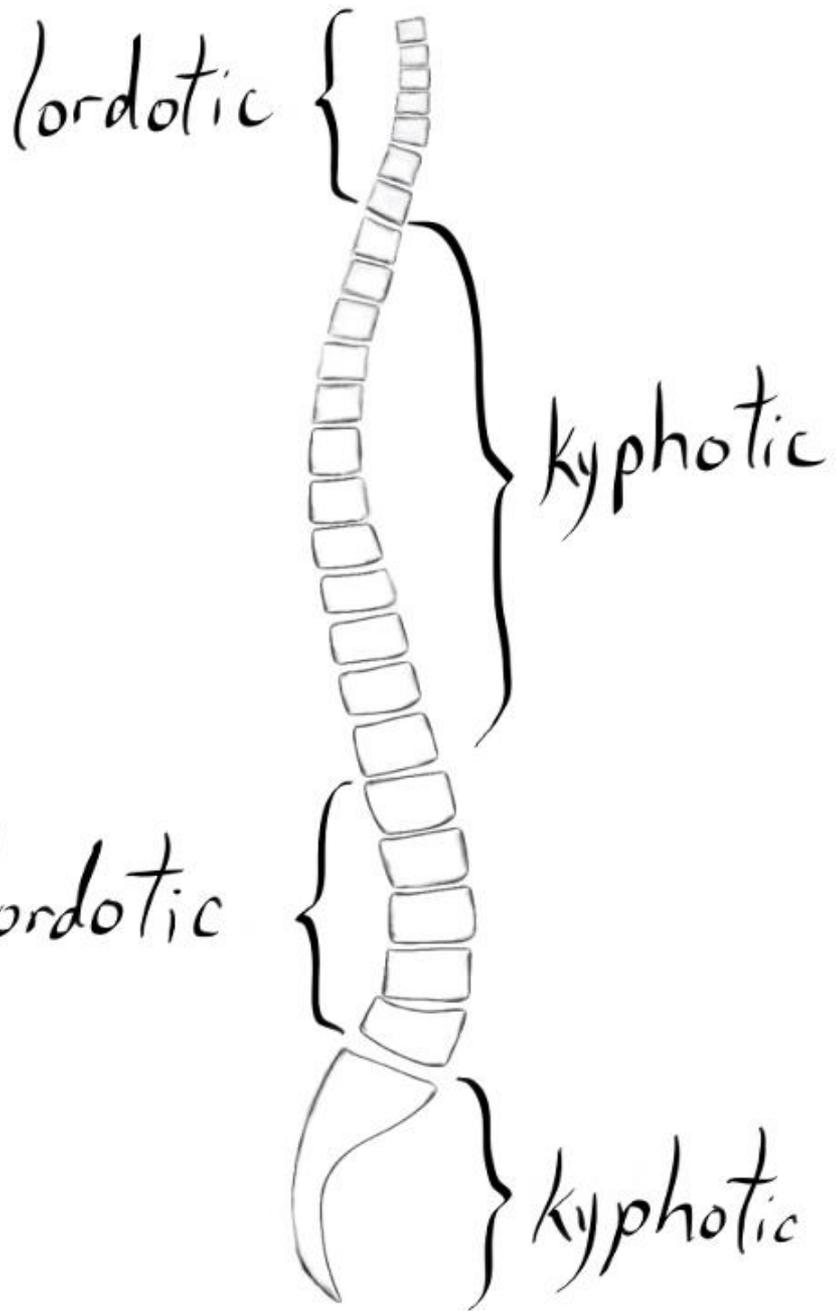


# SPINE IMAGING

**Dr\_Khalil .Abo oura**  
**Dr\_Ahmad .Abuain**  
**Radiologest .PHH**



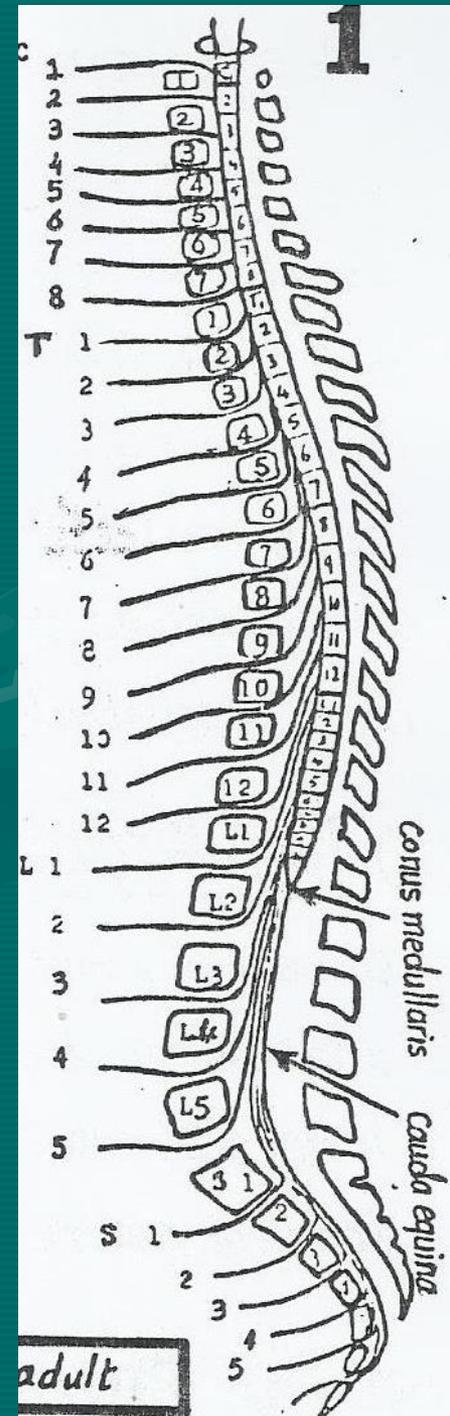
In neonates >> all kyphosis

3 months: starts to have the cervical lordosis as children start lifting their head

Then lumbar lordosis as they learn to sit

Then all curvatures are developed when they start to walk

- \*\* Exit of spinal nerves from the vertebral canal:
- \* C1-7 pass above corresponding vertebrae.
- \* C8 passes below C7 vertebra.
- \* T1-L5 pass below corresponding vertebra. (C2-L5 exit via intervertebral foramina)
- \* S1-4 pass via the ant. & post. sacral foramina.
- \* S5 & Co pass via the sacral hiatus.



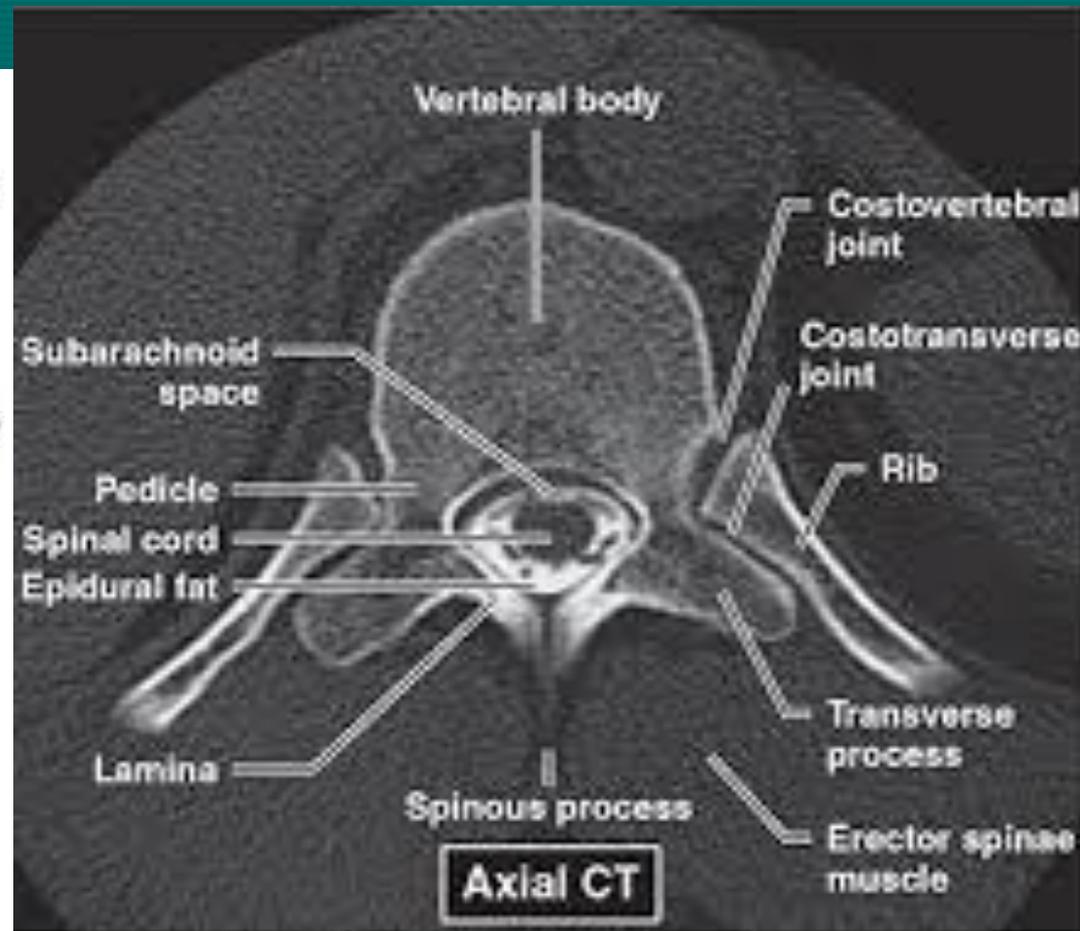
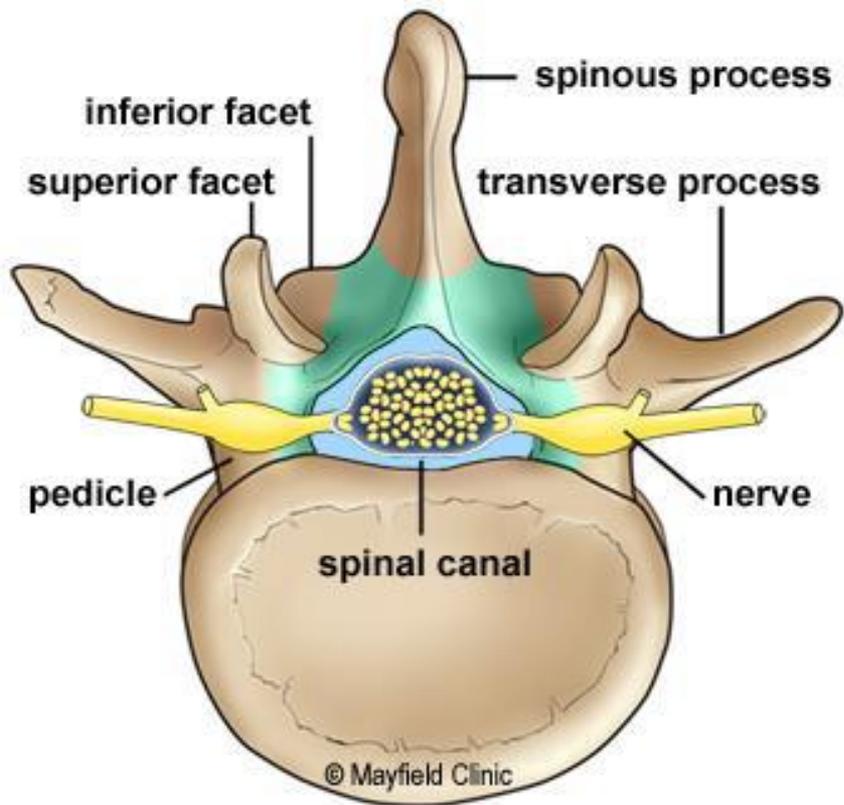
# Spine anatomy

- ❖ The vertebral column forms the central bony axis of the spine and is composed of 33 vertebrae.
- 7 Cervical vertebrae
- 12 Thoracic vertebrae
- 5 Lumbar vertebrae
- 5 Fused sacral segments
- 4 Fused coccygeal segments

- 1) kyphosis (concave) : thoracic + sacral
- 2) Lordosis (convex) : cervical + lumbar
- 3) Absent pedicle sign: a sign of metastasis where the pedicle is lysed
- 4) filum terminale ends at S2 and spinal cord in children ends in L3
- 5) ultrasound of the spine is only useful in neonates where they still have cartilages that are not ossified
- 6) intervertebral disk and tumors of spine are viewed by MRI
- 7) hemivertebra and butterfly vertebra cause scoliosis (S shaped spine)

# Spine anatomy / 2

- A typical vertebra consist of two parts:
  - Anterior ( the body )
  - Posterior ( neural arch )
- The two parts of the vertebrae enclose the vertebral canal which contains:
  - The spinal cord.
  - The meninges.
  - The associated vessels.

