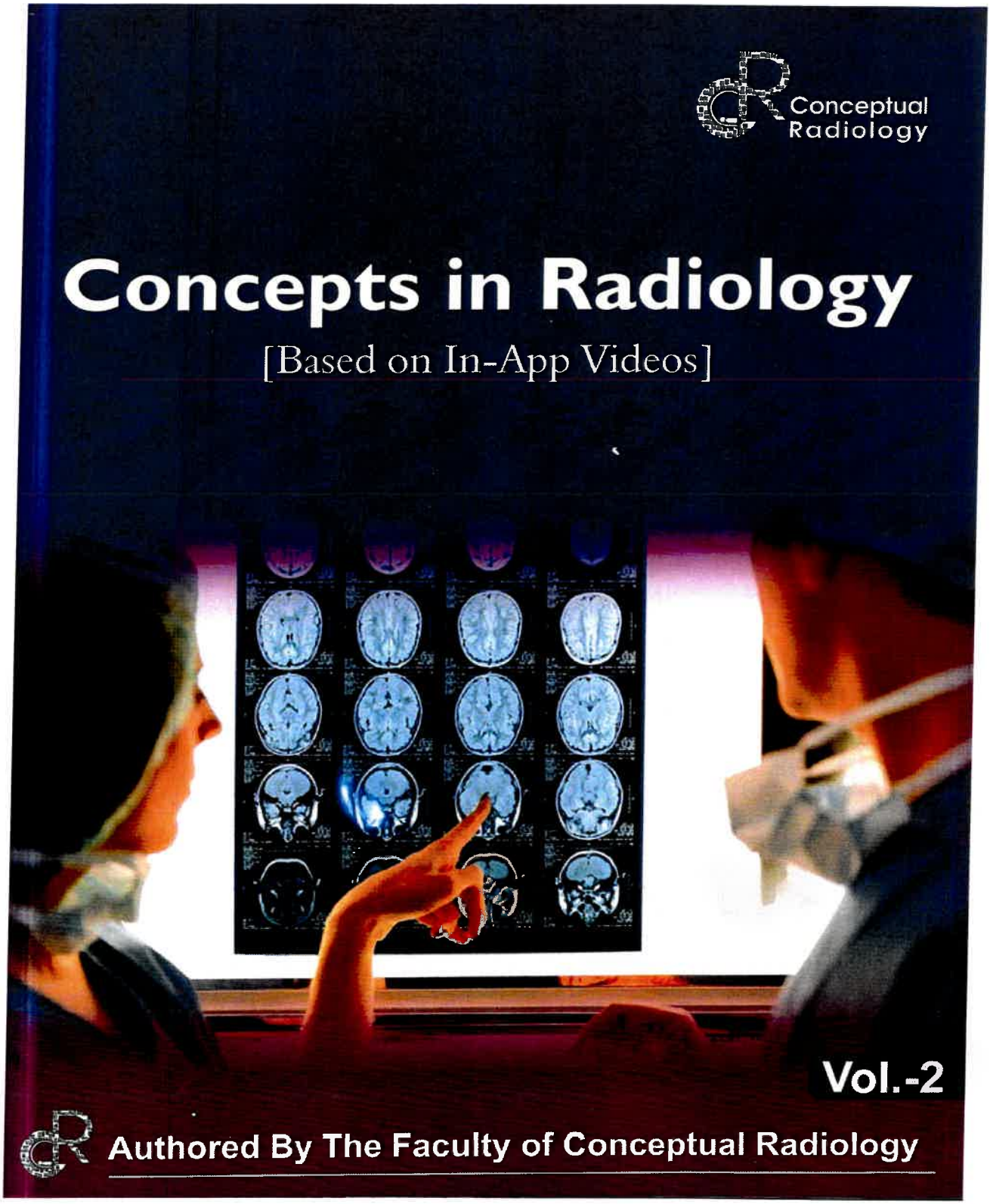
Conceptual Radiology

Concepts in Radiology

[Based on In-App Videos]



Vol.-2

Authored By The Faculty of Conceptual Radiology

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[Based on In-App Videos]

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Section 5

MSK Radiology

CHAPTER 5.1

Imaging of Bone Tumors

ONE LINERS (ACADEMIC RELEVANCE- **Can be asked as one liners for extra edge during viva voce)**

