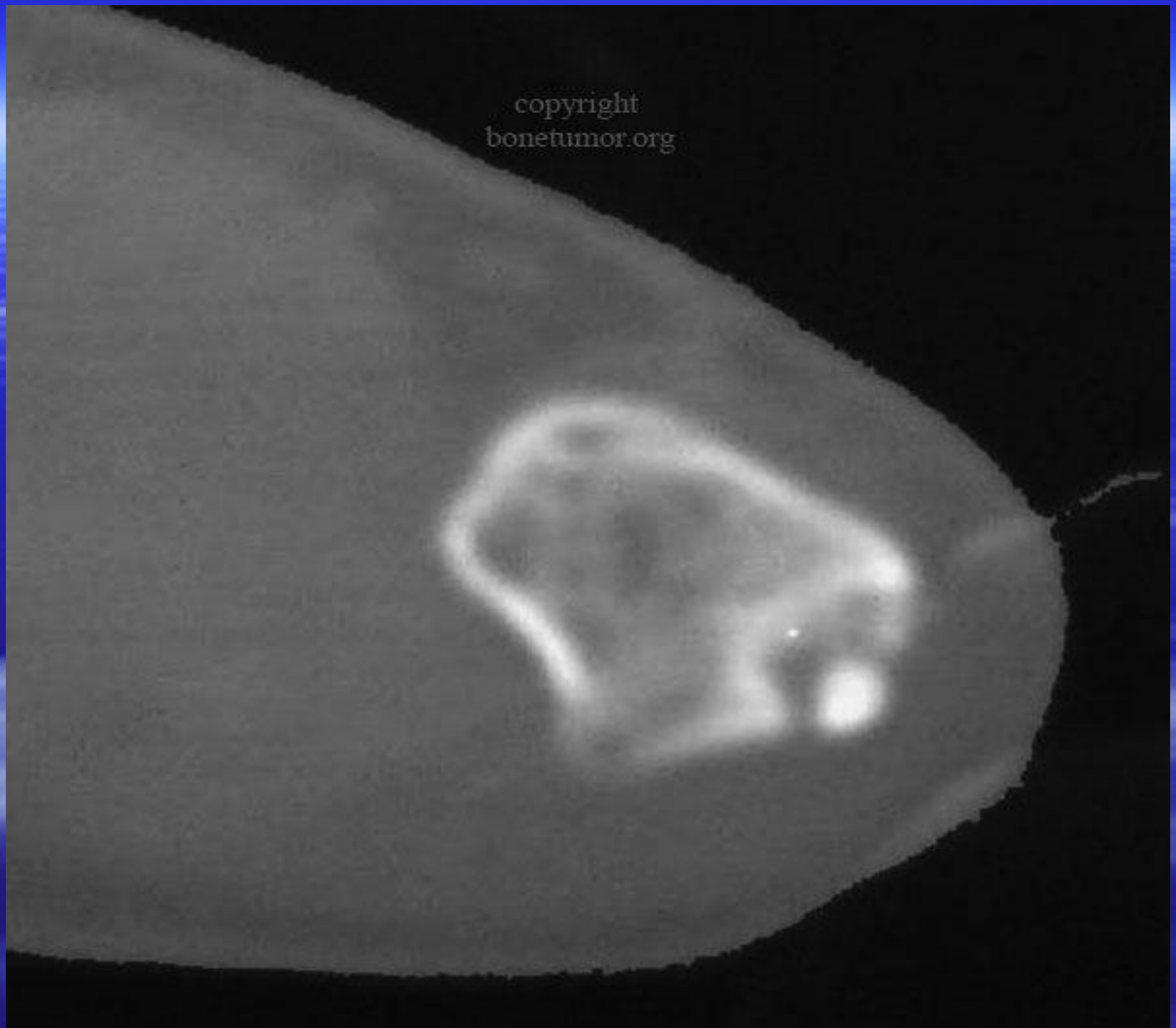
bonetumor.org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Simple bone cyst, pathological **fracture**