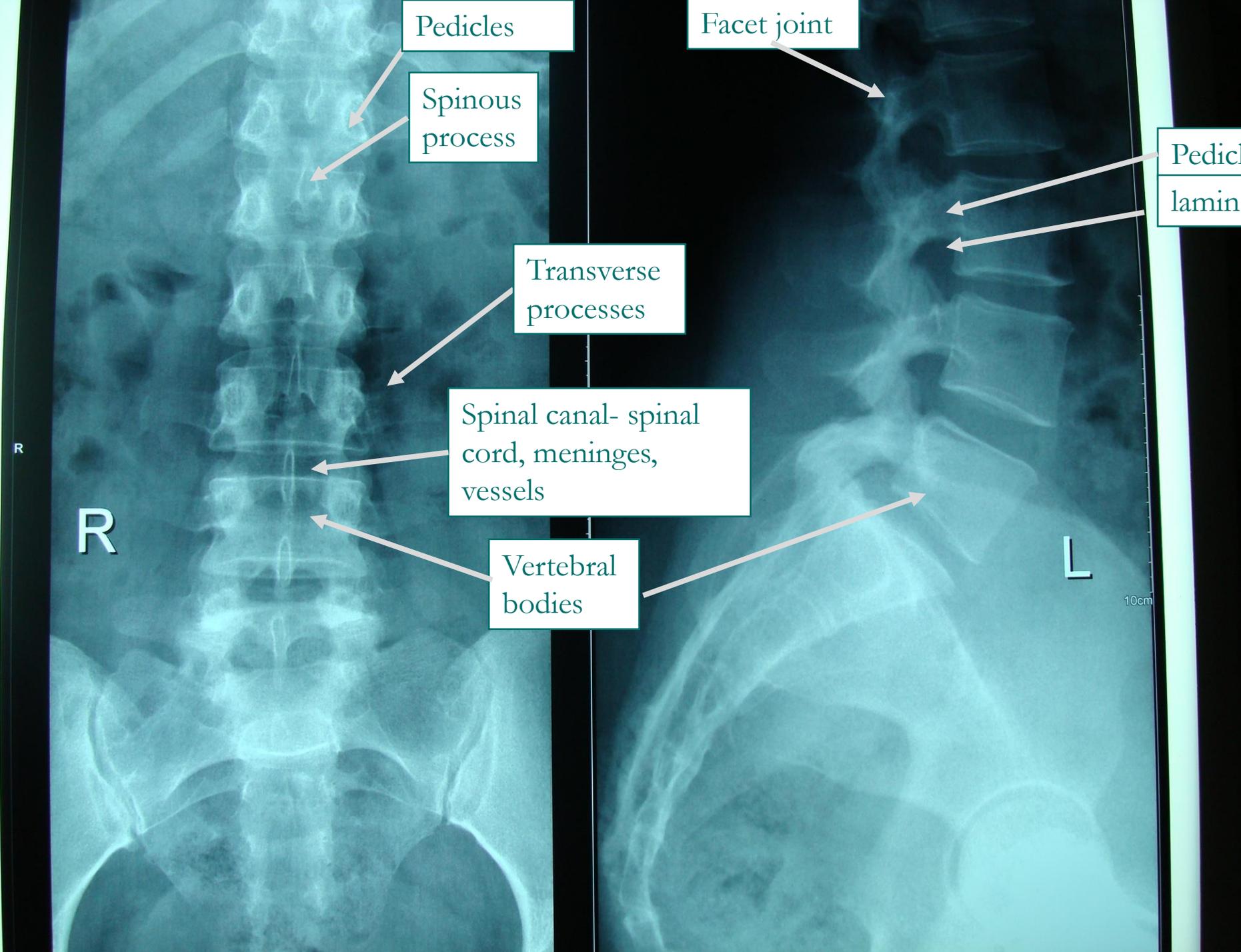


Source: Lynn N. McKinnis: *Fundamentals of Musculoskeletal Trauma*, 4th Edition

We can use US for imaging of the spine in children <3 months bcz the posterior neural arch/ the spinous processes and the laminae are still cartilaginous - not ossified

Initially, x-ray for the spine  
if complex trauma, CT will be needed after X-ray

Pedicle destruction (absent pedicle sign) > mostly due to Mets >> do a CT scan



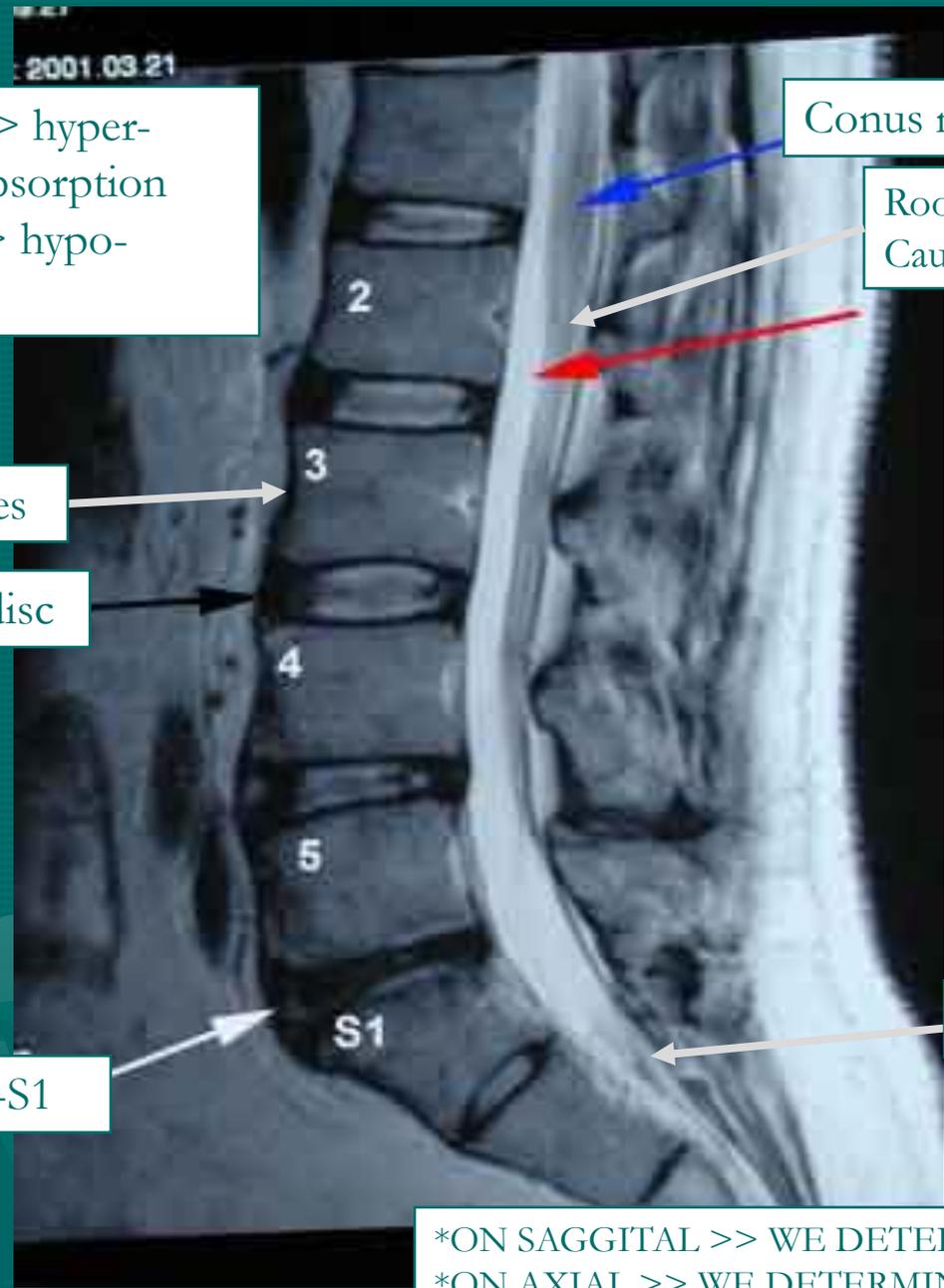
# Spinal cord

- The spinal cord is approximately 45cm long and descends from the medulla oblongata at the level of the foramen magnum and terminates at the conus medullaris between L1-L2.
- The cauda equina is formed by the spinal nerves extending from the lowest portion of the spinal cord to the level of S2.
- The spinal nerves lie free in the subarachnoid space.

\*ON SAGGITAL >> WE DETERMINE THE LEVEL  
\*ON AXIAL >> WE DETERMINE THE TYPE (DIFFUSE/  
CENTRAL/ PARACENTRAL)

MRI- T2 (CSF is bright-hyper-intense)

Nucleus pulposus is gel-like > hyper-intense on T2 – for shock absorption  
Annulus fibrosus is fibrous > hypo-intense on T2



Conus medullaris

Roots of spinal nerves –  
Cauda equina

Vertebral bodies

Intervertebral disc

Transition btwn L5-S1

End of spinal nerves

\*ON SAGGITAL >> WE DETERMINE THE LEVEL  
\*ON AXIAL >> WE DETERMINE THE TYPE  
(DIFFUSE/CENTRAL/ PARACENTRAL)

# DEVELOPMENTAL ANOMALIES OF THE LUMBAR SPINE

- Sacralization or Lumbarization.
- Spina bifida.
- Synostosis (Block vertebra).
- Hemivertebra.
- Butterfly vertebra.
- Myelomeningocele.
- Tethered cord.
- Diastematomyelia.

**Sacralisation:** the bottom lumbar segment (L5) is fused to the pelvis. It can either be fused to the sacrum below, or to the ilium at the side (the large ear-shaped bones of the pelvis) or both. >> more common than lumbarisation

**Lumbarisation:** the uppermost segment of the sacrum is not fused. Rather it is free to move and participates, along with the neighbouring lumbar vertebrae, in spinal activity.

**Spina bifida:** a portion of the neural tube fails to develop or close properly, causing defects in the spinal cord and in the bones of the spine. It can occur in different forms: spina bifida occulta, meningocele (contains meninges) or myelomeningocele (meninges+nerves).

