



Radiology of Bone Infections and Tumors

Objectives

1. Introduce Imaging approach to skeletal metabolic disorders and Identify important findings including sequelae and complications.
2. Introduce Imaging approach to skeletal neoplastic disorders and Identify important findings including sequelae and complications.

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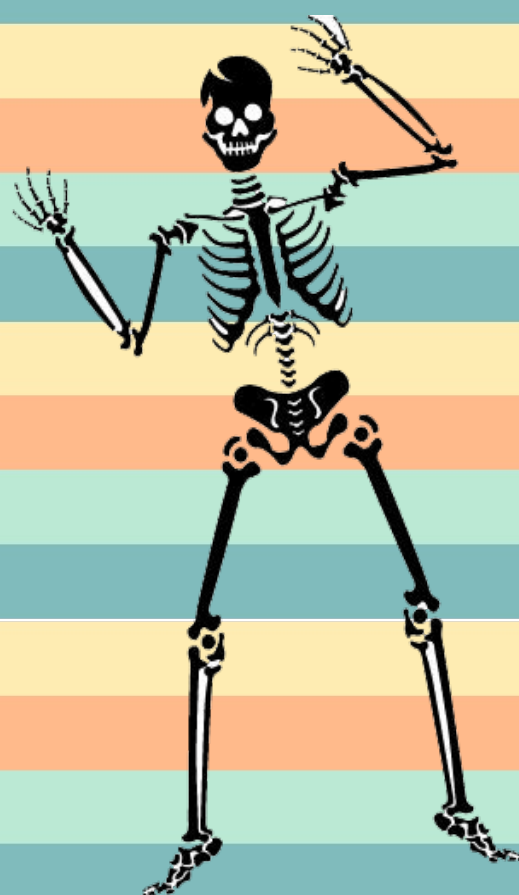


Basel Almeflh

Color Coding

Important | Notes | Extra

Editing
File



Imaging of the musculoskeletal system

Musculoskeletal system pathologies:

- Congenital.
- Arthritis.
- Metabolic.
- Trauma.
- Neoplastic.
- Infectious.
- Hematological.

Metabolic disorders:

1- Describe the bone density:

- Decreased - Increased. eg: (Osteoporosis, Osteomalacia, Osteopenia, Osteosclerosis).

Osteoporosis, Osteomalacia, Osteopenia: reduction in the bone density, while **Osteosclerosis:** increase or over production in the bone density.

2- Describe contexture (constitution):

- Corticomedullary differentiation & outline (Sharp & thinned → Osteoporosis, Hazy → Osteomalacia).
- Trabeculae = are the vertical lines in the medullary portion.

3- Describe Soft tissue changes:

- Density (Swelling, Increased, ..).
- Calcification, **Is it absent or present?** If present is it: (Heterotopic → within the soft tissue plane adjacent to bone or joint, Chondral → in cartilage that covers the articular surface (chondrocalcinosis), vascular, ...).

- **Osteoporosis:** is a loss in the bone matrix. Normally the osteoid matrix has a trabeculae within, so if we lose some of the matrix the trabeculae will be lost too resulting in a larger holes (the holes are filled with blood) therefore the bone become fragile and can be easily broken or fractured. It can be primary or secondary: 1) Primary which is usually seen in elderly, postmenopausal female patients. 2) Secondary to an underlying disease the can lead to osteoclastic activity resorption of the bone such as heparin.

- **Osteomalacia:** a deficit in the bone minerals. If we have an osteoid matrix with a normal calcium and phosphorus it will be more consolidated compared to a matrix which has a deficit in those two resulting in a softer bone that can be easily compressed or bend.

- **Osteopenia:** is not a disease it's a term the describes a reduction in the density of the bone. It can be applied to both osteoporosis & osteomalacia.

