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# Radiology of Bone Infection 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

## Sources

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Same 436 lecture Slides:

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## 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** it is a reduction in the bone MATRIX

-**Osteomalacia** is the reduction of bone MINERALIZATION (with calcium and phosphorus)-> the bone mineralization process is what defines the bone trabeculae and gives its rigidity so when it is deficient trabeculae is HAZY and bone BENDS. In children osteomalacia is called Rickets

Osteomalacia is usually caused by a severe vitamin D deficiency

-**Osteopenia**: reduction in the bone density, while

-**Osteosclerosis**: increase or over production in the bone density.

2- Describe texture (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, ...).

**heterotopic calcification** is usually in patients with trauma, **chondral calcifications** usually in patients with metabolic problem, **vascular calcifications** usually in diabetic patients

- **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**:

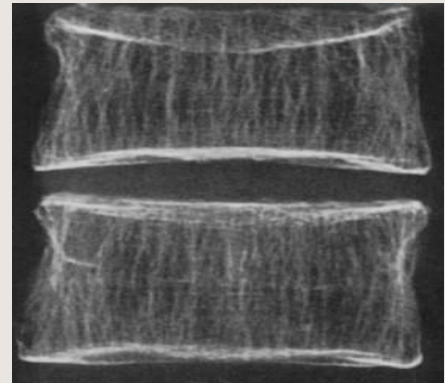
osteolytic: destructive lesions.

osteosclerotic: proliferative lesions.

## Case 1: Osteoporosis

in 50-60 yrs age group (especially post-menopausal women) a common cause of back pain is 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.

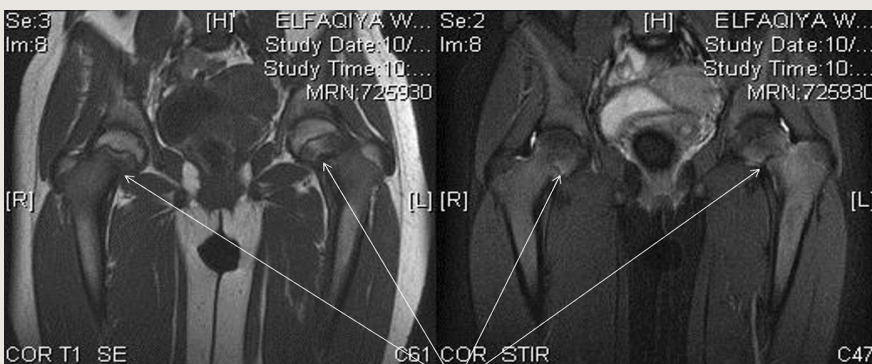
## Case 2: Osteomalacia

20 years old lady, weakness and lower limbs pain:



