



Lecture 1 :  
**Radiology of Spinal Cord**



KSU | Collage of Medicine  
2<sup>nd</sup> Year | CNS BLOCK

# Objective

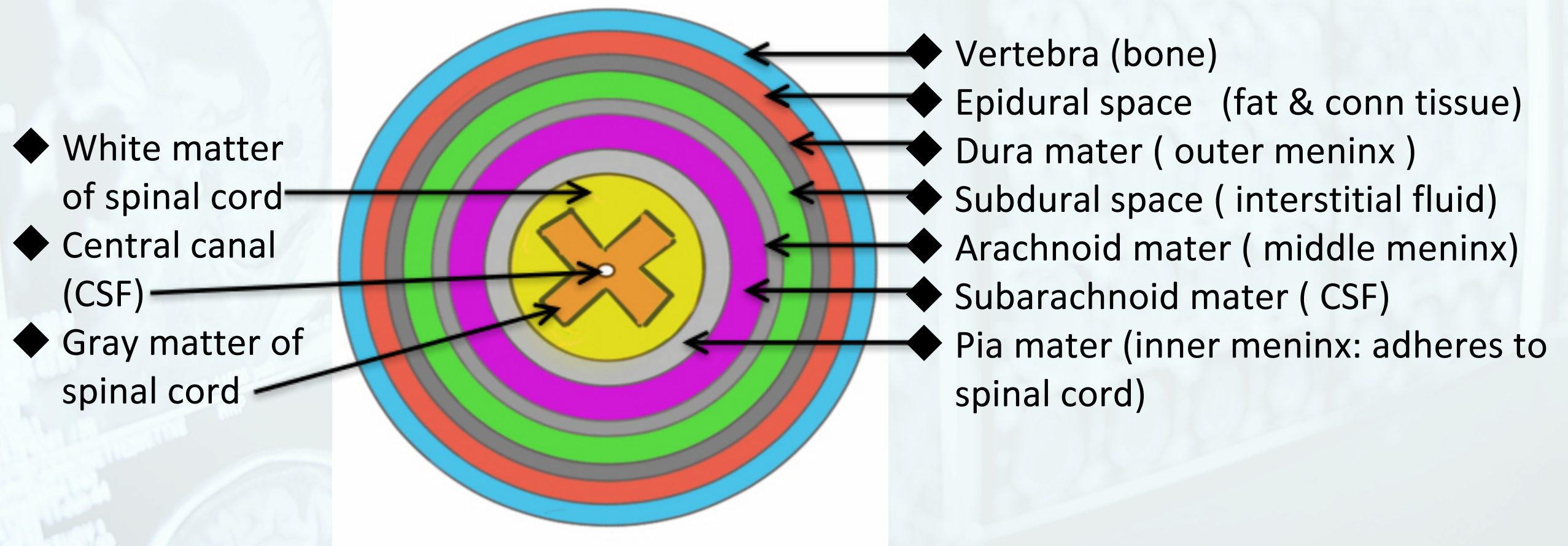
- After completing this module you should be able to :
  1. identify, and distinguish between common types of Radiographic Images including: **Plain X-rays**, X-Ray Myelograms, **CT**, CT Myelograms and **MRI**.
  2. You should also be able to recognize some radiological presentations of spinal cord **diseases**.

## Notes:

We put the pictures in case the lecture is included in the practical, but going through them will help you understand & memorize the information.