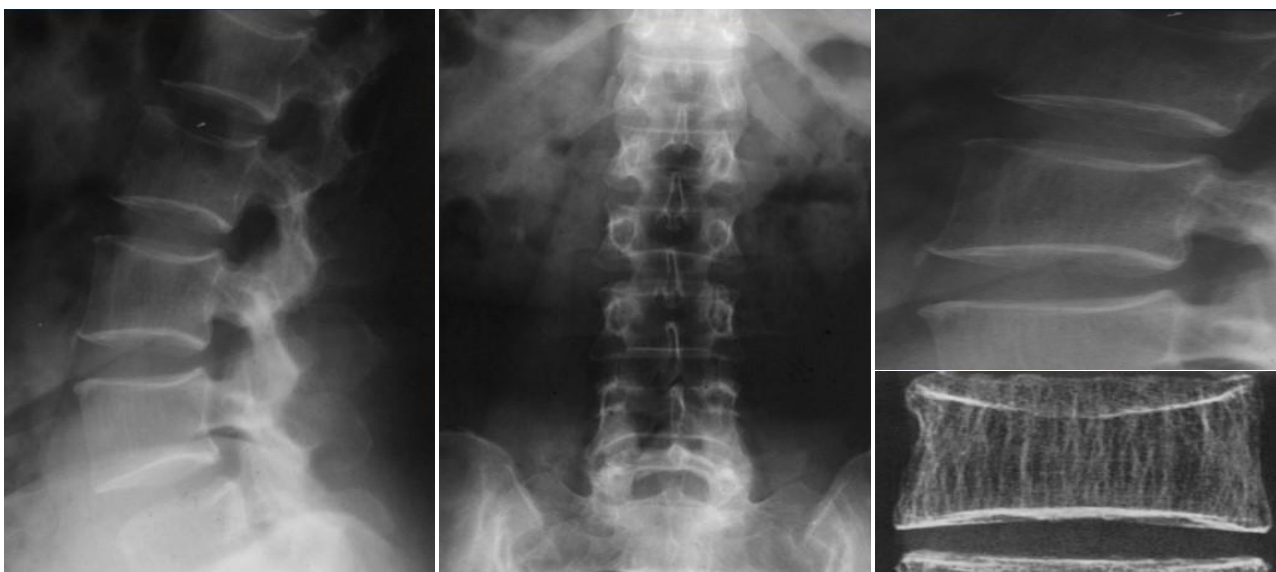
- **Bone lesions:**

osteolytic: destructive lesions.

osteosclerotic: proliferative lesions.

Case 1: Osteoporosis

54 years- old female with low back pain X-ray of lumbosacral spine requested

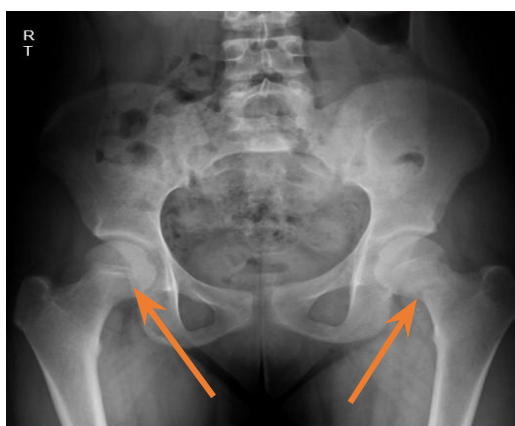


Findings:

- Generalized osteopenia.
- Sharp, thinned out cortices. The vertebral body cortex appears as a sharp pencil like dense cortex its called sharpening & thinning of the cortex (picture frame appearance).
- Sharp trabeculae.

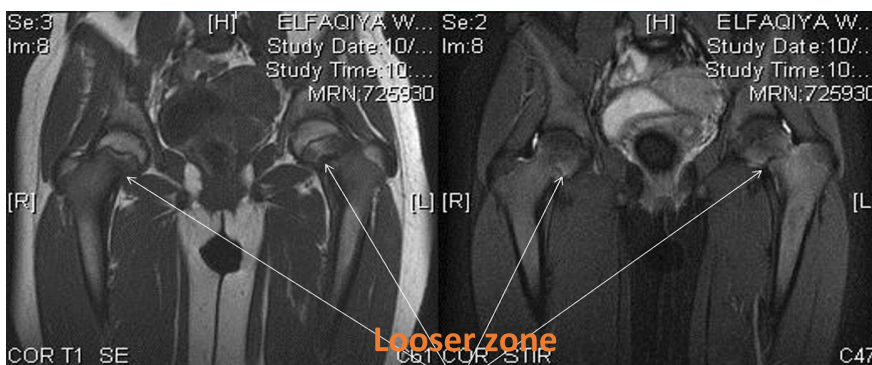
Case 2: Osteomalacia

20 years old lady, weakness and lower limbs pain



Findings:

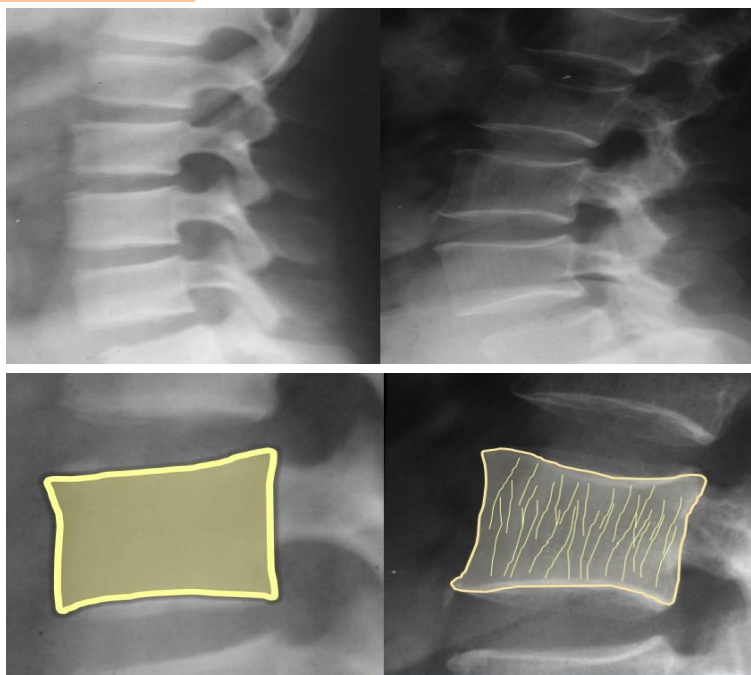
- Generalized mild osteopenia.
- Lucent area within the medial femoral neck (looser zone = faint lucent thin line along the medial aspect of the femur neck which is incomplete fracture).
- Lucent band at physeal plate region, at the physeal plate or growth plate. Normally in a 20 y/o the physeal plate is closed but here because of the loss of minerals it appears as a lucent band.
- Indistinct cortices at symphysis pubis & SI joints.



The looser zone sign appear bilaterally. It can be seen also in the inferior edge of the scapula, the ribs or the medial aspect of the long tubular bone of the lower limb. We used MRI to locate the fracture more precisely.

Osteoporosis vs. Osteomalacia

Osteomalacia
Patient A



Osteoporosis
Patient B

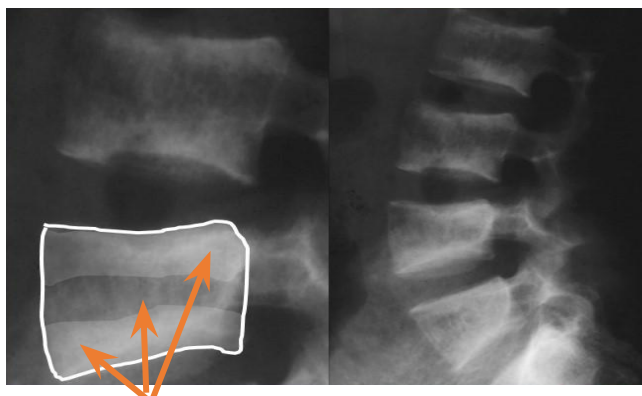
Both have osteopenia but for **patient A** the bone density looks increased because we have increased the density of the film that's why the soft tissues appear white or the image in total to highlight the changes of bone. It's called an apparent increase in density.

The difference between them:

- **Cortex:** patient B's cortex is a thinned line pencil like (picture framed appearance) while patient A the cortex is hazy, fussy and thick.
- **Matrix:** we can see the trabeculae in patient B while in patient A we can't.

Case 3: Renal Osteodystrophy

27 years- old male with long standing history of renal failure X-ray of lumbosacral spine requested.



"Rugger Jersey Spine"

Findings:

- Generalized osteopenia.
- Sclerotic end plates.
- Hazy, indistinct cortices.
- Hazy (Fuzzy) coarsened trabeculae.