INVESTIGATIONS OF BONE TUMOR

- **Initial**- In all cases, an X-ray, even if MRI is given as one of the options.
- **IOC/Best**- MRI (After Xray to narrow down differentials)
  - **Exception,** where CT scan is the IOC, and is better than MRI is an **Osteoid Osteoma**. (MRI is not needed in this case, and excessive oedema seen in MRI may cause misinterpretation of the findings)
- **Gold Standard**- Biopsy. Used whenever in doubt, or if indeterminate findings on X-ray or MRI are encountered. In clinical practice, bone tumours v/s infection becomes a big dilemma. In such cases, one should not hesitate to report indeterminate findings and advice for a biopsy.
- **MC bone tumor:** Metastasis. These are more common than primary lesions.
- **MC primary bone tumor:** Multiple Myeloma
- **MC benign bone tumor:** Osteochondroma. It is considered to be a genetic accident.
- **MC true benign bone tumor:** Osteoid Osteoma.
- **Most chemo-radiosensitive:** Ewing Sarcoma.
- **Most chemo-radioresistant:** Osteosarcoma
- **MC radiation induced tumor:** Osteosarcoma
- **MC mets:** Lungs, come from Ewing sarcoma/ Osteosarcoma. These metastasis in lungs produce cavitation lesions.
- **MC bone to bone mets:** Ewing Sarcoma

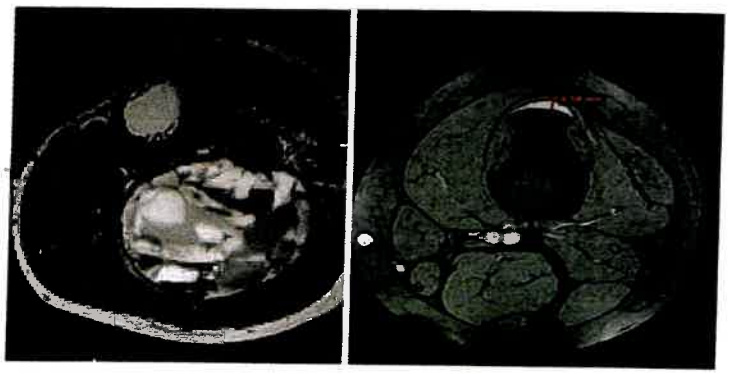
IMAGING MODALITIES-X-RAY

ACADEMIC RELEVANCE- Can be asked as long answer questions. In a theory exam, it is advisable to start with an introduction and talk about each modality.)

- **2 PLANES** - 2 planes are used. These two planes should be perpendicular to each other.
- It is important to note that one joint above and one joint below the location of tumor should be included in imaging.
- Academic Relevance- Job of the X-ray is seldom to give a diagnosis. Things important to describe after an xray while presenting a case-
  - **Neoplastic or non neoplastic** - Differentiating between neoplastic v/s non neoplastic (e.g. infection, infarct)
  - **Aggressive or non aggressive tumor**- At the end of the report, one should describe whether the tumor seems aggressive or non aggressive. Care should be taken **not** to comment on whether the tumor is **benign or malignant.**
  - Presenting differentials depending on a **specific approach** (discussed ahead).
  - **Multifocality**- Scan the xray in case a lesion is suspected to be multifocal.

In the X-ray of the hand below, multiple lesions are visible on the phalanges and the metacarpals. This is typical of **multiple enchondromas**.

IMAGING MODALITIES-MRI



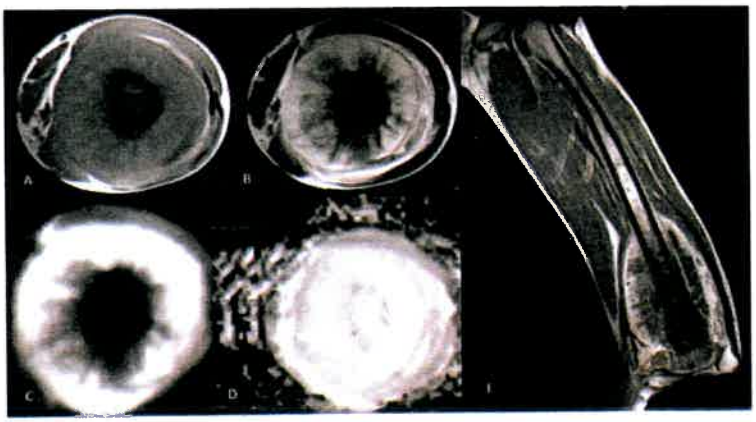
MRI is the best investigation done for almost all aggressive tumors.