# Anatomy of Spinal Cord

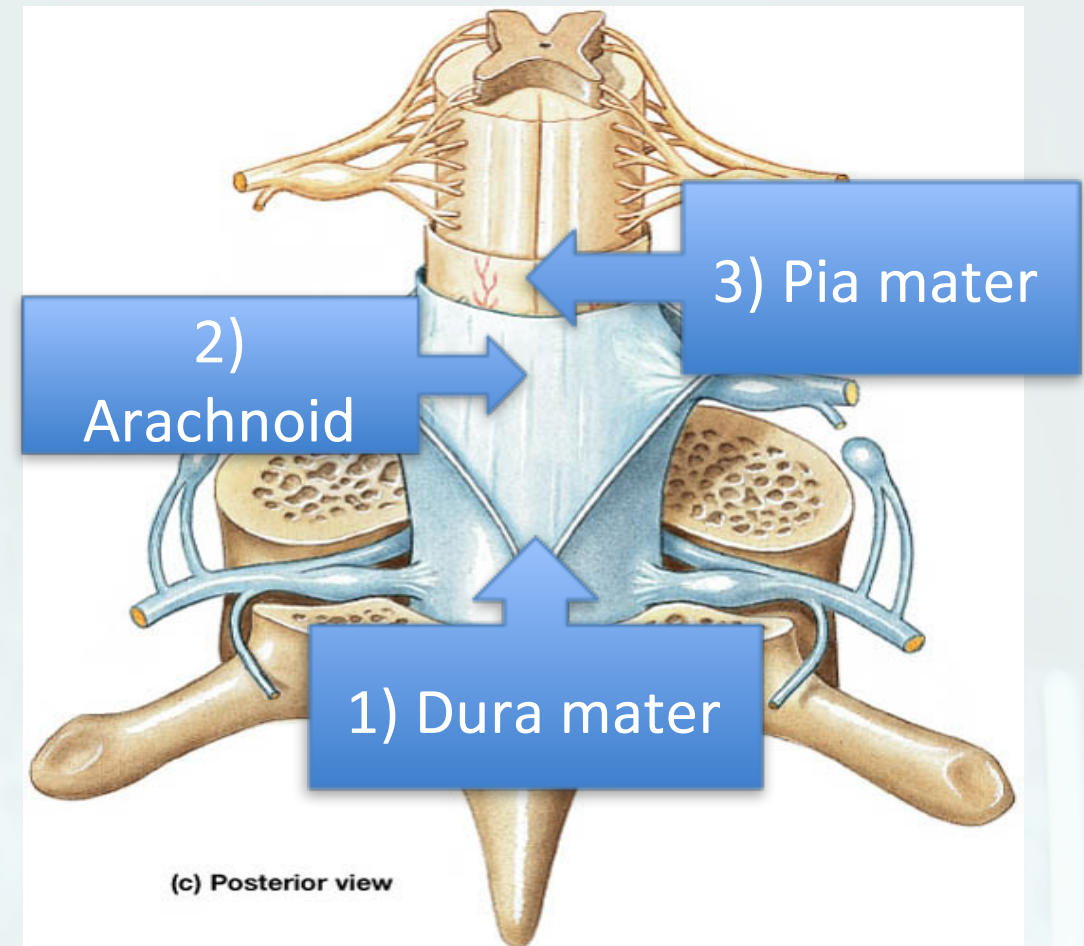
- ▶ Continuous with medulla oblongata
- ▶ Extends to approximately L2
- ▶ Connected to 31 pairs of spinal nerves
- ▶ Gray matter = inside
- ▶ White matter = outside



## ✧ Spinal Meninges:

Three membranes surround all of CNS (PAD):

- 1) Dura mater : "tough mother" strong.
- 2) Arachnoid meninx : spidery looking, carries blood vessels, etc.
- 3) Pia mater : "delicate mother", adheres tightly to surface of spinal cord.



## ✧ Meningeal Spaces

- Between the dura mater and periosteum of the vertebrae is the epidural space that contains many blood vessels and fat.
- Space between dura mater and archnoid-subdural space-**no CSF**.
- Space between arachnoid and pia mater-subarchnoid **space-CSF**, blood vessels, spinal roots.

## Imaging Methods to Evaluate Spine :

1. Plain X-Ray Films
2. Myelogram : injection of contrast medium in CSF followed by x-ray images. **Rarely performed now-a-days because MRI are taking over.**
3. Computed Tomography (CT Scan)
4. Magnetic Resonance Imaging (MRI)
5. Discogram : injection of contrast medium in the disc followed by x-ray images
6. Spinal angiography : to evaluate arteries and veins
7. Ultrasound : more in children
8. Radionuclide Bone Scan : intravenous injection of radioactive material bound to phosphonates which deposit in bones, followed by images by gamma camera.
9. DEXA : radionuclide scan for bone density (osteoporosis)

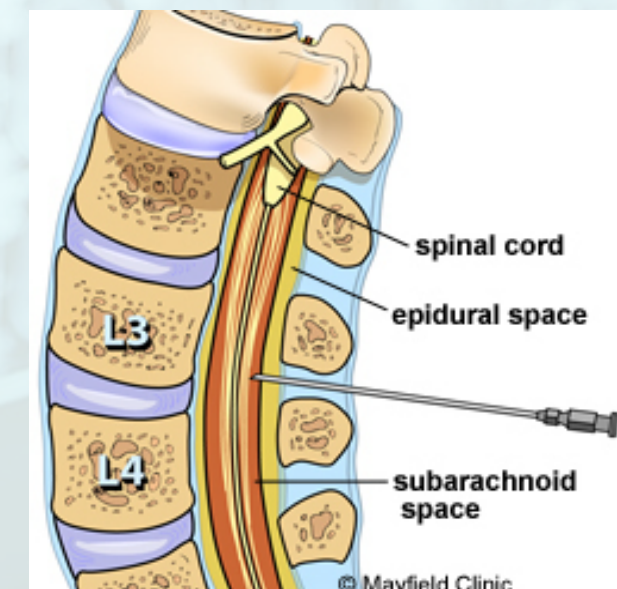
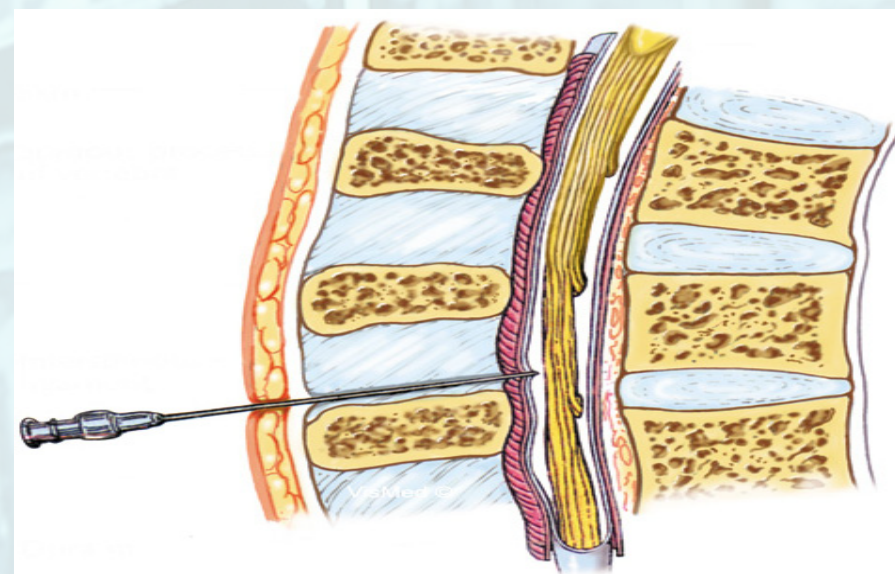
## Imaging Decisions :