**Synostosis:** fusion of vertebral bodies anteriorly and/or posteriorly

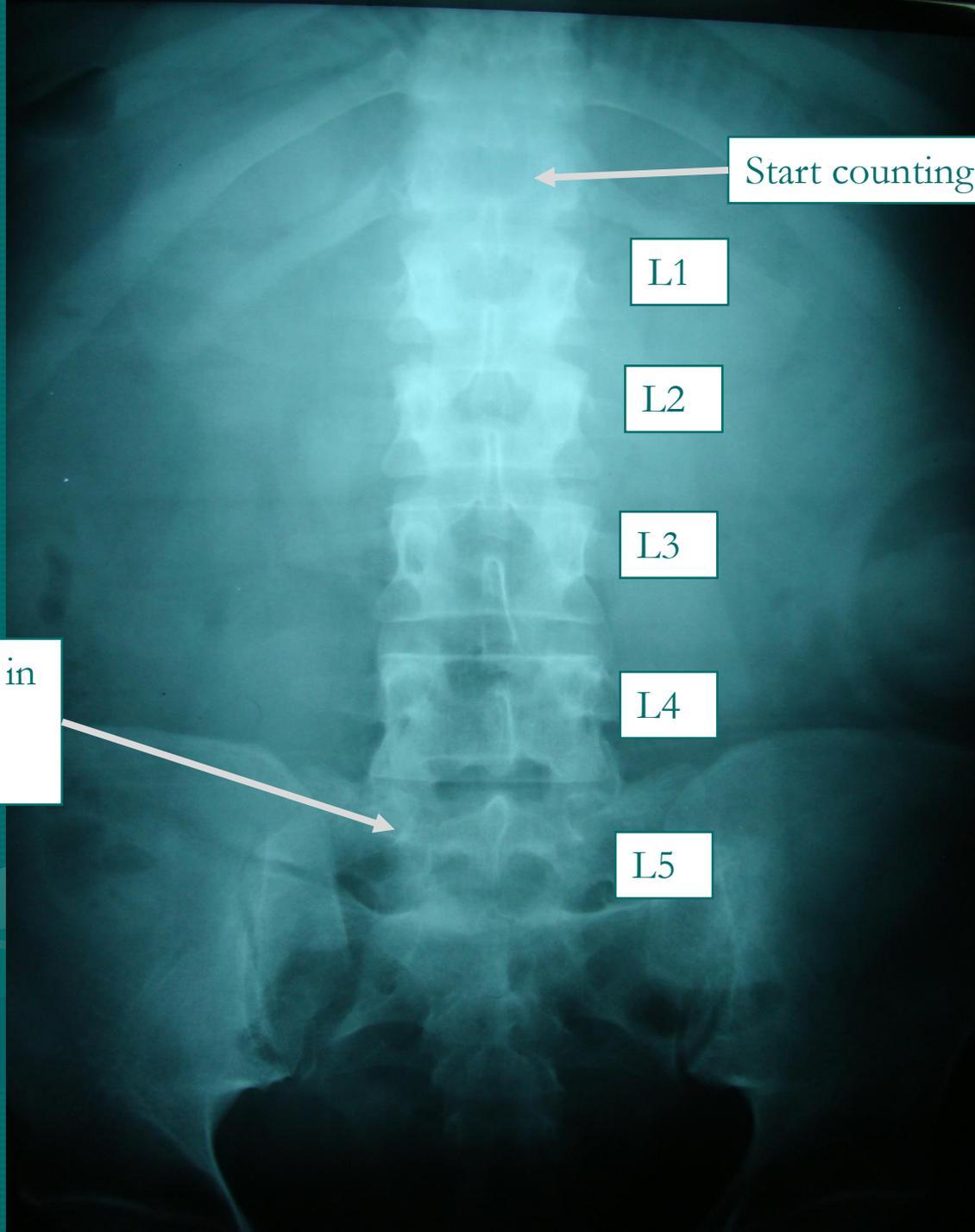
**Hemivertebra:** results from a lack of formation of one half of a vertebral body. It is a common cause of congenital scoliosis

**Butterfly vertebra:** is a sagittal defect in the **vertebral** body caused by failure of fusion of the 2 lateral portions during embryogenesis.

**Myelomeningocele:** The spinal canal is open along several vertebrae in the lower or middle back. The membranes and spinal nerves push through this opening at birth, forming a sac on the back

**Tethered cord:** the spinal cord is "stuck" to a structure within the spine, below L2

**Diastematomyelia:** part of the spinal cord is split, usually at the level of the upper lumbar vertebra



Start counting from T12

L1

L2

L3

L4

L5

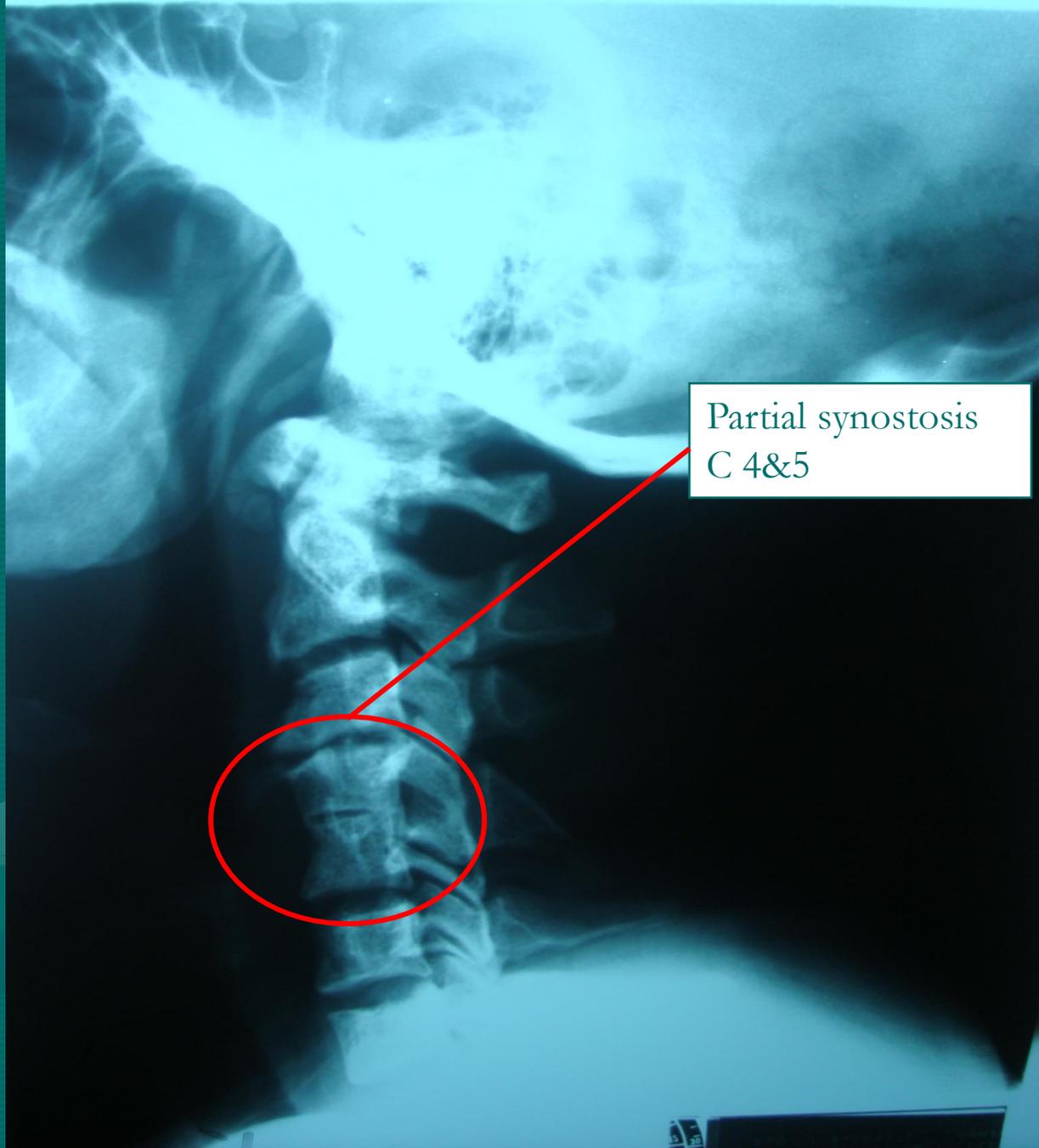
L5 should be free- but in this case is fused >> sacralisation