Academic Relevance - Role of MRI in bone tumors is a commonly asked theory question in MD examinations.

- **SCANNING PROTOCOL** - Contrast is given in call cases. STIR, T1, T2, and Post-Gad imaging are done. These are done in two planes. The most commonly used planes are coronal and axial. In some cases, Post-gad may be done in all planes. Now a days, DWI and ADC are also done in most cases.
  - T1: One scanning (whole bone) T1 is taken. One joint above and below are taken, to look for skip lesions.
    - Difference between skip lesion and bony metastasis is a commonly asked question.- Skip lesions are non-contiguous lesions that occur close to the primary tumor, stay within the bone and do not cross the joint (are not counted in M1). Whereas, the metastasis usually cross the joint (counted as M1).
- MAJOR ADVANTAGES OF MRI
  - Chondroid matrix- Best sequence to pick up a chondroid matrix is T2. It appears hyper intense on T2. This is because the chondroid matrix has a large amount of hyaline cartilage, containing glycosaminoglycans (GAGs). GAGs retain water thus making cartilage hyper intense on T2. Secondly, if contrast is given to a chondroid tumor, it enhances like a hemangioma and shows a peripheral nodular puddling of contrast.
  - Fluid-fluid levels - Helps in identifying fluid fluid levels.
  - Shows bone marrow involvement.
  - Can easily identify cortical breach. On the basis of cortical breach , a tumor can be classified as intracompartmental or extracompartmental.
  - Images neurovascular bundle involvement.
  - Helps visualise skip lesions.

To look for joint involvement. Whenever a tumour can be seen reaching the distal end of the bone, one should confirm the integrity of articulation cartilage at that site. If the tumor crosses the articulation cartilage, it confirms joint involvement.

The MRI imaging of osteosarcoma below shows an axial T1 image, axial T2 image, contrast enhanced image, DWI showing hyper intensity, and ADC showing dark areas.



Helps assess response to chemotherapy- A good response to chemotherapy is confirmed if 90% (or more) of the bone tumor is seen necrosed on MRI. Another way to confirm the response is by looking for an increase in the ADC values (ADC values are normally low in a tumor)

- To assess recurrence, which would show enhancement.

Fluid-Fluid Levels D/D

ACADEMIC RELEVANCE- One of the commonly asked questions in a case showing fluid fluid levels include the differentials. Below differentials can show fluid fluid levels.

1. Primary Aneurysmal Bone Cyst (ABC)- It shows blood fluid levels. This should be the first condition to be mentioned in such a question.
2. D/Ds of secondary ABC (tumors which can become secondary ABC)-
   a. Giant Cell tumor.
   b. Osteoblastoma.
   c. Chondroblastoma.
3. Telangiectatic Osteosarcoma-
4. Vascular Metastasis- These are found in:-
   a. Choriocarcinoma
   b. Follicular CA thyroid
   c. Clear Cell RCC.
5. Brown tumor- This shows hemo spider in deposition, and can rarely show fluid fluid levels.
6. Clear cell variant of Chondrosarcoma-
   Two specific features of this variant of chondrosarcoma are that :-
   a. These are epiphyseal in origin.
   b. Can rarely show fluid fluid levels.

IMAGING MODALITIES-CT

- **Useful in complex anatomy**: CT is always indicated in complex areas where X-rays cannot visualize. These include areas

such as tumors in spine, pelvis, scapula, mandible.