- **X-ray & CT scan are good for bony tissue and MRI for soft tissue.**
- x-rays are usually the first series of images to be ordered by the physician.
- If fractures, or other bony defects are suspected, CT images can provide very detailed information.
- When soft tissue injury is suspected, MRI is usually the imaging technology of choice.
- It is often necessary to utilize multiple imaging modalities. X-ray, CT and MRI to get all the information required for treatment.

# Dyes

Myelogram	Discogram
<p>It identifies areas where spinal cord or spinal nerves may be compressed. It is a diagnostic tool that uses radiographic contrast media (<b>dye</b>) that is injected into the spinal canal's fluid (CSF). After the dye is injected, the contrast dye serves to <b>illuminate</b> the spinal canal, cord, and nerve roots during imaging.</p>	<ul style="list-style-type: none"> <li>• Discs are the cushions between vertebral bodies.</li> <li>• MRI &amp; CT scans provide structural information.</li> <li>• Discogram better identifies the relationship of disc pain.</li> </ul>
<ul style="list-style-type: none"> <li>• Local Anesthesia, a needle is placed in the lower lumbar spinal canal, and then CSF flow is confirmed.</li> <li>• Contrast media (Dye) is then injected, which mixes with CSF around spinal cord making it visible on X-Ray images.             <ul style="list-style-type: none"> <li>• Myelogram have white color in spinal cord</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• A needle is placed into the center of the disc under fluoroscopy (continuous X-ray imaging).             <ul style="list-style-type: none"> <li>• Contrast Material (Dye) is injected</li> </ul> </li> <li>• Radiologist then observes if the patient experiences pain that is similar to their usual pain, and is increased by injecting contrast.</li> </ul>
<p>Often a CT scan is also performed after this. Performed when MRI is contraindicated. Myelogram is rare nowadays because MRI are taking over.</p>	<p>X-rays are then done to see if the dye stays within the center of the disc or leaks to the outer border of the disc indicating a tear in annulus fibrous of the disc which can be a source if pain</p>

✧ Puncture made at L2-L3 or L3-L4 space.

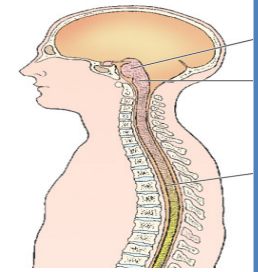


	X-Ray (Radiographs)	CT Scan (Computerized Tomography)	MRI (Magnetic Resonance Imaging)
Features	<ul style="list-style-type: none"> <li>• Often the first diagnostic imaging tests</li> <li>• Quick</li> <li>• Cheap</li> <li>• <b>Small dose of radiation</b> to visualize the bony parts of the spine</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Uses radiation</b> to obtain 2D &amp; 3D images</li> <li>• Cross-sectional images are obtained of the target areas.</li> <li>• Detailed information regarding bony and soft tissues.</li> <li>• Entire spine can be detected within a few minutes.</li> <li>• A contrast material may be injected intravenously or intrathecally (in CSF) to make some areas clear.</li> </ul>	<ul style="list-style-type: none"> <li>• The gold standard of imaging for spinal disorders.</li> <li>• <b>Does not use ionizing radiation.</b></li> <li>• Intravenous contrast is sometimes administered to better visualize certain structures or abnormalities.</li> <li>• MRI is contraindicated in a patient with pacemaker.</li> <li>• Artificial joints and spinal hardware may still have MRI scans.</li> <li>• MRI can be weighted to highlight different tissues and structures within the same anatomy.</li> <li>• The most common “weighting” is T1 &amp; T2. T2 is especially useful in spine surgery.</li> <li>• It highlights the hydrogen in water as bright white, so it shows the cerebral spinal fluid inside the dura mater and the water inside a healthy intervertebral disc very clearly. You can use this phrase to help you remember – “T2 H2O.”</li> </ul>
Can detect	<ul style="list-style-type: none"> <li>• Spinal alignment &amp; curvature</li> <li>• Spinal instability [with flexion &amp; extension views]</li> <li>• Congenital (birth) defects of spinal column</li> <li>• Fractures caused by trauma</li> <li>• Moderate osteoporosis (loss of calcium from the bone)</li> <li>• Infections</li> <li>• Tumors</li> </ul>	<p>better in visualizing:</p> <ul style="list-style-type: none"> <li>• degenerative or aging changes</li> <li>• herniated discs</li> <li>• spinal alignment</li> <li>• fractures and fracture patterns</li> <li>• congenital/childhood anomalies</li> <li>• areas of narrowing in spinal canal through which spinal cord and spinal nerve root pass</li> </ul>	<p>identifies abnormalities of:</p> <ul style="list-style-type: none"> <li>• Bone</li> <li>• Discs</li> <li>• Muscles</li> <li>• Ligaments</li> <li>• Spinal cord</li> </ul>