Spina  
bifida

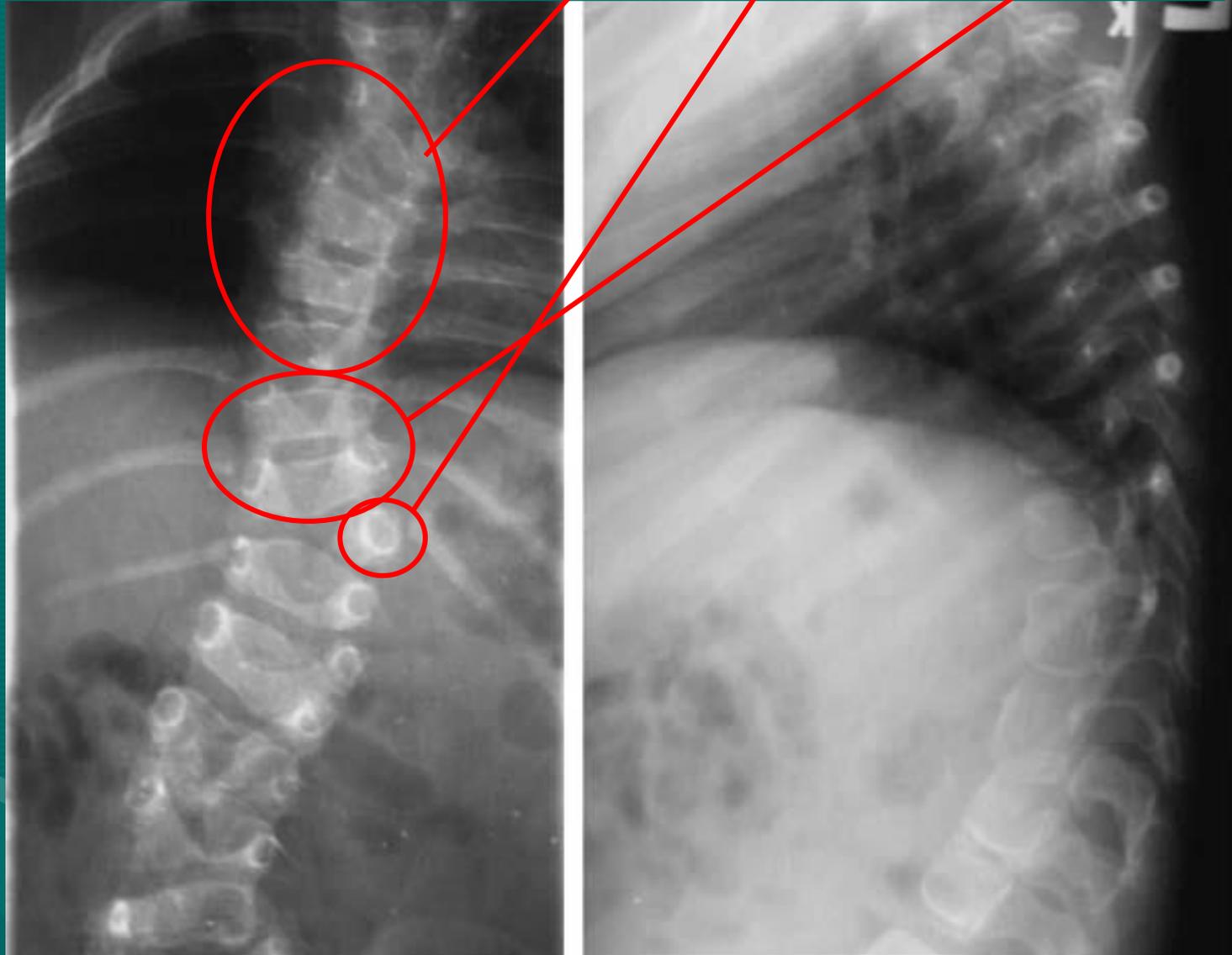


Lumbarisation – sacrum is  
above it's normal level.. S1  
not fused



Partial synostosis  
C 4&5

Multiple developmental anomalies: scoliosis, hemivertebra, butterfly vertebra

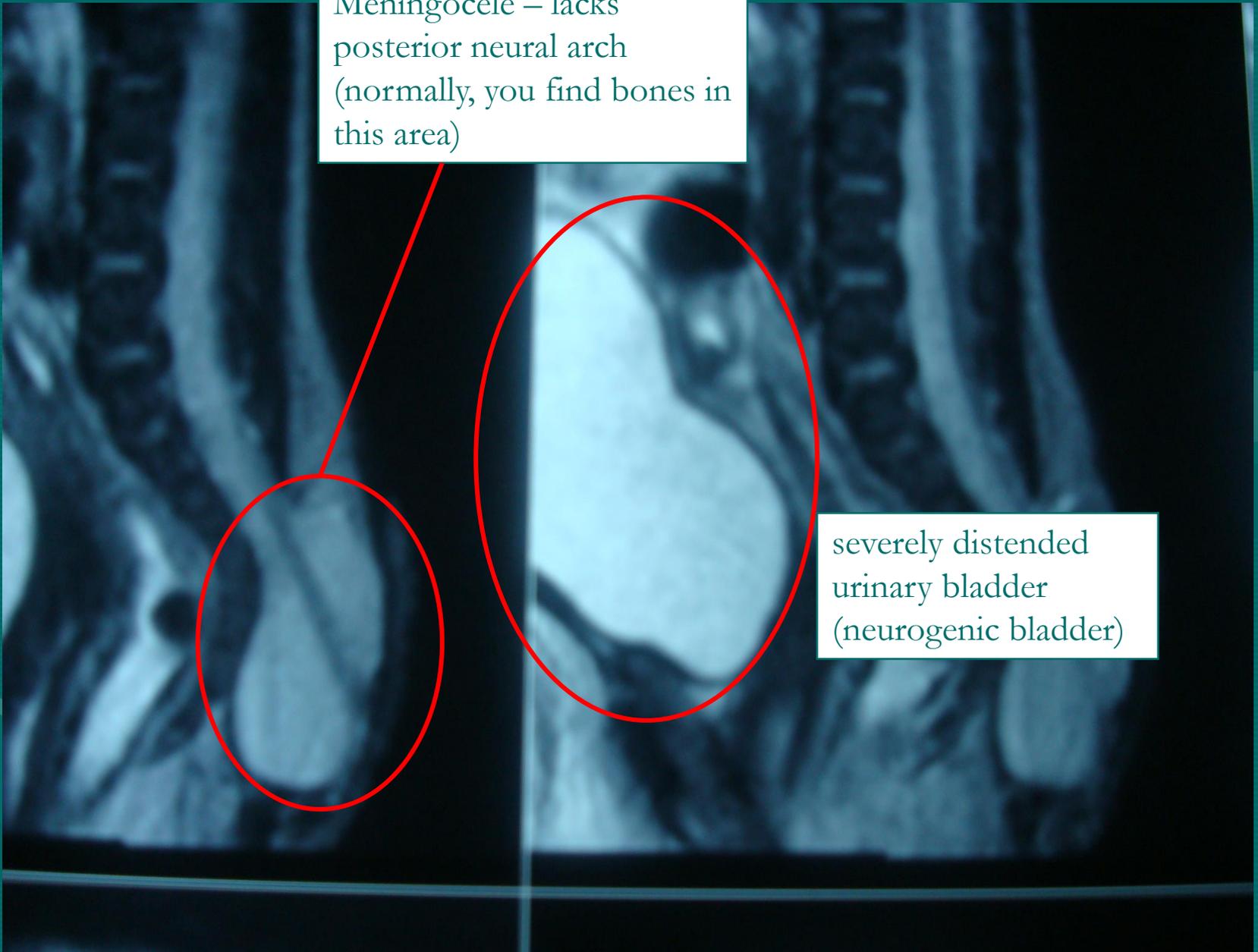


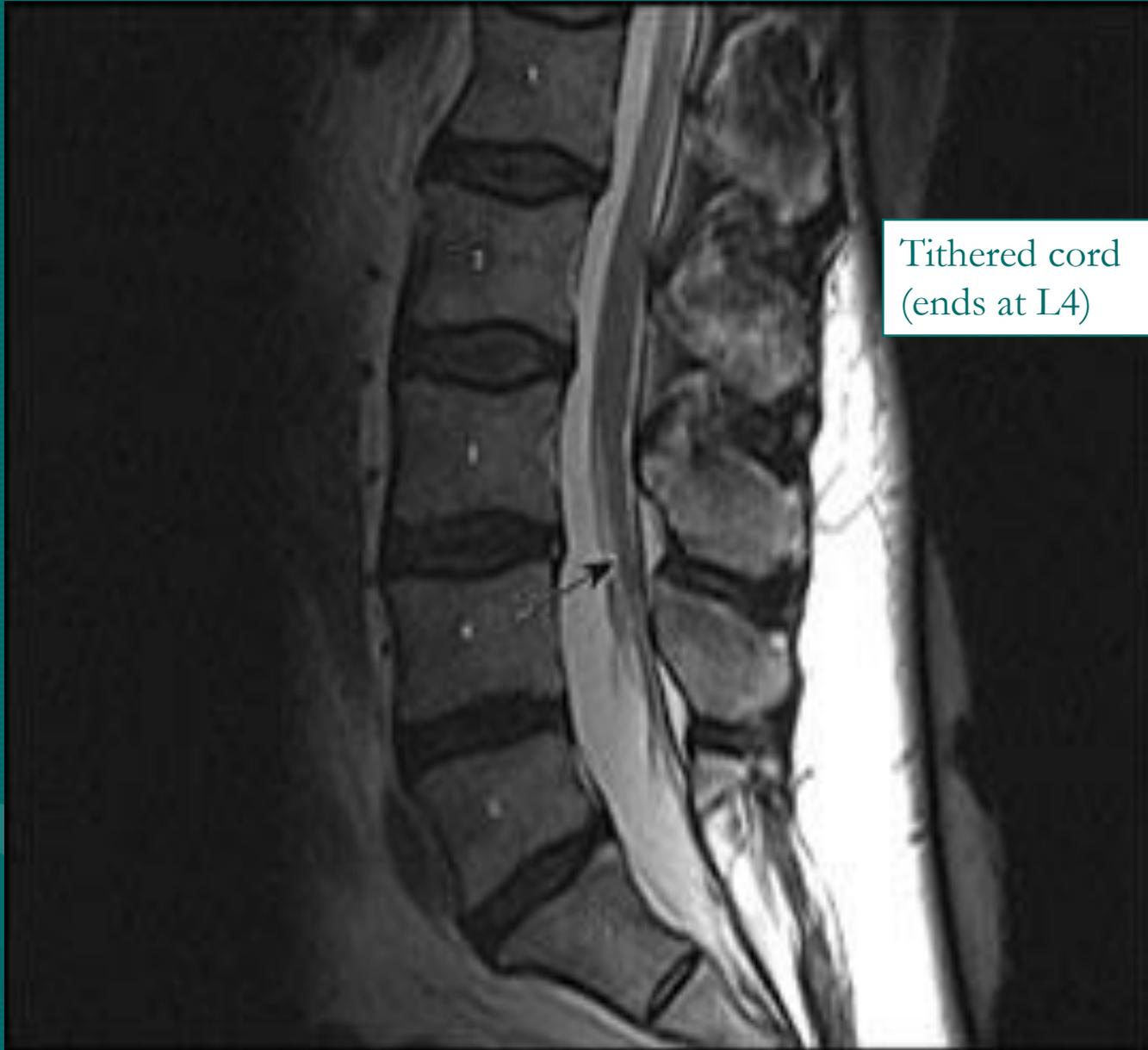
● When pedicles are absent >> compress on nerve roots

\*scoliosis may be acquired as in trauma or in kids who lift the school bags on one shoulder with time will lead to scoliosis → treatment by internal fixation of the spine and this prevent further deviation.

Meningocele – lacks  
posterior neural arch  
(normally, you find bones in  
this area)

severely distended  
urinary bladder  
(neurogenic bladder)





Tethered cord  
(ends at L4)



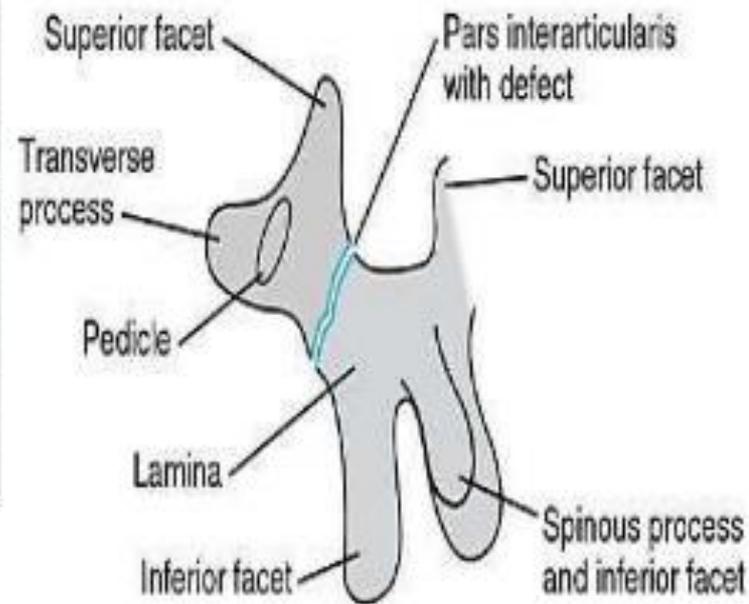
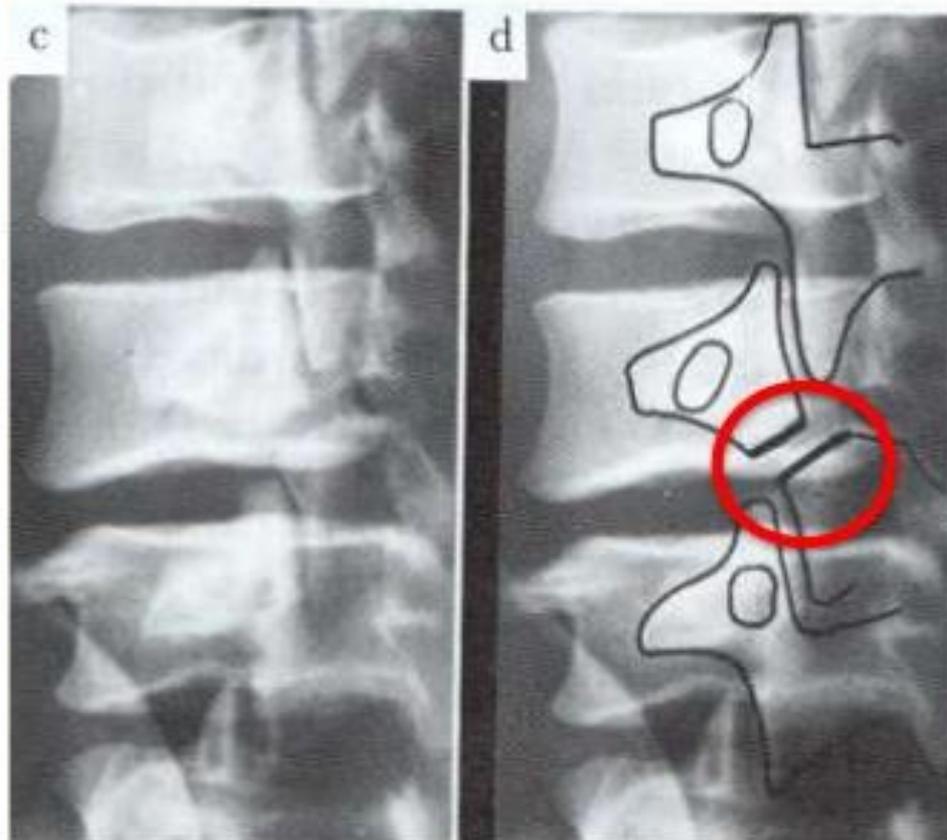
Diastatomyelia

The first causes  
the second

# SPONDYLOLISIS AND SPONDYLOLISTHESIS

## What is spondylolysis ?

- Is a defect in the region of the pars interarticularis of a vertebra, most commonly at the fourth and fifth lumbar level.
- This defect which was considered to be a congenital abnormality, is now thought to be almost always the result of unhealed stress fracture.