Renal Osteodystrophy:

- 1- Osteoporosis.
- 2- Osteomalacia.
- 3- Secondary Hyperparathyroidism:
 - Bone Resorption Bone.
 - Softening Brown Tumors.
 - Osteosclerosis.
 - Soft tissue calcification.
- 4 -Osteosclerosis.

The image shows a combination of osteoporosis and osteomalacia with an ill defined cortex and a matrix with trabeculae. The margins of the vertebral body varies in densities with 3 bands (black, white and black) called rugger jersey spine. One of the basic bone changes signs of renal failure is an increase in PTH because of the reduction of Ca in the blood that will stimulate the parathyroid to over produce the PTH.

Case 4: Acromegaly

45 years- old male presented with history of bone enlargement X-ray of skull and hand are requested.



Increased heel pad thickness

Findings:

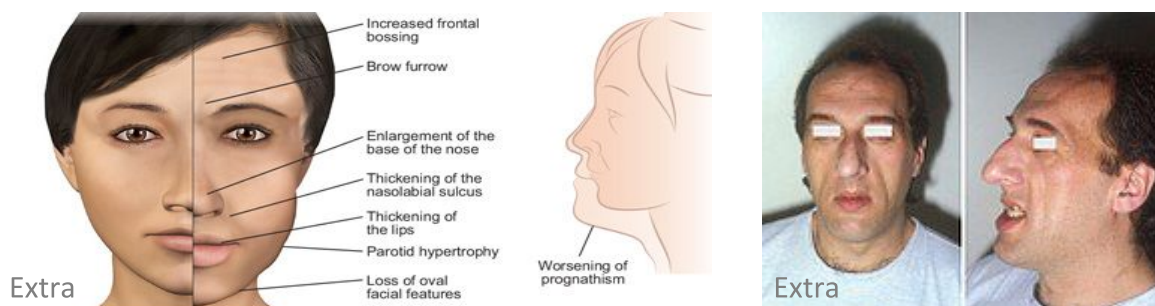
- Calvarial thickening.
- Enlargement of the sinuses (bossing of **glabella** → the smooth part of the forehead above and between the eyebrows).
- Enlargement of mandible.
- Enlarged sella turcica (pituitary fossa).
- Prominent digits.
- Increased heel pad thickness.

The patient will not come and say my bone is enlarged, but he would say I bought a hat or shoes few months back but now it doesn't fit my head or my feet.

It's usually related to overgrowth of the bones because of overproduction of the growth hormone, and it's produced from the pituitary gland which is located within the pituitary fossa (sella turcica at the base of the skull).

Signs of the acromegaly:

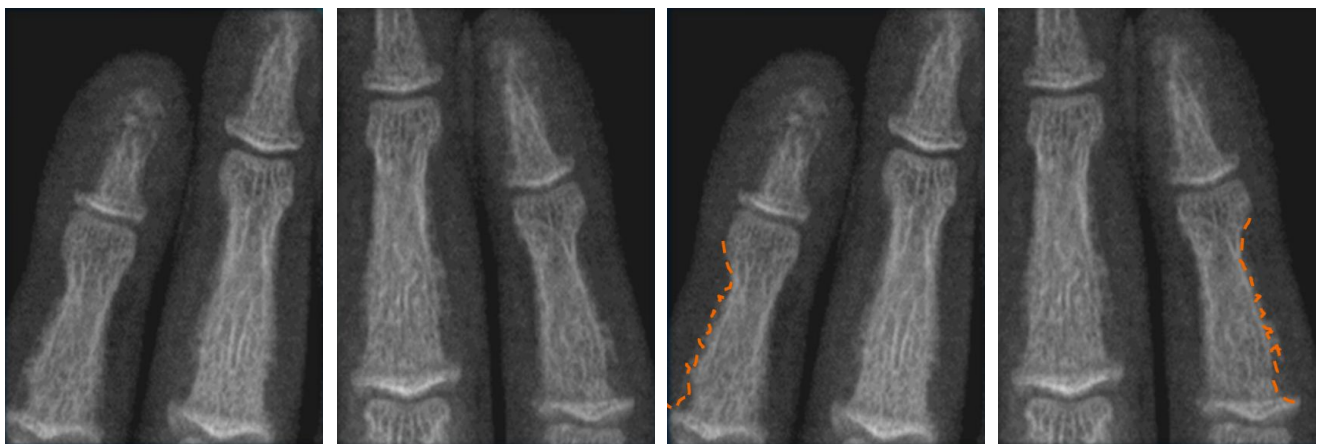
- 1- Enlargement of sella turcica.
- 2- Enlargement of the air sinuses (prominent forehead or glabella).
- 3- Enlargement of the mandible compared to the rest of the facial bones.
- 4- Enlargement of the bones of the extremities, and a prominent areas at the site of the attachment of the muscle tendons called hooking of the metacarpal bones.
- 5- Widening of the joint spaces due to there is hypertrophy of articular cartilage.
- 6- The soft tissue appearance of the heel will increase in patients with acromegaly which is usually ranged between 20,21 to 23 mm in females compared with males, and if it's above 26 mm we should look for the **possibility of acromegaly**.