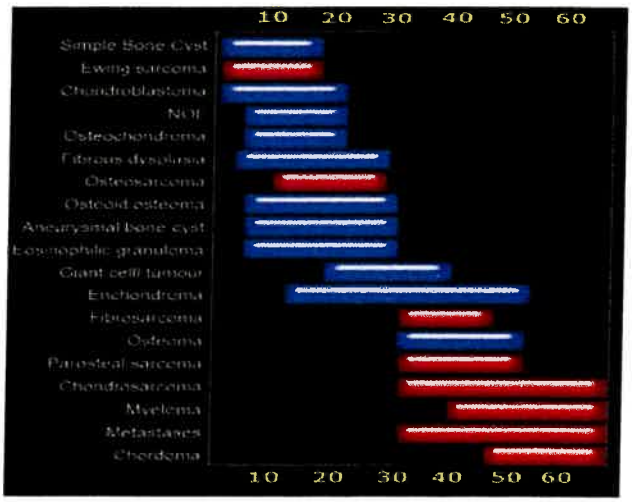
- **Osteoid osteoma.** On CT, it shows a cortical based lesion (cortical thickening) and solid periostea's reaction. (Shown below)
- CT helps in superior delineation of cortical expansion, re-modeling, and endosteal scalloping. Endosteal scalloping is important to distinguish between enchondroma and a low grade chondrosarcoma. If there is more than two third endosteal scalloping visualised on CT, it likely is a low grade chondrosarcoma.
- CT can also detect subtle calcifications.
- Radio graphic imaging should be cautiously used in paediatric population.

SYSTEMATIC APPROACH

One should always start by commenting on the age, followed by location of the tumor and later commenting on whether the lesion looks aggressive or non aggressive.

1. Age
2. Location
3. Aggressive versus non aggressive
4. Pattern of destruction

Age



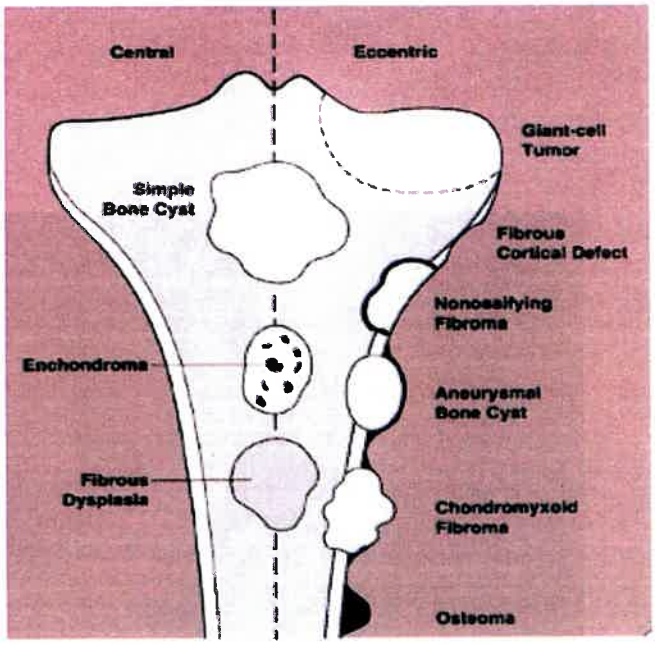
Location

1. Firstly, mention the bone (for e.g. Tumor is located in distal end of femur)
2. Secondly, confirm its location in the longitudinal axis of the bone i.e. whether the tumor is located in the epiphysis or the diaphysis (for e.g. the tumor is located in the distal end of femur and is an epiphyseal based lesion)
3. Thirdly, describe the location on the transverse axis. i.e. whether it is a central lesion/ eccentric lesion/ cortical lesion/ juxtacortical lesion.

Differentials based on location:-

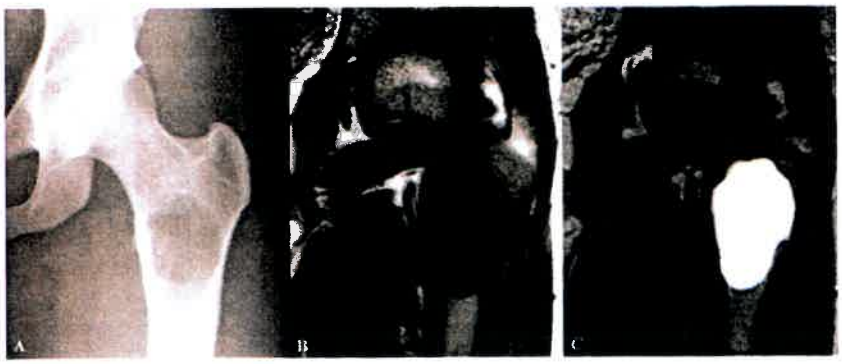
- Epiphysis (Mnemonic- ECG)
  - Chondroblastoma,
  - Giant Cell tumor,
  - Clear cell variant of chondrosarcoma.
- Diaphyses
  - Adamantinoma (m/c in tibia)
  - Ewing sarcoma (child, aggressive, spiculated periosteal reaction)
  - Osteoid Osteoma (Solid, continuous periosteal reaction, nocturnal pain relieve on taking NSAIDs)