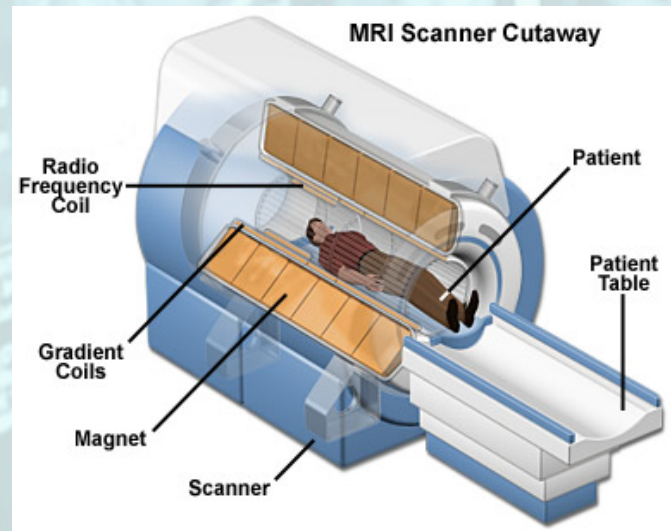
	X-Ray (Radiographs)	CT Scan (Computerized Tomography)	MRI (Magnetic Resonance Imaging)
Position of patient	may be taken in different positions ie: bending forward and backward to assess for instability	patients must lie still on a table that moves through a scanner	patients lie still in a tunnel-like structure for about 25 minutes
Disadvantages		poor in visualizing inner details of spinal cord main disadvantage is radiation	-claustrophobic* patients may need sedation -children often need general anesthesia -contraindicated in patients with implanted devices (e.g. cardiac pacemakers)

- Claustrophobia\*: is the fear of being in closed or narrow space and more common in female.
- Claustrophobic patients could use Open type MRI, Myelogram, or need sedation or general anesthesia with closed MRI.