Acromegaly facial features

Hyperparathyroidism

a. Bone Resorption



Subperiosteal sign

- (Sub Periosteal) Most useful sign.
- Virtually Diagnostic.
- Location.

The cortex is not well differentiated from the medulla portion.

On magnification: there is a definite irregularity along the radial aspect of the 2nd and 3rd finger (lateral side of the index and middle fingers) these changes are a pathognomonic changes called bone resorption that happen in patient with hyperparathyroidism. This sign is almost a confirmatory for hyperparathyroidism.

- b. Bone Tumors** (caused by osteoclasts which causes brown tumors in bones, notice the black holes)



Neoplastic

a) Types:

1. **Osseus:** Osteoma - Osteosarcoma.
2. **Chondral:** Enchondroma - Chondrosarcoma.
3. **Fibrous:** Osseous Fibroma - Fibrosarcoma.
4. **Soft tissue:** Lipoma - Liposarcoma.

b) Key Features:

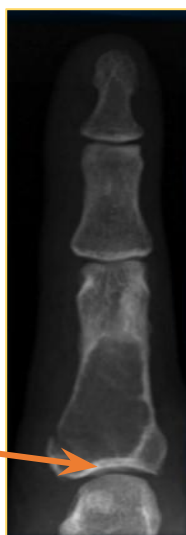
1. **Morphology:** Pattern of bone destruction Size, Shape & Margin of lesion texture of lesion Matrix Cortex & Periosteal reaction.

2. **Behavior of lesion:** Slow grow -Rapid grow (Aggressive).



Geographic

Lesion (clear cut off between normal and abnormal)



Osteolytic
Osteosclerotic
Mixed
Soft tissue

- Black so it's an osteolytic lesion (the bone space become empty and replaced by blood and air).
- **Margins:** a lesion with defined margins called a geographical lesion or narrow zone of transition.
- **Narrow zone of transition:** if the cutoff point between the lesion and the normal bone is a line, which suggests a benign lesion.

- **Outline:** ill defined outline, it could infiltrate the adjacent bone.
- The zone of transition is wide.
- **Matrix:** the is pinpoint holes, black dots like its called moth-eaten appearance suggests a more aggressive lesion.
- It has more aggressive behavior and more extension inside the bone as if it has thread of irregular lucencies in the bone it's called **permeative appearance of the destruction**.



Moth-eaten



Permeative



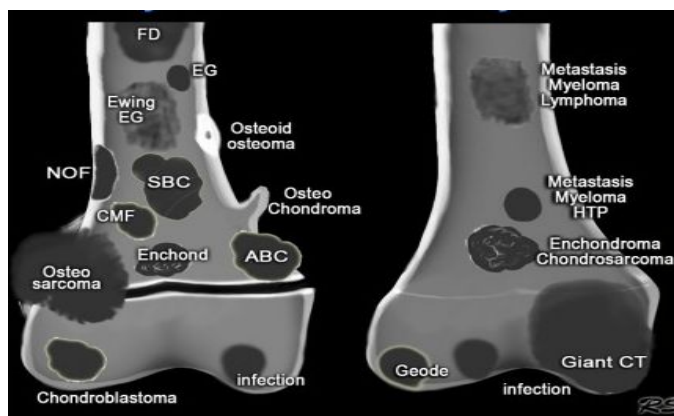
- The thick line adjacent to the cortex: thick consolidate periosteal reaction it's a benign lesion.
- So if it's thick consolidate periosteal reaction → benign lesion.
- If the lesion is rapidly growing it will have no time for the periosteal reaction to accumulate so it will appear either as a parallel line or sun-ray appearance as the previous example → malignant lesion.