- Everything else is in the meta-diaphyseal territory. For e.g. osteosarcoma, non ossifying fibroma, fibrous dysplasia, simple bone cyst, aneurysmal bone cyst.
- Central versus eccentric (in the transverse plane)
  - Central Lesions (mnemonic-SEF, and rest are eccentric)
    - Simple bone cyst (Aneurysmal bone cyst is eccentric)
    - Enchondroma
    - Fibrous dysplasia (Non Ossifying fibroma is always eccentric)
  - Eccentric lesions
    - Non ossifying fibroma,
    - Chondromyxoid fibroma
    - Osteoma (it is based on the cortex of the bone)
    - Giant Cell Tumor.



Examples

1. Consider the xray and MRI image below. Firstly, the age of the patient should be commented upon. Thereafter, the location should be mentioned. In this case, the lesion is described to be in the proximal femur. It is a central lesion which is based in the metaphysics of the femur. On the basis of the MRI, this appears to be a simple bone cyst.



2. The. Imaging below shows septations in the metaphysis of the radius. This is an aneurysmal bone cyst.

3. The imaging below shows an eccentric distal tibial lesion with a well defined sclerotic corticalrim. This is a Non Ossifying Fibroma, which is typically found in the metaphysis of distal tibia.

Aggressive Versus Non Aggressive

After commenting on the age of the patient and the location of tumor, one should comment on whether the lesion looks benign or malignant on imaging. However, terms such as benign and malignant are not used in case reports. Instead, analogous terms such as aggressive and non aggressive are used respectively.

The tumors should be explained using the below systematic approach.

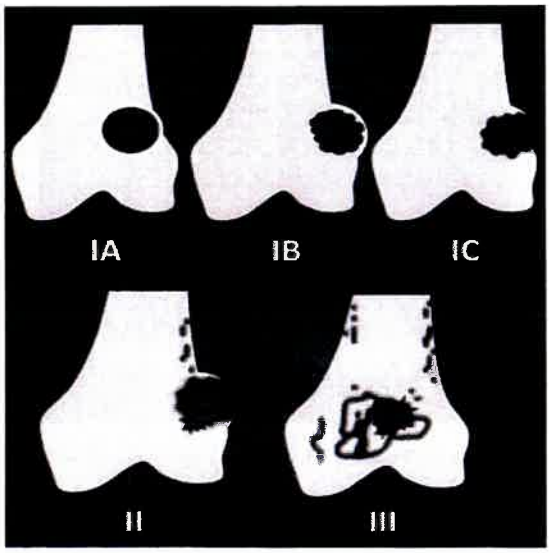
1) Type of destruction
2) Zone of transition/ margins
3) Cortical integrity
4) Periosteal reaction
5) Matrix mineralisation
6) Soft tissue

Pattern of Destruction

After describing the lesion on the basis of age, location, aggressive versus non aggressive, one should comment on the pattern of destruction that is visualised on imaging. Firstly one should understand whether the lesion is sclerotic or lytic. In case it appears lytic, this could be further described as geographic lytic lesion or permeative lytic lesion or moth eaten lytic lesion.

- The pattern of destruction can be classified using **Lodwick classification.**

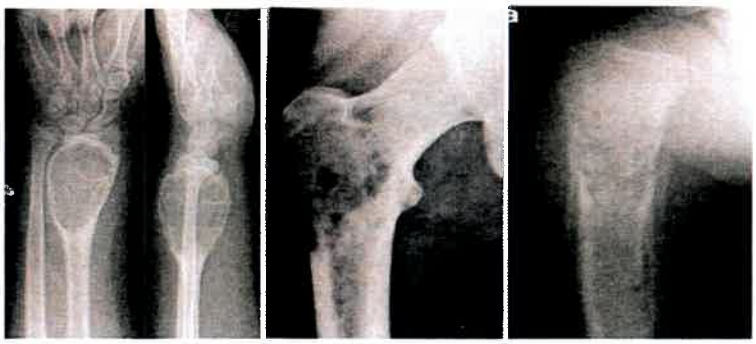
According to Lodwick Classification **Type I - Geographical lytic lesion.** It is a **non aggressive** pattern of destruction. I is divided into Ia, Ib, Ic depending on the presence of a sclerotic rim.