We call this view :  
 X-ray = lateral  
 CT & MRI = sagittal



CT scan



MRI

Closed type



Open type



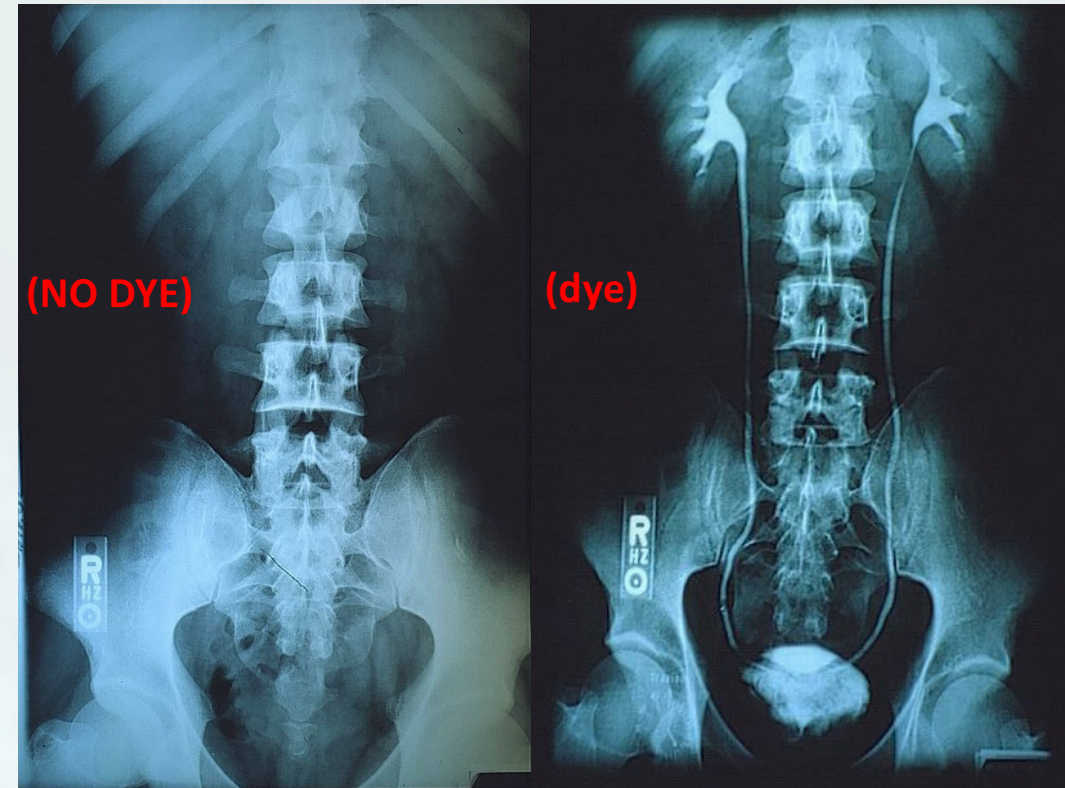
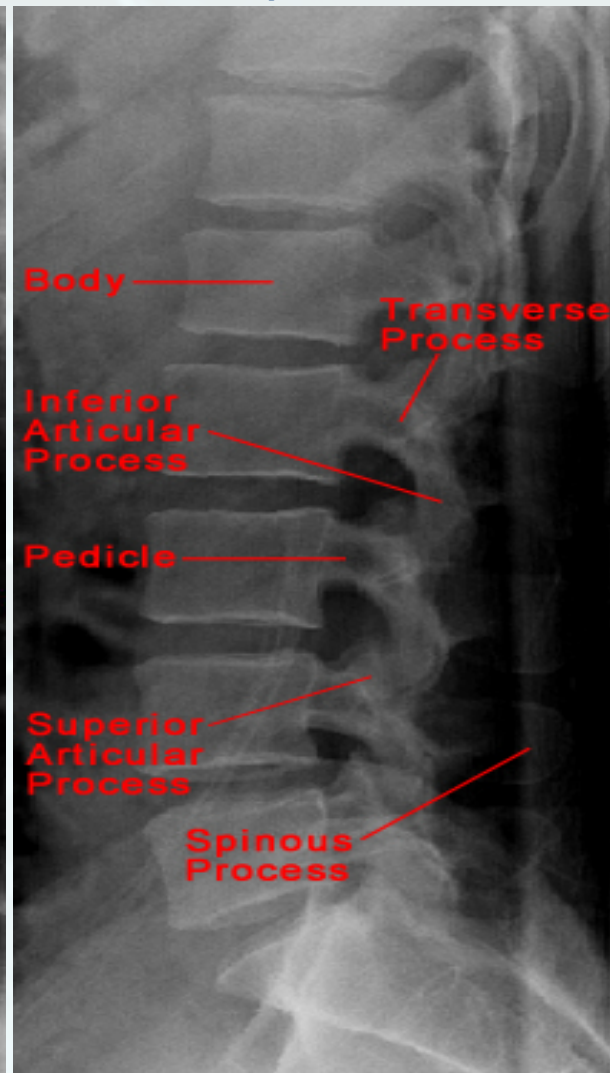
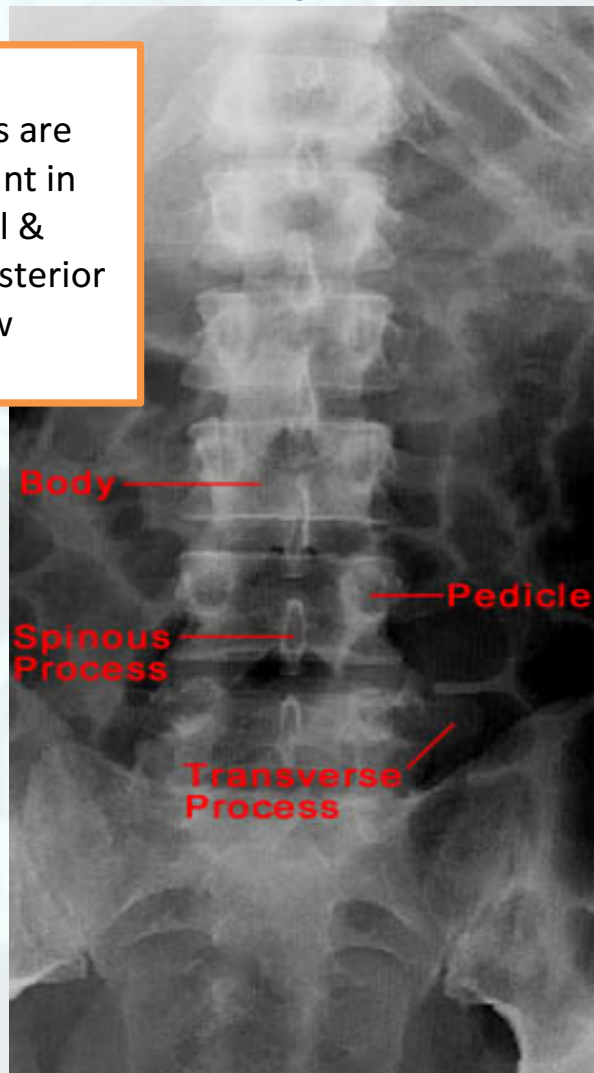