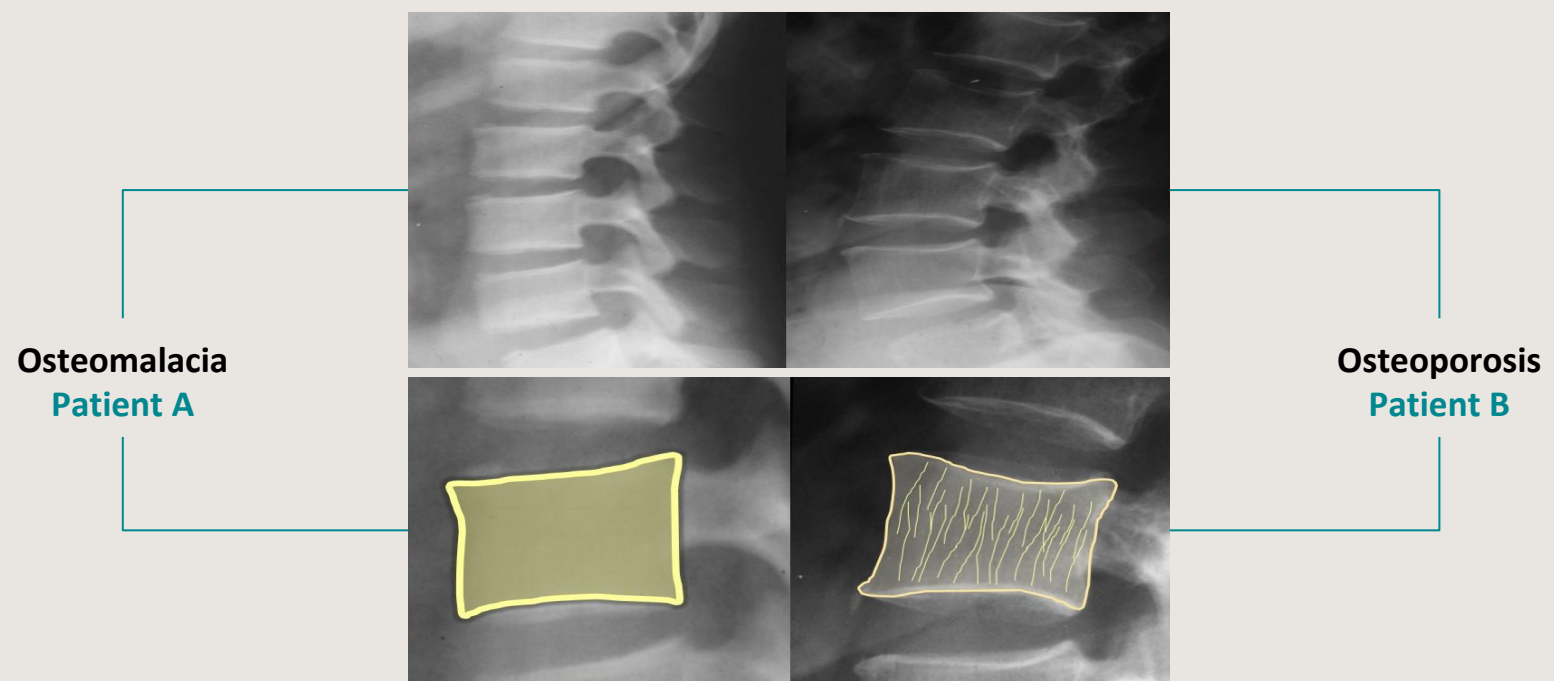
### Findings:

- 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 (pathognomonic sign of osteomalacia and patients usually have a severe vitamin D deficiency) 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



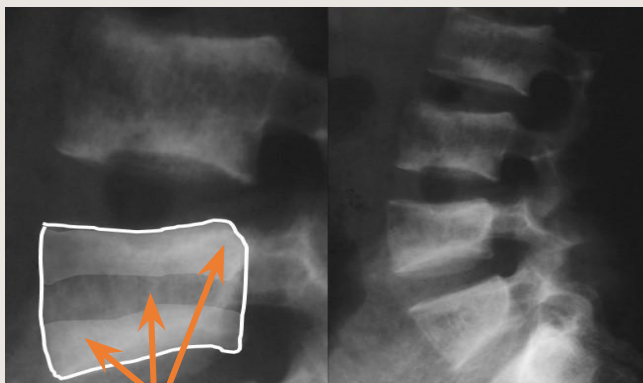
Both have osteopenia but for **patient A** the bone density looks increased because we have increased the density of the film that's why the soft tissues appear white or the image in total to highlight the changes of bone. It's called an apparent increase in density.

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.



**Renal Osteodystrophy:**

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

**Findings:**

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

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:

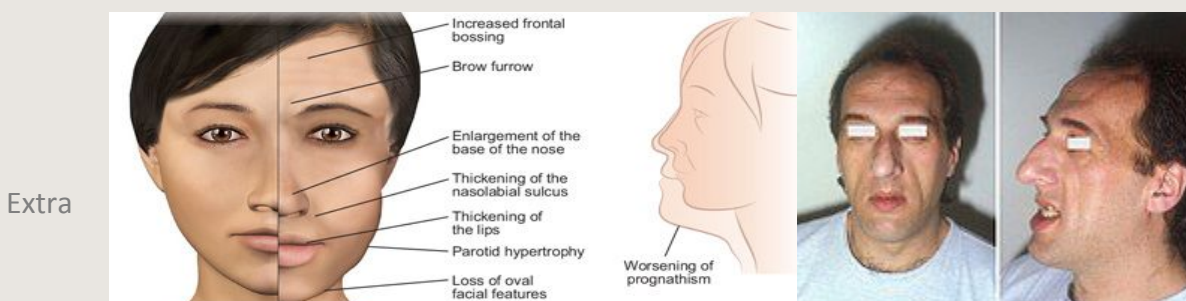
- Calvarial thickening.
- Enlargement of the sinuses (bossing of **glabella** → the smooth part of the forehead above and between the eyebrows).
- Enlargement of mandible.
- Enlarged sella turcica (pituitary fossa).
- Prominent digits.
- Increased heel pad thickness.

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).

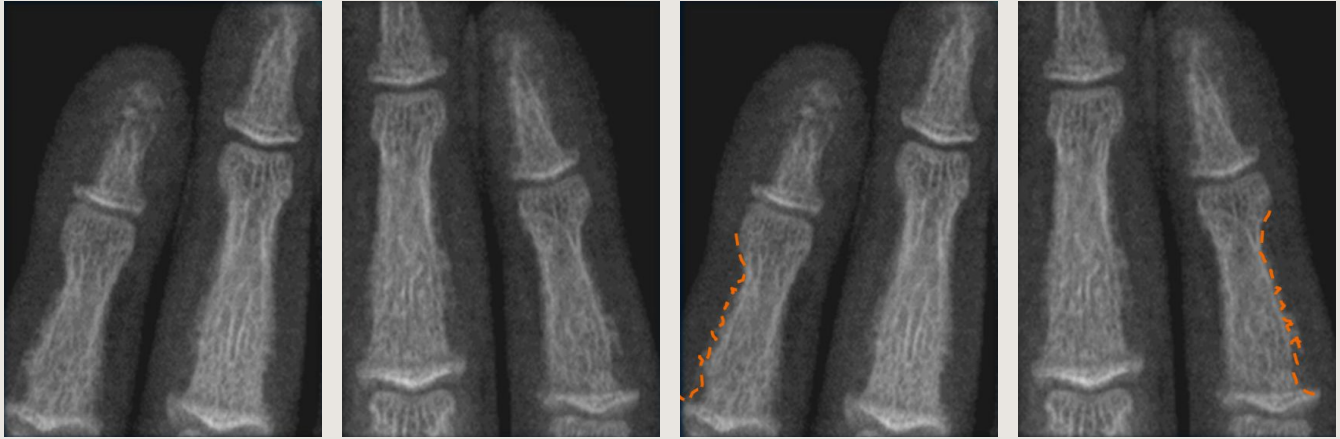
### Signs of the acromegaly:

- 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

## a. Bone Resorption



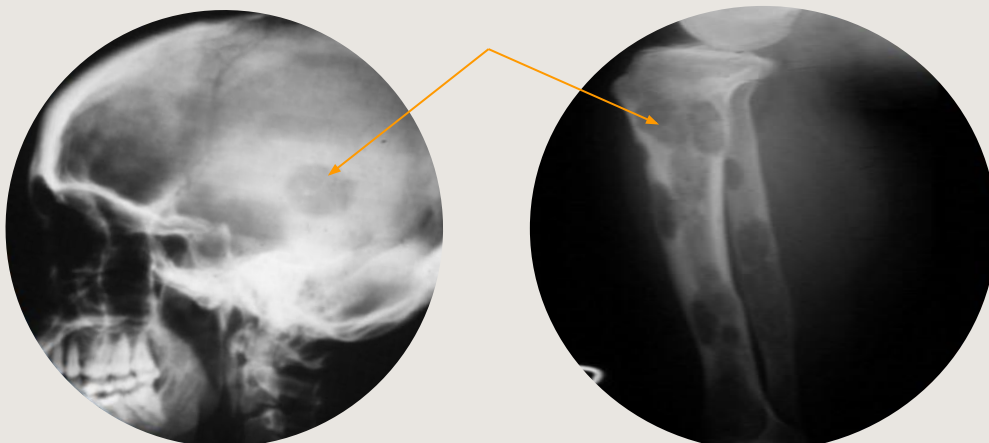
### Subperiosteal sign

- (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)