SCOTTY DOG

A2

Defect in the pars interarticularis -  
 'collar' around the 'neck' of an illusory  
 'dog' - oblique xray



# WHAT IS SPONDYLOLISTHESIS ?

Is anterior slipping or subluxation of a vertebra (or the spine above) in relation to the vertebrae below.

The main causes of spondylolisthesis are:

- Spondylolysis, is the most common cause
- Degenerative disc disease and osteoarthritis of the facet

joints.

Aging/ wt gain/ anything that causes more friction on the disc >> dehydration of the disc >> decrease in disk height >> approximating bones >> friction >> end-plate degeneration / sub-chondral sclerosis / osteophyte formation

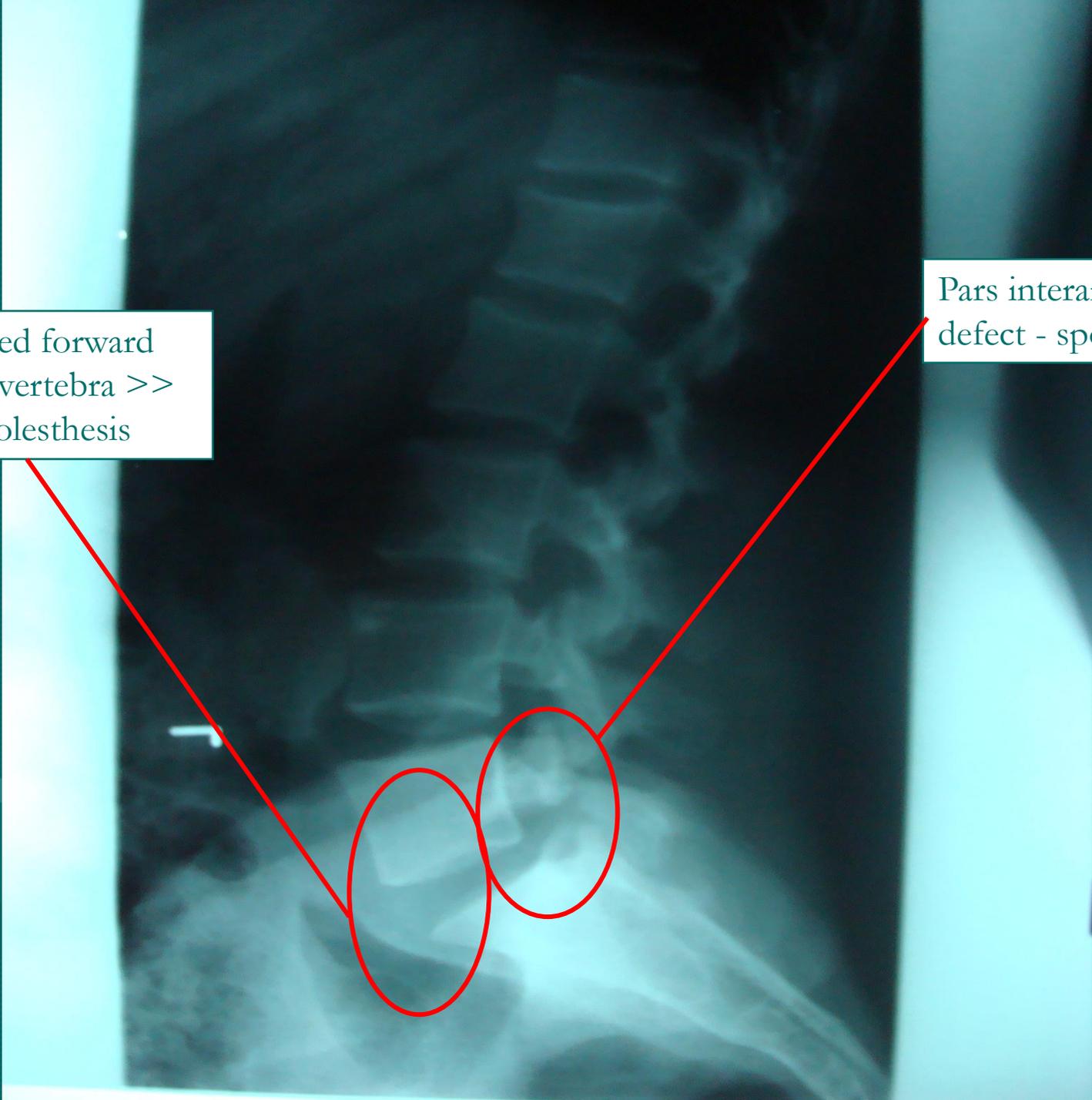
- Fracture of the posterior elements of the vertebra

هاي الصورة مش  
واضحة



L5 slipped forward  
over S1 vertebra >>  
spondylolesthesis

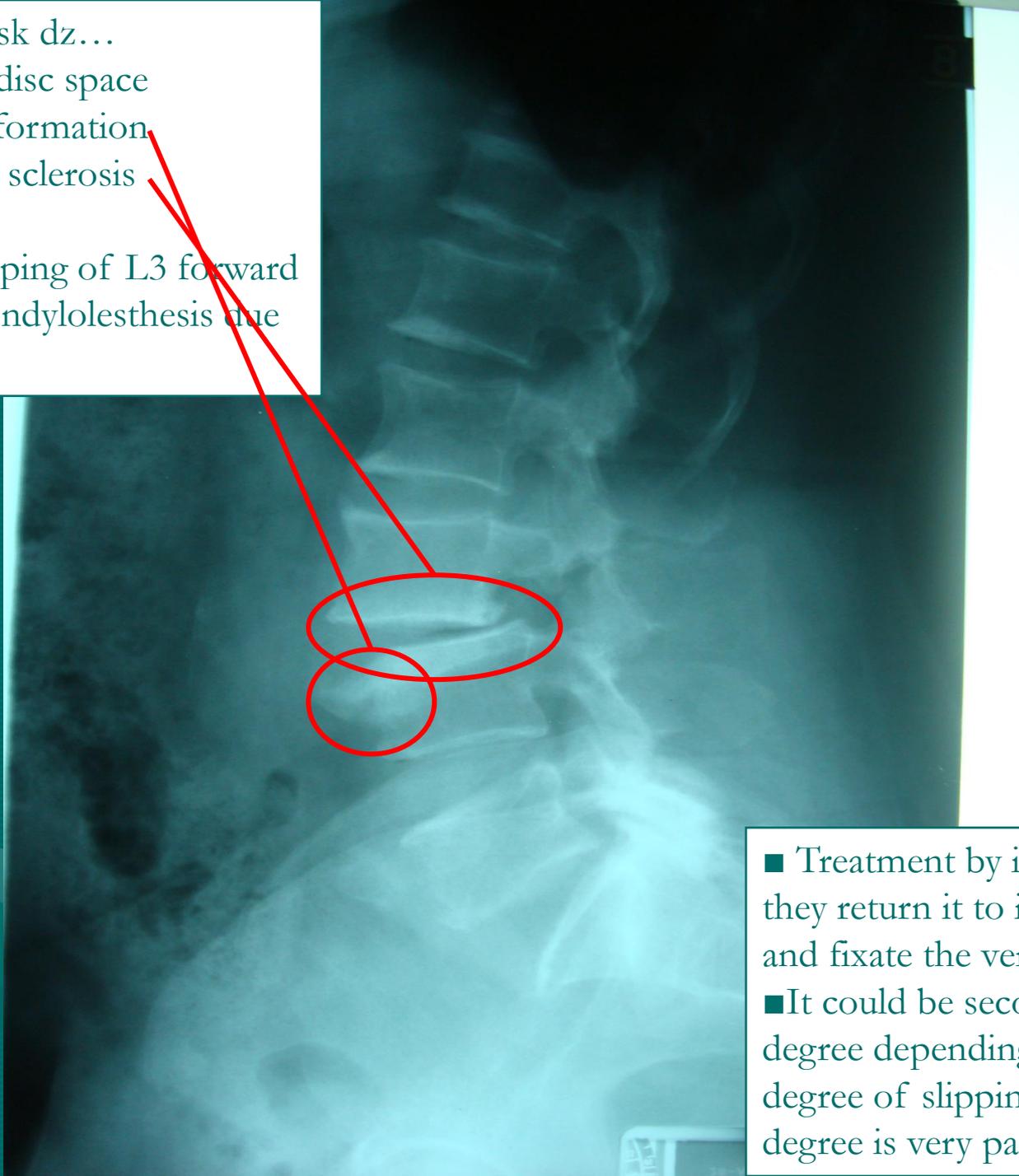
Pars interarticularis  
defect - spondylosis



## Degenerative disk dz...

- Decrease in disc space
- Osteophyte formation
- Subchondral sclerosis

>> anterior slipping of L3 forward over L4 >> spondylolesthesis due to DDD



- Treatment by internal fixation ; they return it to its normal site and fixate the vertebrae together
- It could be second or third degree depending on the degree of slipping ( the third degree is very painful)

# INTERVERTEBRAL DISC PATHOLOGY

- **The intervertebral disc** which lies between each two vertebral bodies is composed of a central gelatinous core known as the nucleus pulposus and surrounded by fibro cartilage called annulus fibrosus.
- **Most common articular disorders :**
  - ❖ Degenerative disc disease.
  - ❖ Disc bulging and herniation.
  - ❖ Infection.