Ia - indicates the presence of a sclerotic rim (like in Non ossifying fibroma)

Ib- It won't have a sclerotic rim but is well defined. It can be demarcated by a pen.

Ic- In this, the tumor is without a margin of sclerosis, and the tumor cannot be demarcated. However, one can make out where the normal bone begins.



Type 1b-geographical lytic lesion. **Type 2 – Aggressive moth eaten** **Type 3 - Permeative**

ZONE OF TRANSITION/ MARGINS

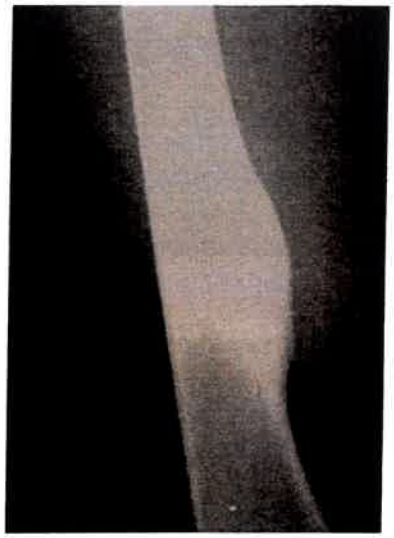
- There could be a wide zone of transition, or a narrow zone of transition.
- A well defined zone of transition means that the tumor is not well demarcated, i.e it is aggressive. It is an ill defined lesion.
- Narrow zone of transition is a well defined lesion.

CORTICAL INTEGRITY

- By understanding the changes by the tumor to the overlying cortex. A slow growing benign tumor could thin out the cortex. Conversely, a tumor could be solid like osteoid osteoma. Additionally, a very destructive tumor could break the cortex and come out.
- Cortex should not be confused with periosteum. Periosteum lies over the cortex. Changes by the tumor on the periosteum are described as periosteal reaction. CT scans help in differentiating between cortex and periosteal reaction. But, cortex and periosteal reaction are not easily differentiated in xray image.

- Cortical Integrity can be explained as below

CORTICAL EXPANSION
It is usually associated with thinning, and is mostly found in benign/ non aggressive lesions. Image below shows a lobulated scalloping which occurs in cortical expansion.



CORTICAL THICKENING
It is found in osteoid osteoma, stress fractures, and sometimes in osteomyelitis. Image below shows cortical thickening.

CORTICAL DESTRUCTION
This occurs in an aggressive tumor. The image below shows an epiphyseal aggressive tumor with septations. This is a giant cell tumor, which is benign but locally aggressive.

PERIOSTEAL REACTION

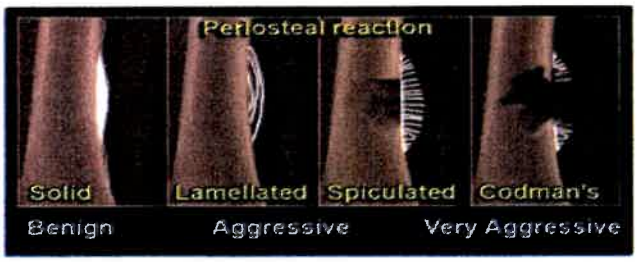
It is of multiple types.

- **CONTINUOUS-** It is seen in non aggressive or benign lesions. It is of further two types
  - **Solid** continuous periosteal reaction.
  - **Lamellated** continuous periosteal reaction.- This can be further separated on whether there is a **single** or **multiple** lamellae.

Aggressive tumors usually produce the following three periosteal reactions.