## 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.

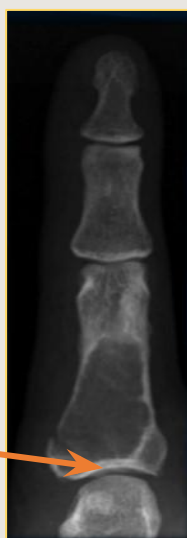
2. **Behavior of lesion:** Slow grow -Rapid grow (Aggressive).

Osteolytic  
Osteosclerotic  
Mixed  
Soft tissue



**Geographic**

Lesion (clear cut off between normal and abnormal)



- 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



lamellated

spiculated/  
sun-ray

Consolidate

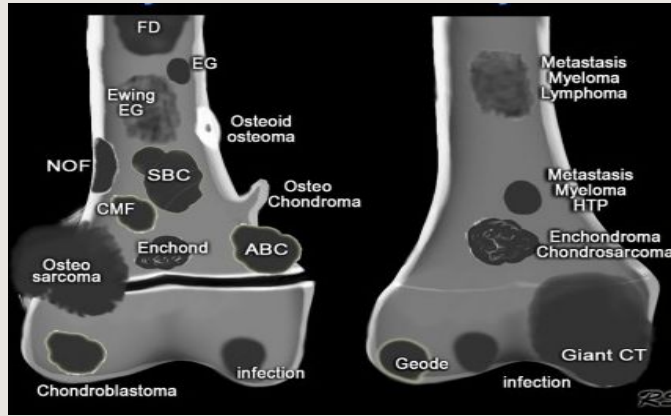
- **Least aggressive:** consolidation (slow process, usually benign lesion)
- more aggressive: lamellated (onion peel appearance)
- **MOST aggressive:** spiculated/ sun-ray (has a soft tissue component that starts to strip off the periosteum and this is why the periosteal reaction is vertical or perpendicular to the cortex)

### 3. Age of patient:

Pediatric, Adult, Elderly.



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



< 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

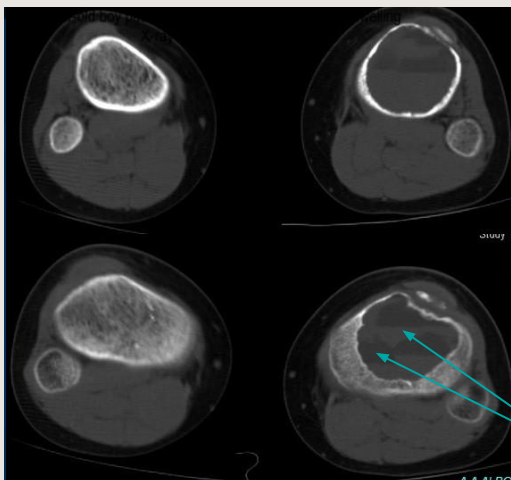
13 year-old boy patient presented with knee pain and swelling. X-ray of knee requested.



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**



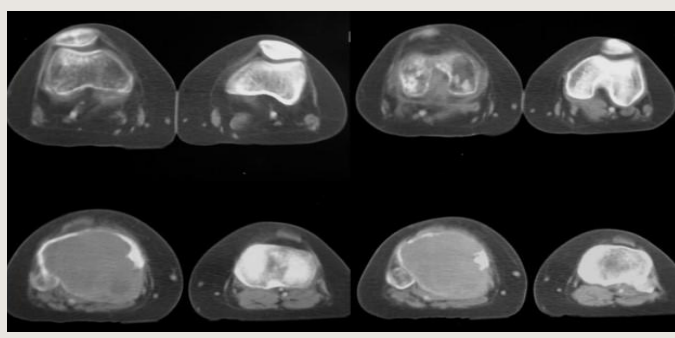
# Osteolytic / Benign lesions in an adult

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.