## L.Sp AP\*

## L.Sp Lt

## Radiographic Contrast Media

Pedicles are important in lateral & Anteroposterior view

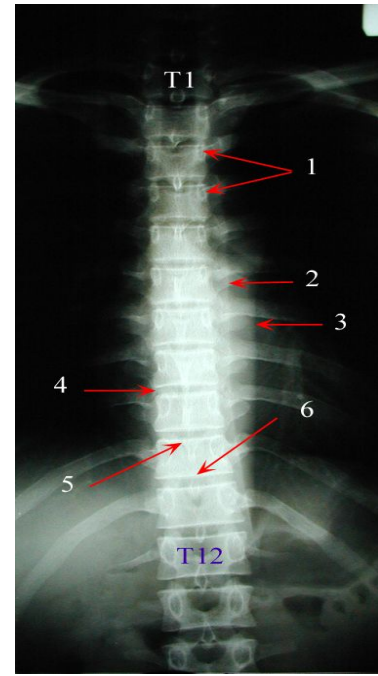


Odontoid process is very important in C2

\*Note:  
 C.Sp = Cervical spine  
 T.Sp = Thoracic spine  
 L.Sp = lumbar spine  
 AP = Anteroposterior view  
 Lt = Lateral View



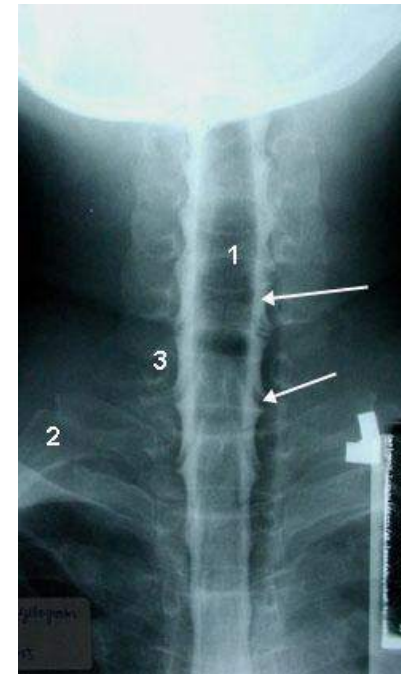
T.Sp Lt