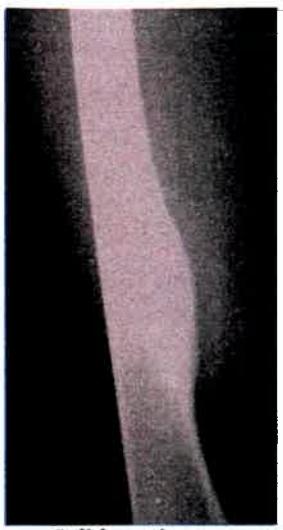
- **INTERRUPTED-** For e.g. a multiple lamellated periosteal reaction is present, which gets interrupted in between by a tumor. Codman's triangle is a type of interrupted periosteal reaction.
- **SPICULATED-** Sunburst periosteal reaction is an example. Horizontal lamella is also an example of spiculated periosteal reaction.
- **COMPLEX-** In this, there are multiple types of periosteal reaction coexisting. For e.g. a tumor shows codman's triangle,

sunburst appearance and interrupted periosteal reaction. It is commonly found in Ewing Sarcoma, Osteosarcoma.



A Periosteal reaction excludes the diagnosis of Fibrous dysplasia, Enchondroma, NOF and SBC unless there is a fracture

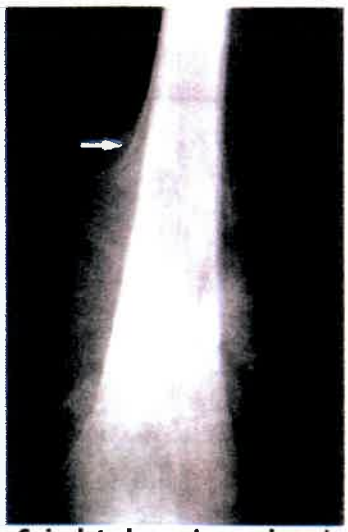
Examples-



Solid continuous periosteal reaction. This is usually benign. Two D/Ds include osteoid osteoma and stress fracture.

Single Lamellated continuous periosteal reaction. This is usually benign, but may also be rarely malignant. D/Ds include infections, eosinophilic granuloma, benign non aggressive.

Spiculated aggressive periosteal reaction. If it appears in a child and in diaphysis, the first D/D is Ewing's sarcoma.



Spiculated margins, codman's tumor, and interrupted periosteal reaction. This is a complex periosteal reaction (having multiple types). D/D includes osteosarcoma.

MATRIX MINERALISATION

Osseous Matrix- Other synonyms that can be used to describe osseous matrix include ivory, dense, fluffy, and cloud-like.

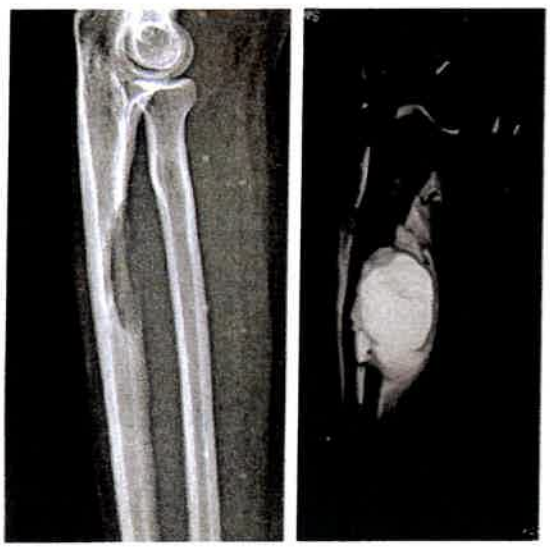
Chondroid Matrix- This can be described as ring and arc calcification, stippled, or flocculent matrix.

Fibrous Matrix- This can be described as ground glass, hazy matrix.

EPICENTRE: SOFT TISSUE VS BONY LESION

After describing the matrix, it is important to see whether there is a soft tissue component or not.