[Amazing website explains the systemic approach and DDX of bone tumors.](#)

3. Age of patient:

Pediatric, Adult, Elderly.



< 30 years

> 30 years

4. Site (Location):

Diaphyseal, metaphyseal or epiphyseal.

Cortical vs. Medullary (eccentric → peripheral vs. concentric → central).

Osteolytic / Benign lesions in a child

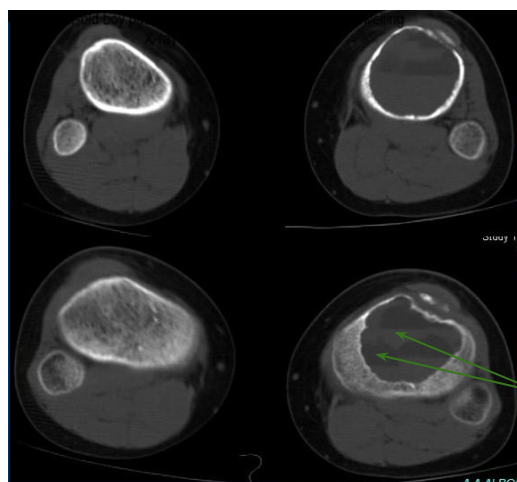
13 year-old boy patient presented with knee pain and swelling. X-ray of knee requested.



An **aneurysmal bone cyst** (which is often abbreviated ABC) is one such abnormality. ABCs are blood-filled, fibrous **cysts** that expand the **bone** and can cause pain, swelling and fractures. They are benign **cysts** (non-cancerous) that don't spread.

Aneurysmal Bone Cyst

Osteolytic lesion that has a narrow transitional zone (geographical lesion) in the proximal aspect of the metaphyseal part of the tibia which is considered a benign lesion.



Findings: For the picture on the upper left

- Expansile lytic lesion.
- Metaphyseal.
- Homogeneous, no calcification.
- No cortical destruction and no periosteal reaction.
- No soft tissue swelling.

Fluid-fluid level: two densities with a straight line.

Aneurysmal Bone Cyst

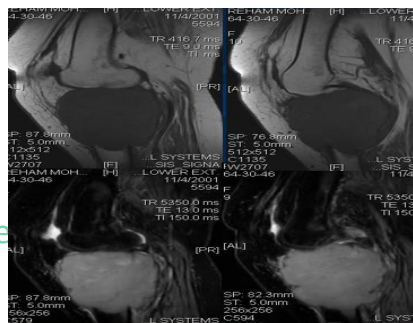
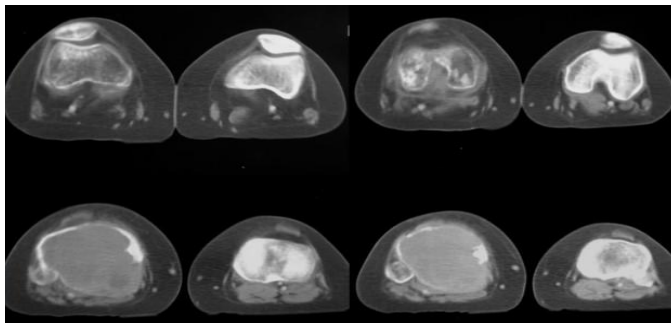
Osteolytic / Benign lesions in an adult

Adult man with knee pain and swelling.



Findings:

- Expansile lytic lesion.
- Metaphyseal / Subarticular.
- Homogeneous, no calcification.
- Cortical destruction and periosteal reaction.
- Soft tissue swelling.



Giant Cell Tumor

Black osteolytic lesion with a defined margins that extends to epiphysis until the sub-articular surface (proximal aspect of the bone), the only difference between this lesion and the previous one is that this lesion is change in the behavior and age of the patient.