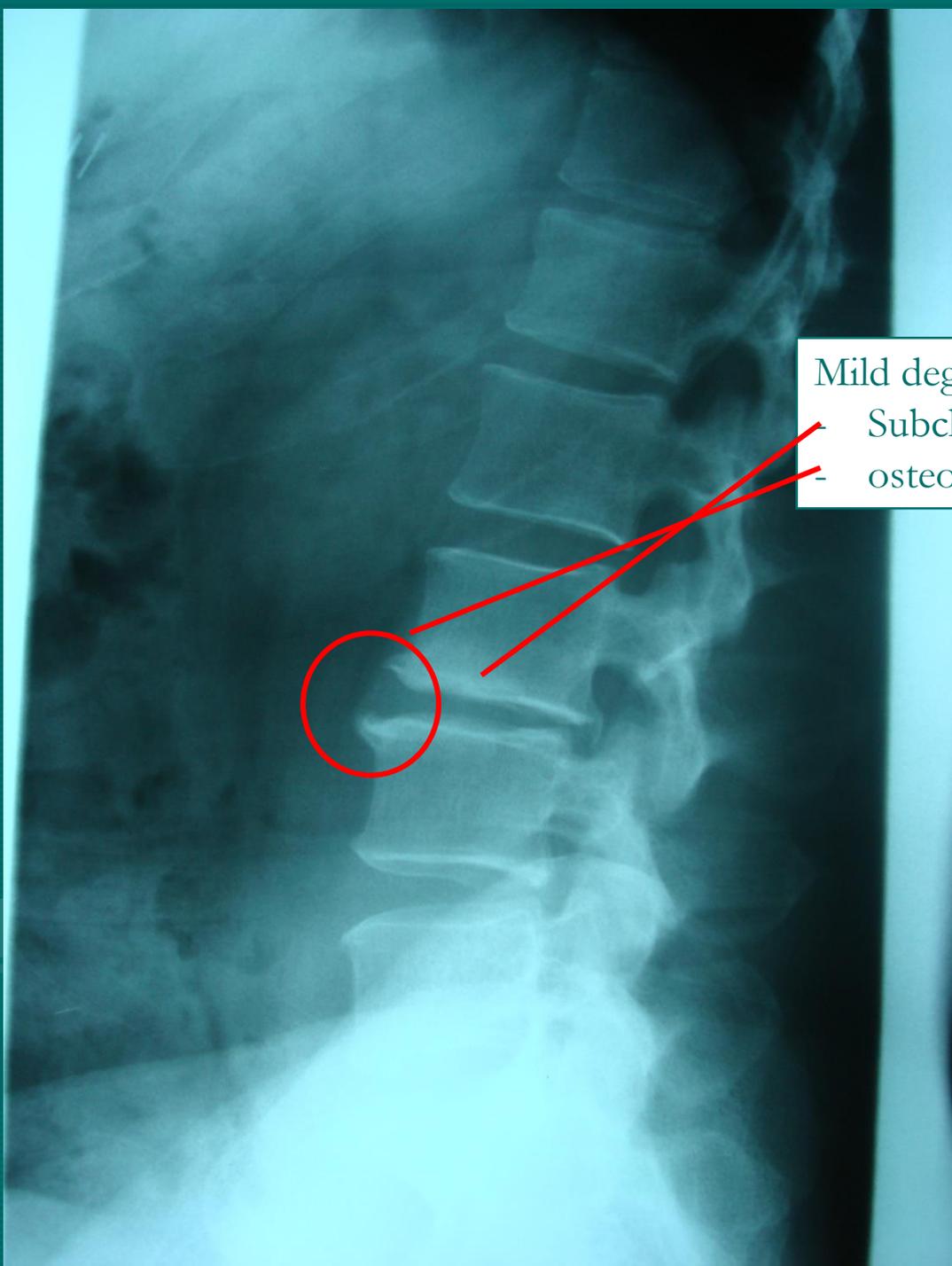
# DEGENERATIVE DISC DISEASE

- ❖ Is not really a disease but a term used to describe the natural degenerative changes in the intervertebral discs .
- ❖ Disc degeneration is part of the natural process of aging, and is one of the most common causes of low back pain.

## ❑ The DDD is characterized by:

- Disc space narrowing.
- Osteophytes formation at the vertebral body margins.
- Subchondral bone sclerosis ( mainly at the end plates ).
- In some cases, collection of gas is seen in the intervertebral disc ( vacuum disc phenomenon ).

Lesions in the bone :  
· Black → lytic lesion  
· White → sclerosis  
Mixed \*vacuum  
phenomena : gas in  
the intervertebral  
disc seen on CTscan



Mild degeneration

- Subchondral sclerosis
- osteophyte

# DISC HERNIATION

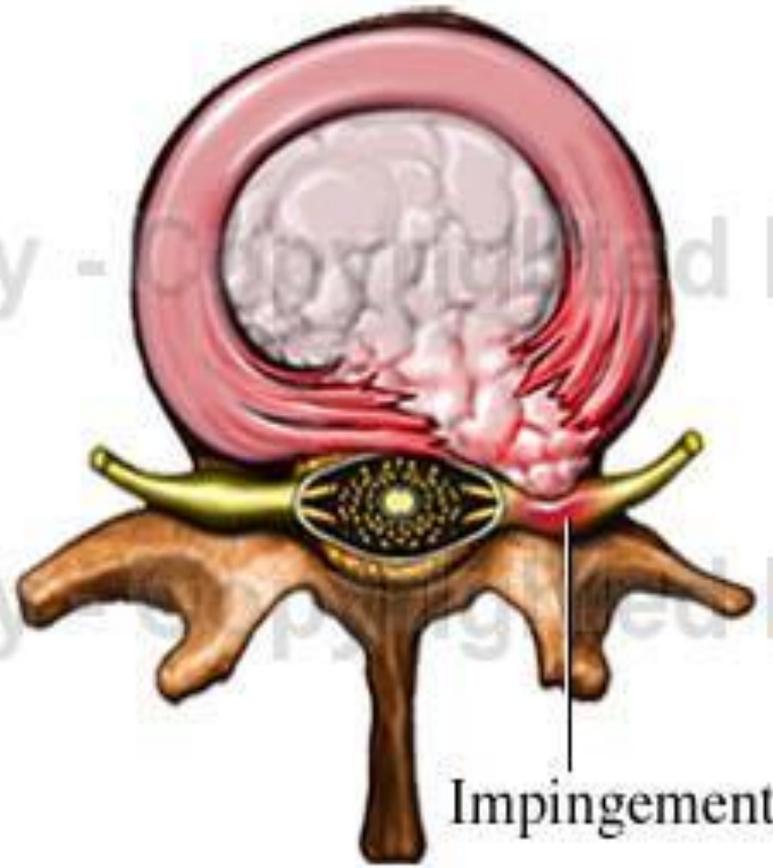
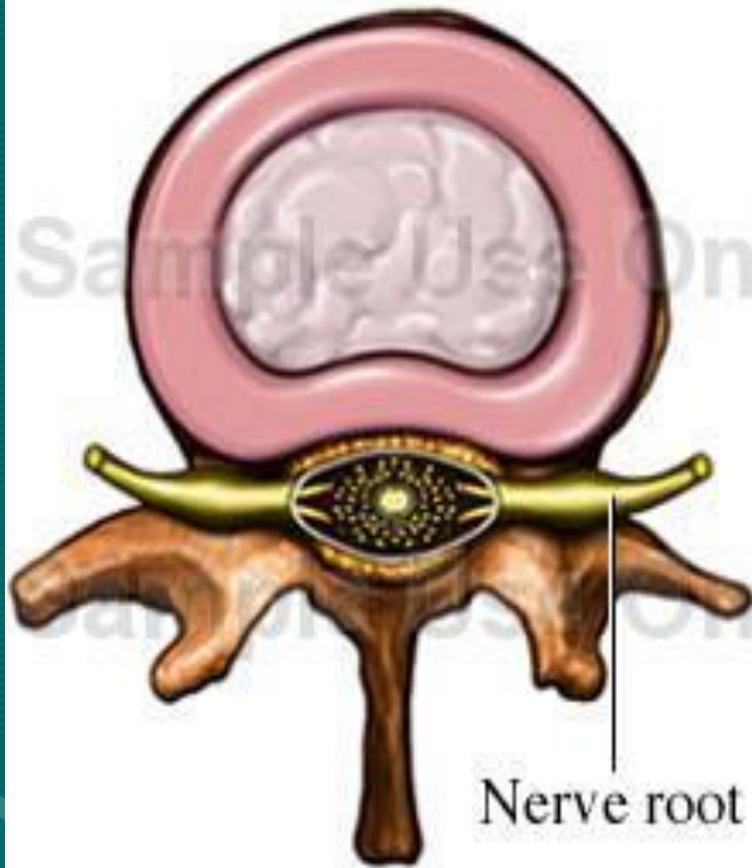
- The herniated disc is a portion of the nucleus pulposus extends through a tear in the annulus fibrosus, resulting in a focal protrusion at the margin of the disc.
- About 90% of disc herniation occurs at L4-L5 and L5-S1, with most of the remainder at L3-L4.
- **Types of disc herniation:**
  - ✓ Prolapse.
  - ✓ Extrusion.
  - ✓ Sequestration.

Herniation is usually postero-lateral because the post longitudinal ligament is central > strengthening the central part > herniation shifts laterally

- ◆ Mostly lumbar and cervical and need a surgical intervention but if thoracic then nothing can be done

Normal disc

Herniated disc



Nerve root

Impingement

# DISC PROTRUSION

The herniated nucleus pulposus extends through a tear in some of the annular fibers, but still confined by the intact outermost annular fibers

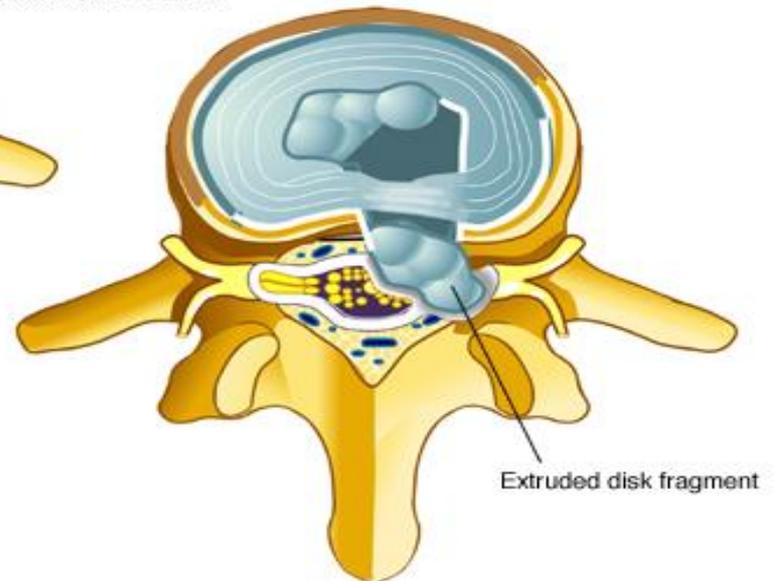
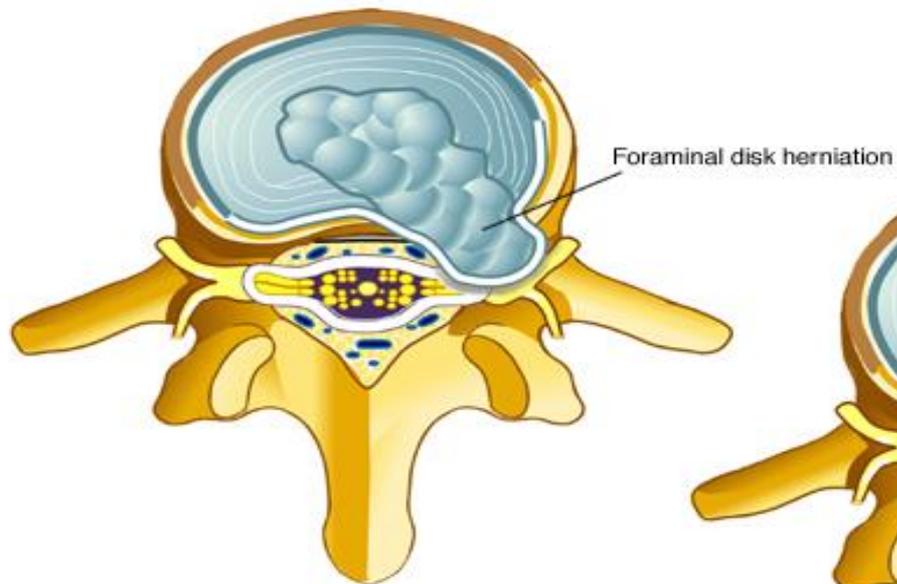
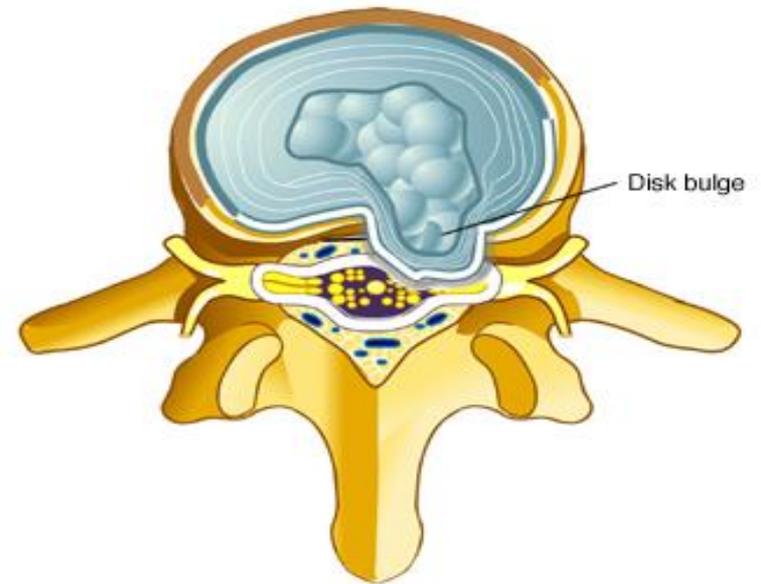
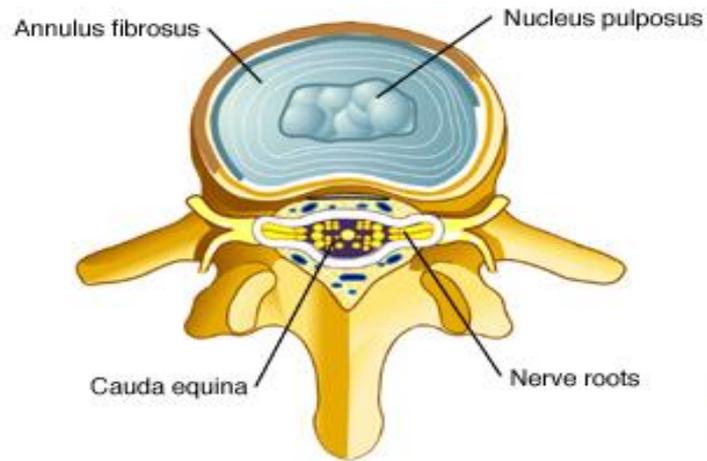
# DISC EXTRUSION