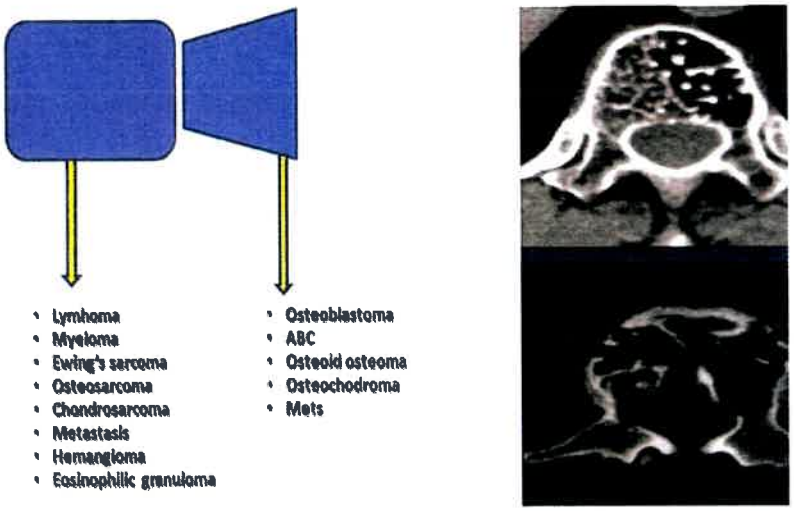
- If it is a **soft tissue component,** it could be either a primary soft tissue lesion pressing on the bone, or it could be a bone tumor having a soft tissue component. Following 4 things should be considered to differentiate between the two (academic relevance- important question)
  - **Locate the epicentre/site of lesion**- If the epicentre is outside the cortex, it indicates primary soft tissue tumor. If the lesion appears within the bone, it indicates bony tumor.
  - **Check bevelling of the cortex**- If the cortex appears bevelled towards the bone (as if someone is pressing from outside), it indicates a soft tissue tumor. Conversely, if the cortex appears bevelled outside the bone, it could be a bony tumor.
  - **Periosteal reaction**- It will be absent in a primary soft tissue, and would be present in a primary bone tumor with a soft tissue component.



Example- The imaging below shows a primary soft tissue tumor involving the bone. Bevelling of the cortex inside/towards the bone can be visualised.

SEPTATIONS

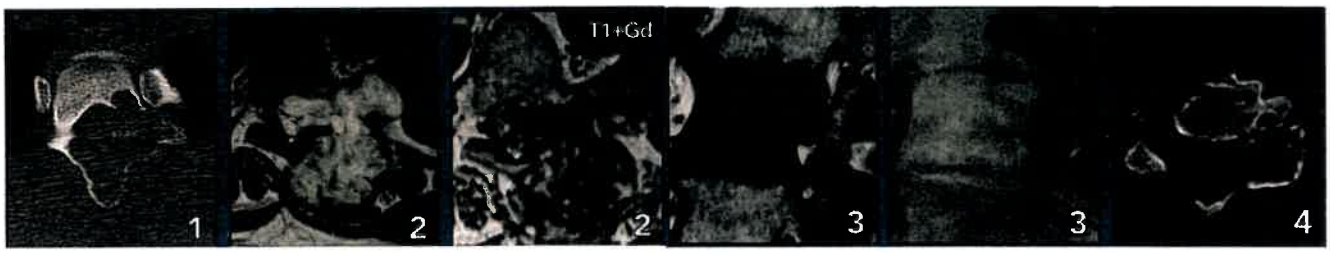
Septations	Lesions
Coarse, thick	Chondromyxoid fibroma
Delicate, thin	Giant cell tumour
Horizontal	Aneurysmal bone cysts
Lobulated	Nonossifying fibroma
Striated, radiating	Haemangioma



- The image (a) below shows a polka dot appearance of haemangioma.
- The image (b) shows a mini brain appearance, found in plasmacytoma.

Examples-

- In the (1) image below, one can see involvement of posterior elements such as spinous processes, transverse processes and pedicel. This is a case of osteoblastoma, which normally involves the posterior element. In order to differentiate it with osteoid osteoma, size of the lesion can be seen. Osteoid osteoma is usually less than 1.5 cm in size. Additionally, osteoid osteoma is more common in the long bones, whereas osteoblastoma is more common in posterior elements.
- The image (2) shows a hyper intense lesion on T2 MRI, and post contrast (2) shows puddled peripheral nodular contrast enhancement, and looks like a hemangioma. Furthermore, this appears to be a chondroid matrix (the term stippled is used in Xray) and narrows down to the diagnosis of chondroblastoma. It can rarely involve posterior elements.
- (3) shows metastasis in the vertebral body.
- (4) shows an expanded lesion like an osteoblastoma. These tumors that occur in the posterior element are usually expansive and benign.



D/Ds to keep in mind in case of involvement of posterior elements.:-

1. Osteoblastoma
2. Aneurysmal bone cyst.