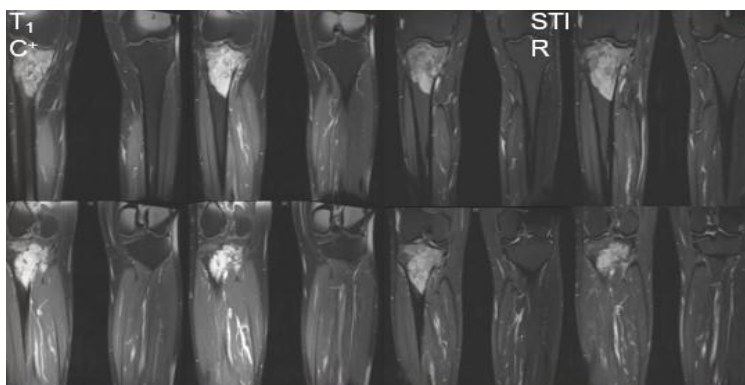
Osteolytic / Malignant lesions in an adult

Adult man with knee pain.



Findings:

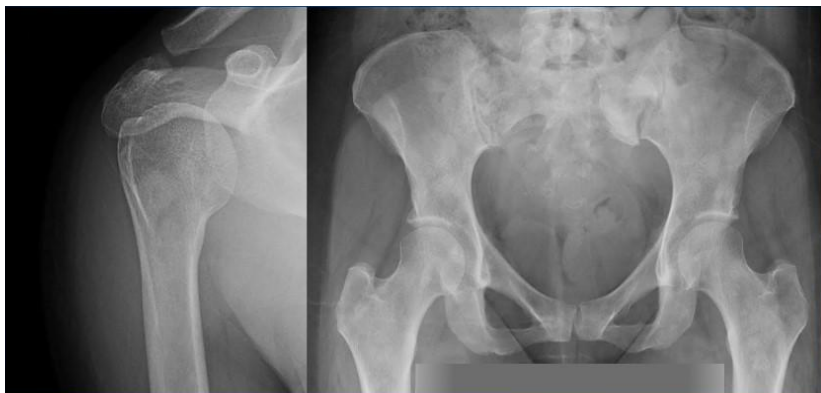
- Eccentric (peripheral) osteolytic lesion.
- Metaphyseal / Subarticular.
- Heterogeneous texture.
- Cortical destruction and periosteal reaction.
- Localized soft tissue extension.
- Ill defined lesion
- Texture is heterogeneous permeative.
- Aggressive behavior (malignant).



Permeative Pattern Osteosarcoma / Lymphoma

Sclerotic Osseous Lesion

57 years old female patient presented with bone ache had history of breast carcinoma.



Sclerotic bone metastasis

Soft tissue Mass

Findings:

- Preserved bone density in general.
- Sclerotic foci of variable sizes (islands).
- No destructive lesion.

Diffuse scattered white patches of osteosclerosis suggests bone metastasis.

If the patient is female, the most likely cause of metastasize is breast cancer, while in males is prostate cancer.

Adult female patient presented with hand swelling X-ray of hand requested.

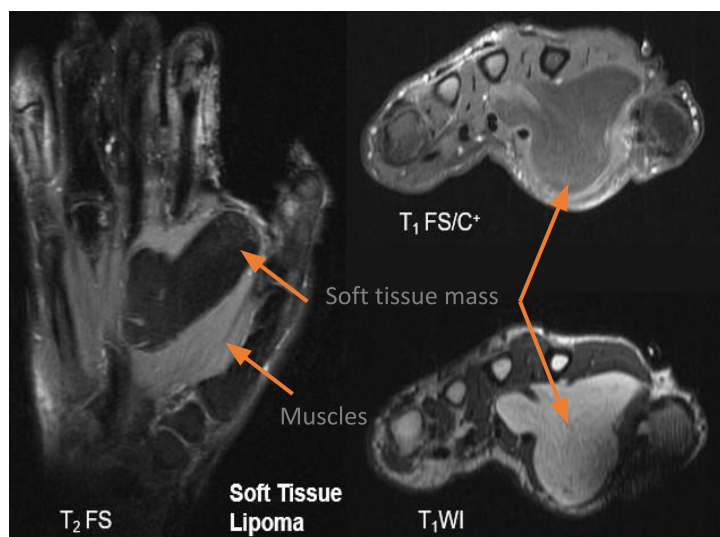


Findings:

- Soft tissue swelling (relatively lucent).
- No calcification.
- No osseous involvement.