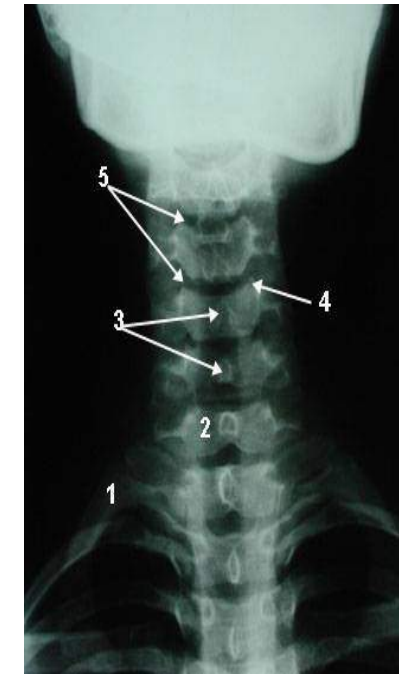
T.Sp AP



C.Sp Lt



C.SP AP  
With CONTRAST  
in spinal canal



C.SP AP  
NO CONTRAST

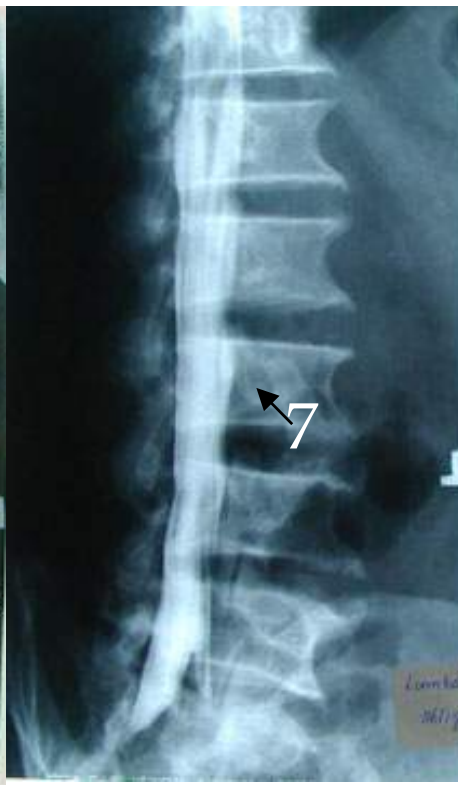
## Lumbar myelogram



Lt



AP

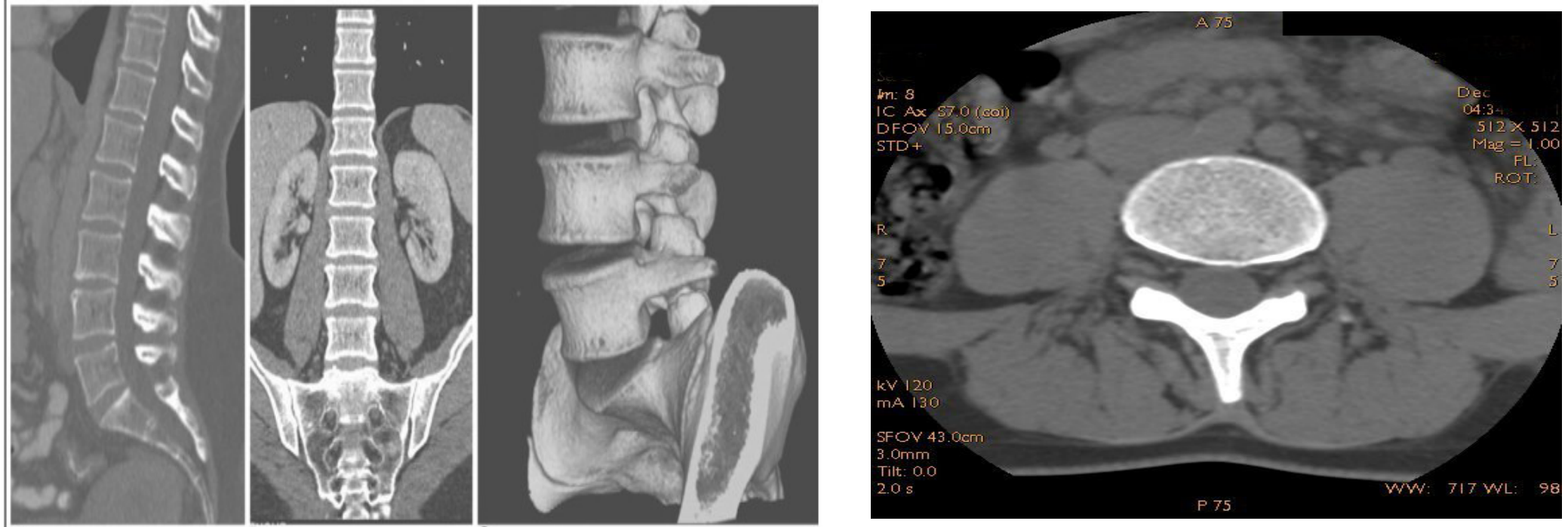


Oblique view

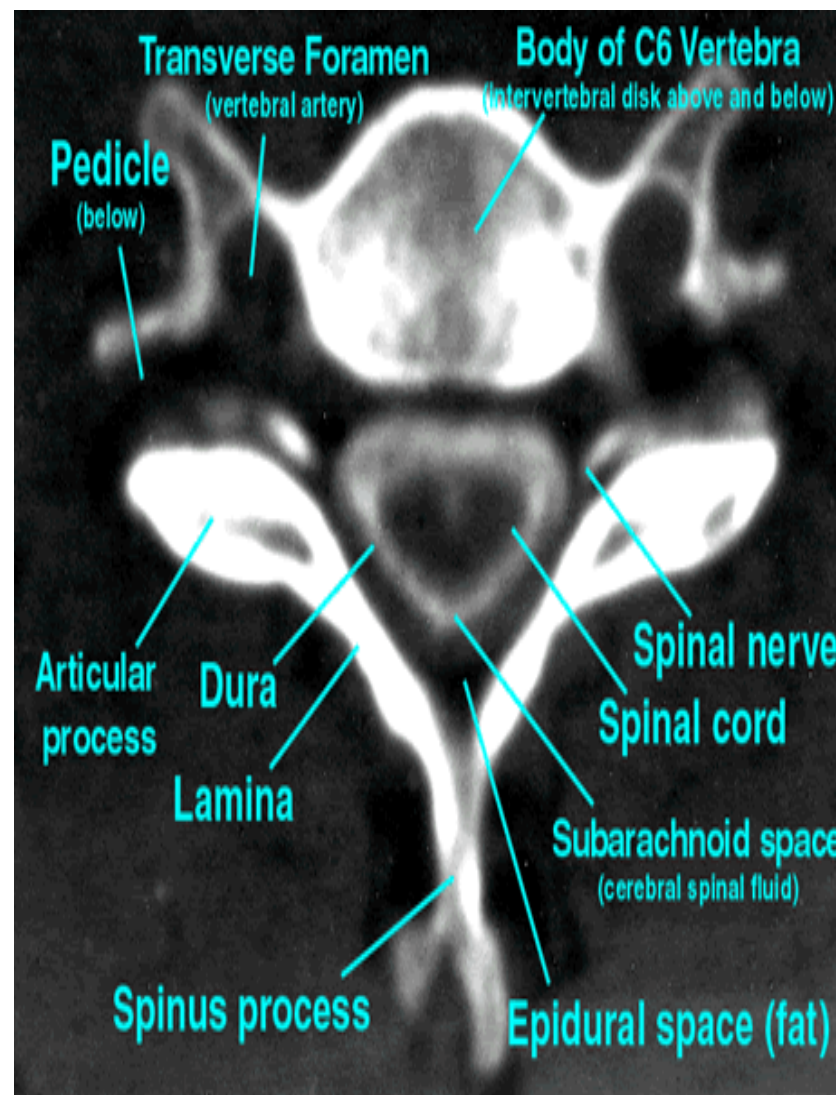
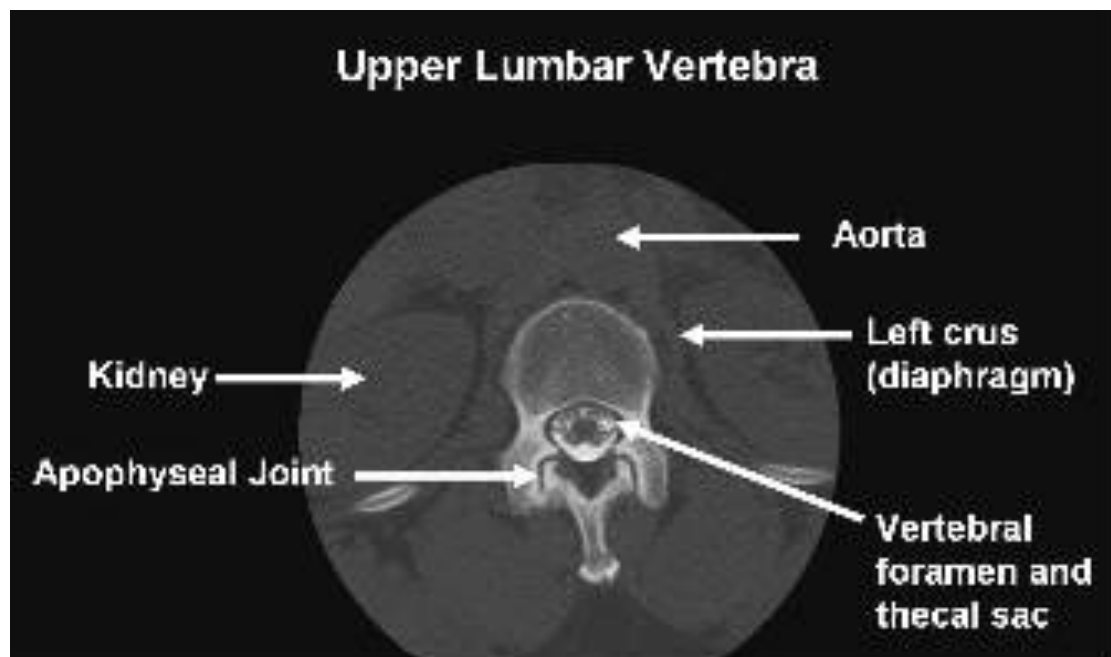


- 1- Conus Medullaris
- 2- Cauda Equina