- The herniated nucleus pulposus penetrates through a complete tear of the annulus fibrosus.
- The extruded disc material may extend superiorly or inferiorly, but remain attached to the parent disc.

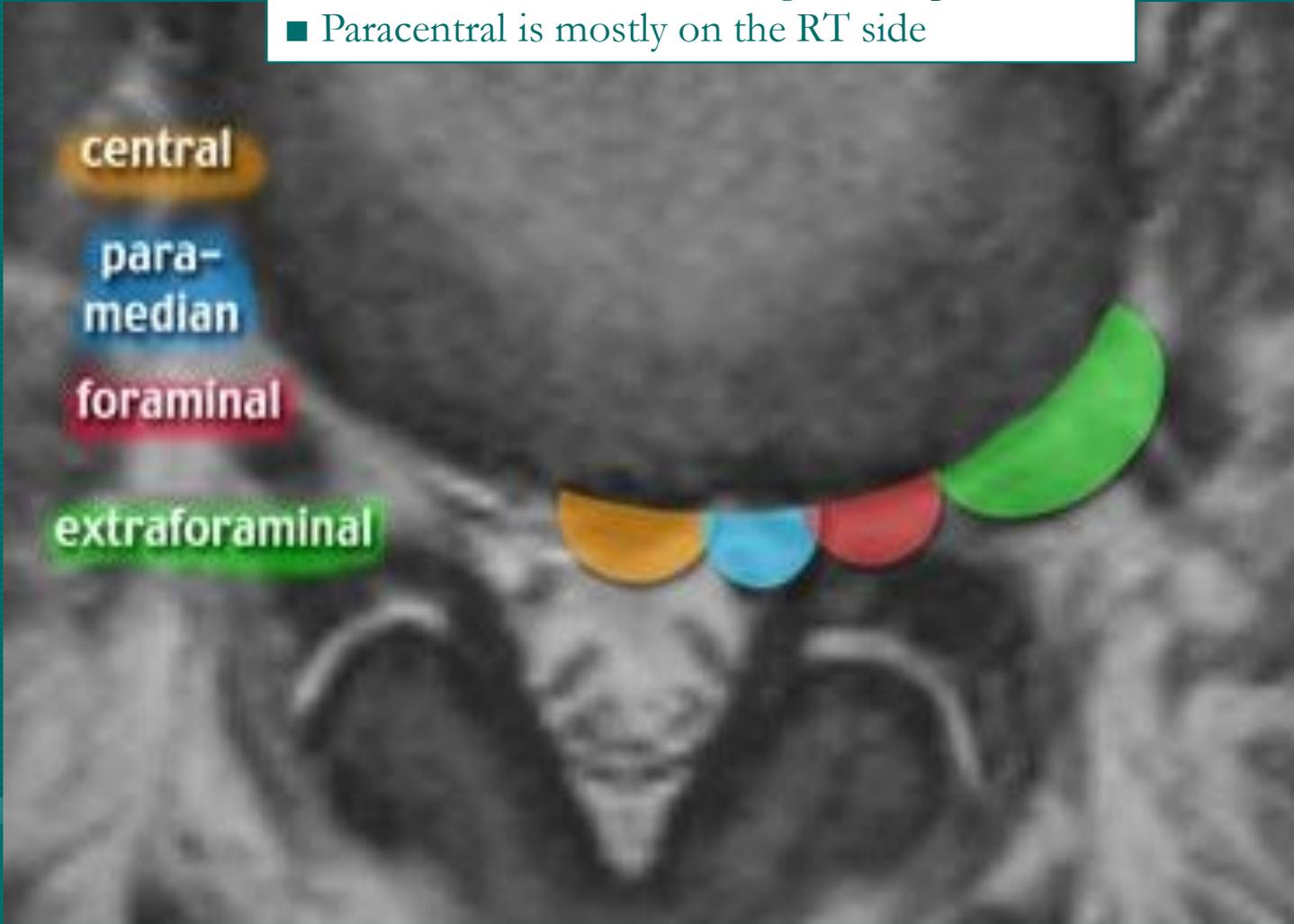
# DISC SEQUESTRATION

## (Free fragment)

- The disc herniates through a complete tear and penetrates the posterior longitudinal ligament and lies within the epidural space.
- The herniated disc breaks free of the parent disc and can migrate superiorly or inferiorly within the epidural space or into the neural foramen as a separate fragment.



- Central can cause narrowing in the spinal canal
- Paracentral is mostly on the RT side



MRI T2

\*10-Oct-71, M, 35Y

MR 2004V  
HFS  
+LPH

STUDY 1  
10-Oct-06  
14:08:20  
2 IMA 9 / 1

Normal,  
hydrated discs

L4-L5 disc:  
Dehydration, disc  
bulge compressing  
nerve roots ad  
thecal sac



10cm

10cm

P R4  
SL 4  
00\*300  
2\*320s  
ra(1.1)  
v 398  
c 199  
A3/SAT1  
C:SP2-5  
\*tse2d1\_25 / 150

MF 1.09  
E  
TR 4000.0  
TE 113.0  
TA 03:13  
BW 190.0  
M/ND  
FoV 300\*300  
272\*320s  
Sag>Tra(1.1)  
W 398  
C 199  
A3/SAT1  
C:SP2-5  
\*tse2d1\_25 / 15

When talking about X-ray or CT, never say 'inter-vertebral disc' – intervertebral discs aren't seen on CT and X-ray > instead, say 'inter-vertebral disc space'

## Disc herniation / plain film

Can plain film be used to diagnose disc herniation ?

NO

Modality of choice for disc >> MRI  
We can't depend on CT or X-ray

**Then why are plain films routinely ordered for patients with low back pain ?**

Plain film is essential and may reveal the presence of one of the common causes of back pain such as:

- Degenerative disc disease.
- Sacralization
- Facet joint osteoarthritis.
- Spondylolysis and / or spondylolisthesis.
- Neoplastic disease.

# LUMBAR SPINE TUMORS

Can be classified into two groups:

1- Bone Tumors.

2- Spinal Canal Tumors.

Osteoid osteoma in spine : young adults, (male) painful scoliosis, relieved by aspirin  
Most common bone T : haemangioma

# TUMORS OF THE SPINE

## 1- Tumors of bone

benign

- Hemangioma of Vertebral body.
- Osteoid osteoma
- Osteoblastoma
- Aneurysmal bone cyst
- Histiocytosis x (Eosinophilic granuloma)

Malignant

- Multiple myeloma
- Metastasis

- Hemangioma on MRI is hyper in both T1 & T2
- Most patients have hemangioma and it has no effect
- The difference between multiple myeloma and METS is :
  - ~ multiple myeloma → in the vertebral body
  - ~ METS → in pedicles

Spinal tumors :

- intradural & extradural
- Intramedullary & extramedullary >>> defined on axial cut

# Tumors of the spinal canal

- Intramedullary: occur inside the cord

- ❖ Ependymoma
- ❖ Astrocytoma
- ❖ Lipoma

No need to differentiate the types

Cause cord expansion  
– epidural spaces are normal

- Extramedullary-intradural:

Occur within the meninges covering the spinal cord:

- neurofibroma and schwannoma
- Meningiomas
- Dermoid and epidermoid

Meningioma or Schwannoma?  
Look similar, homogeneously enhancing.

The difference is that schwannoma follows the tract of nerve > leaves the exit-canal

# Tumors of the spinal canal /2

## - Extradural:

Appear between the meninges and the bones of the spine:

- Metastasis:
- Meningiomas

BM infiltration (metastasis):

- On T1 >> intensity of the mass is similar to the disc (low-signal)
- Contrast >> enhancement

★we need an Axial cut on MRI to decide whether the lesion is extra- or intra-medullary .....  
intradural extramedullary→ compress on the spinal cord

★ In intramedullary : the mass is inside the spinal cord and lead to enlargement of the cord on the axial cut