The swelling in the web-area between the thumb and the second finger.

If want to delineate what's the possible underlying tissue character of this lesion? MRI.



Soft Tissue Lipoma

Findings:

- High signal on T1WI and low in T2FS fat saturated.
- No enhancement.

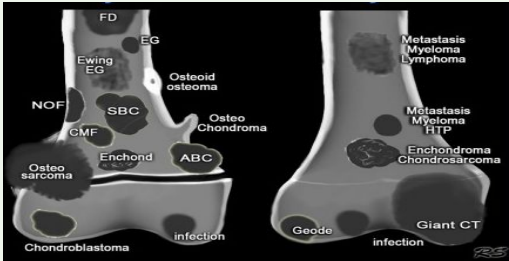
T1 is for anatomy that could differentiate whether the bone marrow is a fatty marrow, yellow marrow, muscles and subcutaneous fat.

Bright lesion similar to subcutaneous fat so it's fatty tumor such as lipoma.

How do we confirm? we do a T2FS (fat saturation), it suppresses the fat signals so they appear black in color and we can confirm that there is no vascularity (vessels will appear white).

How to differentiate between lipoma and liposarcoma? by the outline of the margins, and if there's any underlying pathology. We perform T1FS/C+ (C+ is the IV contrast that we give to the patient to see if there is any strands or vascularity) to differentiate.



The disease	Key features
1) Osteoporosis.	<ul style="list-style-type: none"> ● Generalized osteopenia. ● Sharp, thinned out cortices. ● Sharp trabeculae.
2) Osteomalacia in lower Limb.	<ul style="list-style-type: none"> ● Generalized mild osteopenia. ● Lucent area within the medial femoral neck (looser zone). ● Lucent band at physeal plate region. ● Indistinct cortices at symphysis pubis & SI joints.
3) Renal Osteodystrophy.	<ul style="list-style-type: none"> ● Generalized osteopenia. ● Sclerotic end plates. ● Hazy, indistinct cortices. ● Hazy (Fuzzy) coarsened trabeculae. <p>(DON'T FORGET RUGGER JERSEY SIGN)!!!!</p>
4) Acromegaly In Skull, hands and ankles.	<ul style="list-style-type: none"> ● Calvarial thickening. ● Enlargement of the sinuses (bossing of glabella). ● Enlargement of mandible. ● Enlarged sella turcica (pituitary fossa). ● Prominent digits. ● Increased heel pad thickness.
5) Hyperparathyroidism.	<ul style="list-style-type: none"> ● Sub Periosteal (Pathognomonic). ● Bone tumors (Brown Tumors)
6) Neoplastic.	 <p style="text-align: center;">< 30 years > 30 years</p>



Questions

Q1- A female patient came to the clinic with osteomalacia what are the possible bone changes will you see?

- A. Bending of the bone.
- B. Fractured bone.
- C. Loss of the matrix.
- D. Trabeculae.

Q2- A patient came to the clinic complaining of change in the size of their feet over time and bossing of glabella, what is the diagnosis?

- A. Osteosarcoma.
- B. Osteolipoma.
- C. Acromegaly
- D. Osteoporosis.

Q3- Rugger Jersey Spine sign comes with which of the following?

- A. Secondary hypoparathyroidism.
- B. Primary hyperparathyroidism.
- C. Secondary hyperparathyroidism.
- D. Primary hypoparathyroidism.

Q4- Osteoporosis can present secondary to which of the following?

- A. Healed fracture.
- B. Heparin.
- C. Chronic stress.
- D. Heart failure.

Q5- A male patient presented to you with diffuse scattered white patches of osteosclerosis on X-ray suggested bone metastasis. Which type of cancer is most likely the cause?

- A. Breast cancer.
- B. Bladder cancer.
- C. Brain cancer.
- D. Prostate cancer.

Answers:
1-A.
2-C.
3-C.
4-B.
5-D.