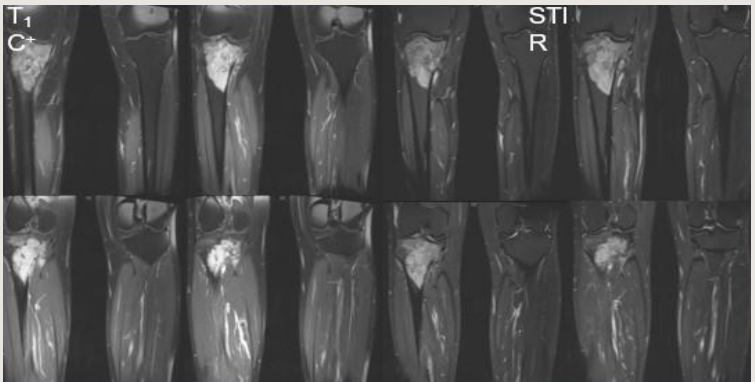
# Osteolytic / Malignant lesions in an adult

Adult man with knee pain.



**Findings:**

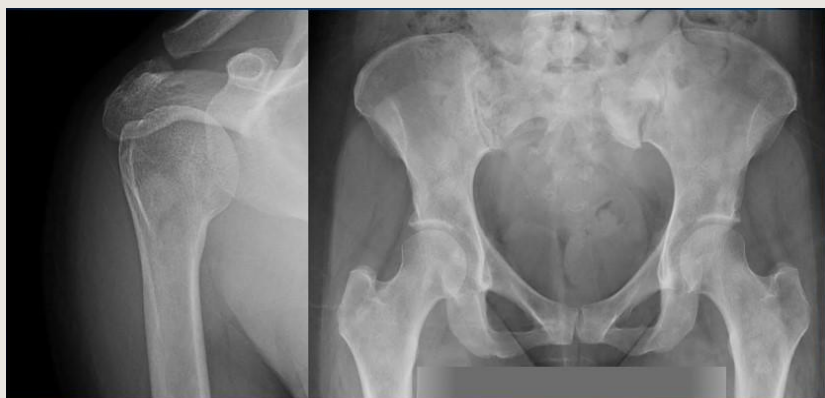
- Eccentric (**peripheral**) osteolytic lesion.
- Metaphyseal / Subarticular.
- Heterogeneous texture.
- Cortical destruction and periosteal reaction.
- Localized soft tissue extension.
- **Ill defined lesion**
- **Texture is heterogeneous permeative.**
- **Aggressive behavior (malignant).**



**Permeative Pattern** this is the most aggressive pattern it's seen in 2 cases  
**Osteosarcoma / Lymphoma** 1-malignant neoplasms  
 2-infections such as osteomyelitis

## Sclerotic Osseous Lesion

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



### Sclerotic bone metastasis

there are 2 causes of multiple bone lesions in adult patients  
1-metastases (can be osteosclerotic or lytic)  
2-multiple myeloma (usually lytic)

### 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.

## Soft tissue Mass

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.**

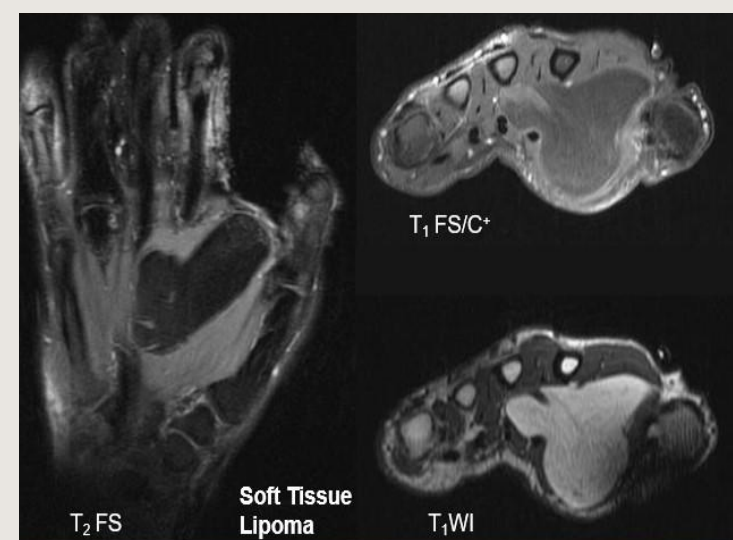
### Findings:

- 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).