★ In extramedullary : mass compresses on the spinal cord

# Tumours of the spine

Tumours of the spinal cord

Bone tumours

## **Extradural:**

- Bones >> bony mets
- Meninges >> meningioma

## **Intradural-extramedullary:**

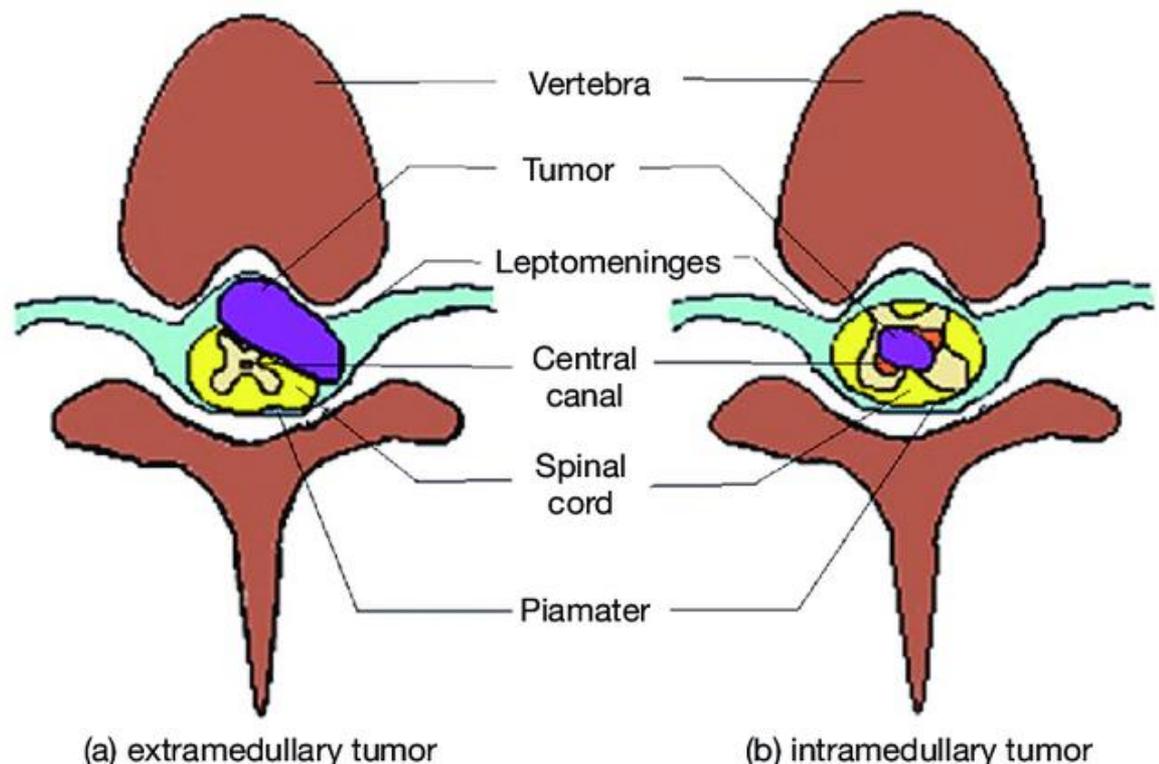
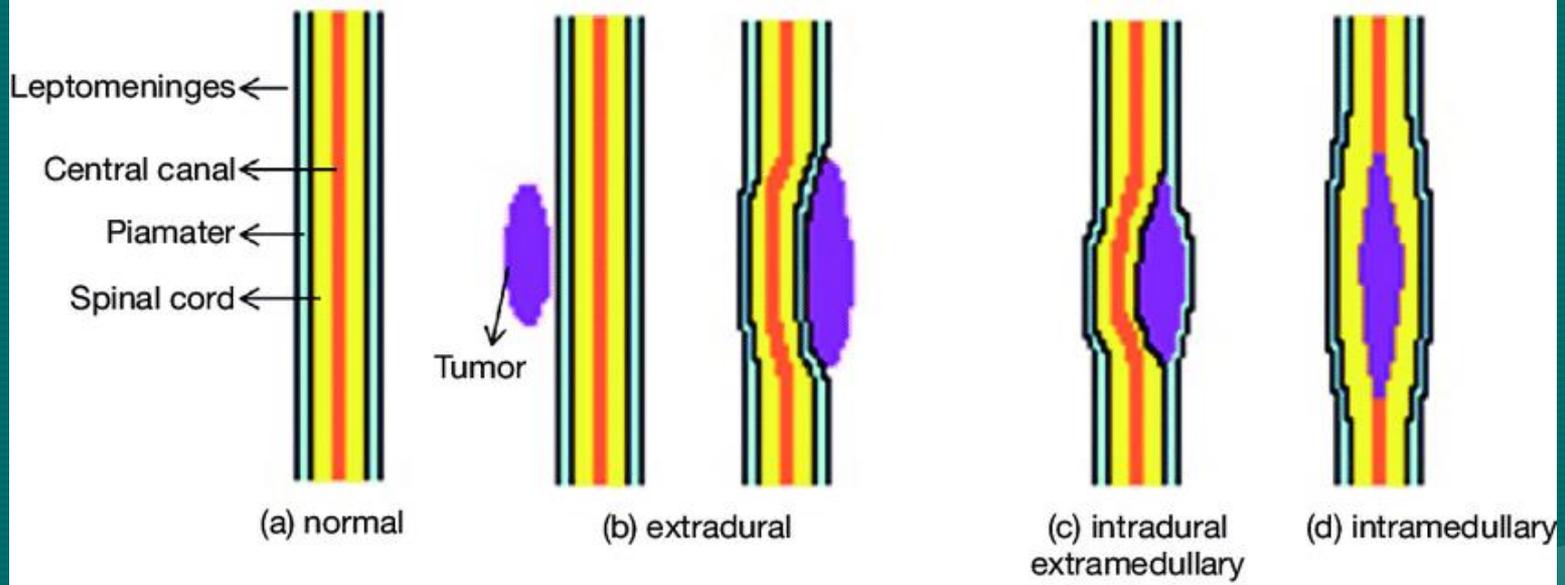
Outside the S.C, within epidural space

- Meninges >> meningioma
- Nerve roots >> schwannoma/neurofibroma
- Dermoid / epidermoid: below conus medullaris, around filum terminalis

## **Intramedullary:**

Within the S.C, causes cord expansion

- Glial cells >> astrocytoma
- Ependymal cells >> ependymoma
- Fat cells >> lipoma



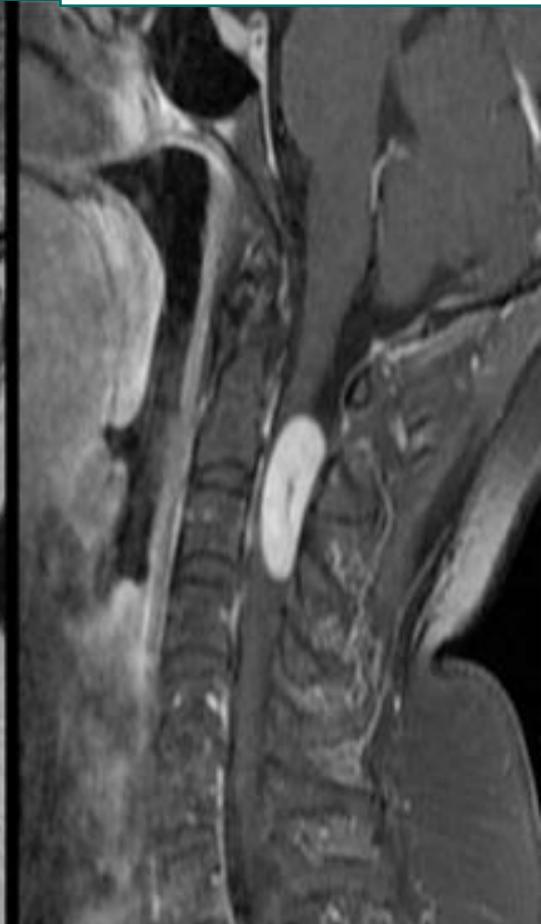
MRI- T1



MRI- T2 (CSF is bright-hyper-intense)



MRI- T1 with contrast



**Cervical Spinal schwannoma.**

Extramedullary intradural  
Tumour pushed the space  
forward but is still within  
the dural space  
With enhancement

Intramedullary  
Expanded cord

MRI- T2



MRI- T1 with contrast



kidney hilum is L1-L2 >> these images are below the cord  
>> no cord = the lesion must be extramedullary

Meningioma or schwannoma? It's schwannoma bcz it's following the nerve through the inter-vertebral foramen

kidneys

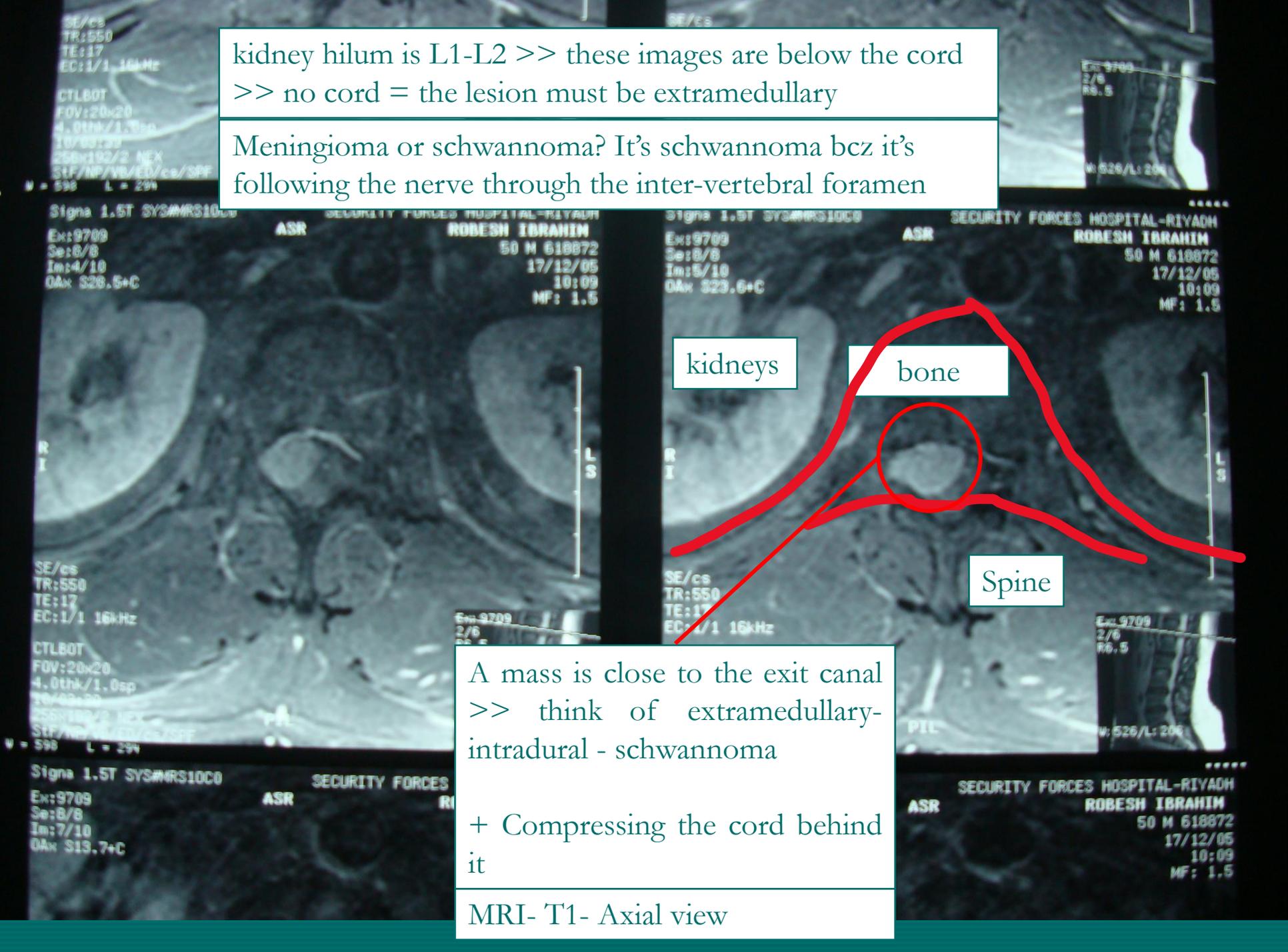
bone

Spine

A mass is close to the exit canal  
>> think of extramedullary-intradural - schwannoma

+ Compressing the cord behind it

MRI- T1- Axial view



T1 sequence : notice the intensity of the mass is similar to the disc



+ contrast- enhancement >> it is a metastatic lesion

Could also be a haemangioma

spondylodiscitis - infection of the disc and the spine  
pyogenic is the most common + could be TB potts dz

pyogenic starts with discitis then spondylitis

TB usually involves the vertebrae (spondylitis) then the disc (discitis)  
so, when you see involvement of disc but not the bone = pyogenic...

This is T1 pre- and post- contrast

post: enhancement around the disc, in the bone, in the surrounding soft-tissue





Thank  
You