### Soft Tissue Lipoma

**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.

# SUMMARY

## Metabolic & Endocrine Disorders:

The Disease	Key features
Osteoporosis.	Generalized osteopenia. Sharp, thinned out cortices. Sharp trabeculae. loss of trabeculations
Osteomalacia in Lower Limb.	Generalized mild osteopenia. Lucent area within the medial femoral neck (looser zone). Lucent band at physal plate region. Indistinct cortices at symphysis pubis & SI joints.
Renal Osteodystrophy.	Generalized osteopenia. <b>Sclerotic end plates.</b> <b>Hazy</b> , indistinct cortices. Hazy (Fuzzy) coarsened trabeculae. <b>(DON'T FORGET RUGGER JERSEY SIGN)!!!!</b>
Acromegaly in skull, hands and ankles.	Calvarial thickening. <b>Enlargement of the sinuses (bossing of glabella).</b> Enlargement of mandible. <b>Enlarged sella turcica (pituitary fossa).</b> Prominent digits. <b>Increased heel pad thickness.</b>
Hyperparathyroidism.	<b>Sub Periosteal</b> (Pathognomonic). Bone tumors (Brown Tumors)
Neoplastic.	<p style="text-align: center;"> <span data-bbox="949 2078 1109 2107">&lt; 30 years</span> <span data-bbox="1220 2078 1348 2107">&gt; 30 years</span> </p>

# QUESTIONS

1. 27 year old female known to have polycystic kidney disease and is on weekly dialysis complains of new lower back pain.

An X ray is taken and shows the following:

What is the name of this sign and what is it associated with?

- |  |  |
|--|--|
| a) Rugger Jersey sign, primary hyperthyroidism       | c) Rugger Jersey sign, secondary hyperparathyroidism |
| b) Rugger Jersey sign, secondary hyperparathyroidism | d) Rugger Jersey sign, primary hyperparathyroidism   |

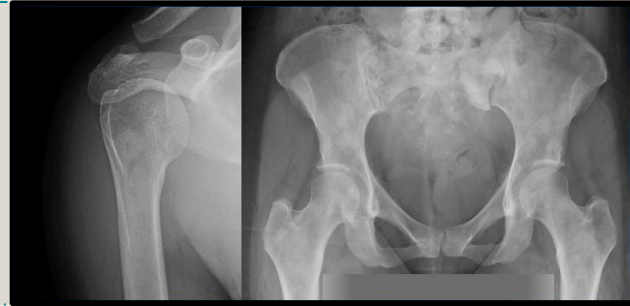


2. Which of the following is most suggestive of a highly aggressive bone lesion?

- |                  |               |
|------------------|---------------|
| a) Geographic    | c) Moth-eaten |
| b) Consolidation | d) Permeative |

3. A 65 year old male known to have prostatic cancer complains to his oncologist of bone pain. An X ray was taken showing the following. What does it show?

- |                     |                              |
|---------------------|------------------------------|
| a) Benign bone cyst | c) Giant cell tumor          |
| b) Multiple lipomas | d) Sclerotic bone metastases |



4. A patient came to her family clinician complaining that her feet, nose and jaw are too big and wanted a referral to a good plastic surgeon. her x-ray is shown here, what condition could this patient have?

- |                        |                 |
|------------------------|-----------------|
| a) Acromegaly          | c) Osteomalacia |
| b) Hyperparathyroidism | d) Osteosarcoma |



5. Osteoporosis can present secondary to which of the following?

- |                    |                    |
|--------------------|--------------------|
| a) Healed fracture | c) Chronic stress. |
| b) Heparin.        | d) Heart failure.  |

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## References

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