- 3- Left S1 nerve root
- 4- Osteophyte
- 5- Epidural compression due to herniated L4-L5 disc
- 7- Root sleeve

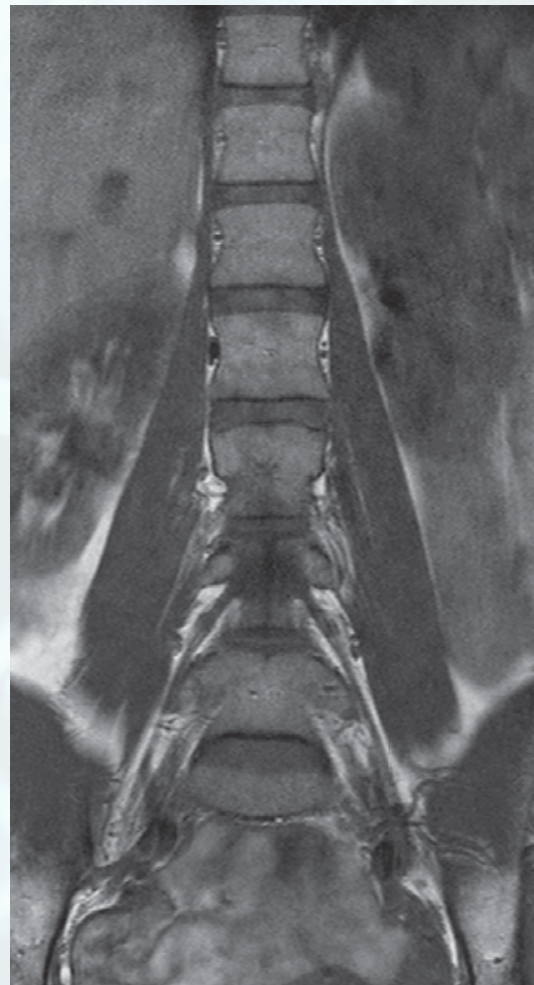
CT scan :



CT myelogram :



MRI images are multi-planar, and have very high resolution



Coronal (Frontal)



Sagittal (Median)



Transverse



In MRI image:

- (T1) the CSF will be black
- (T2) the CSF will be white

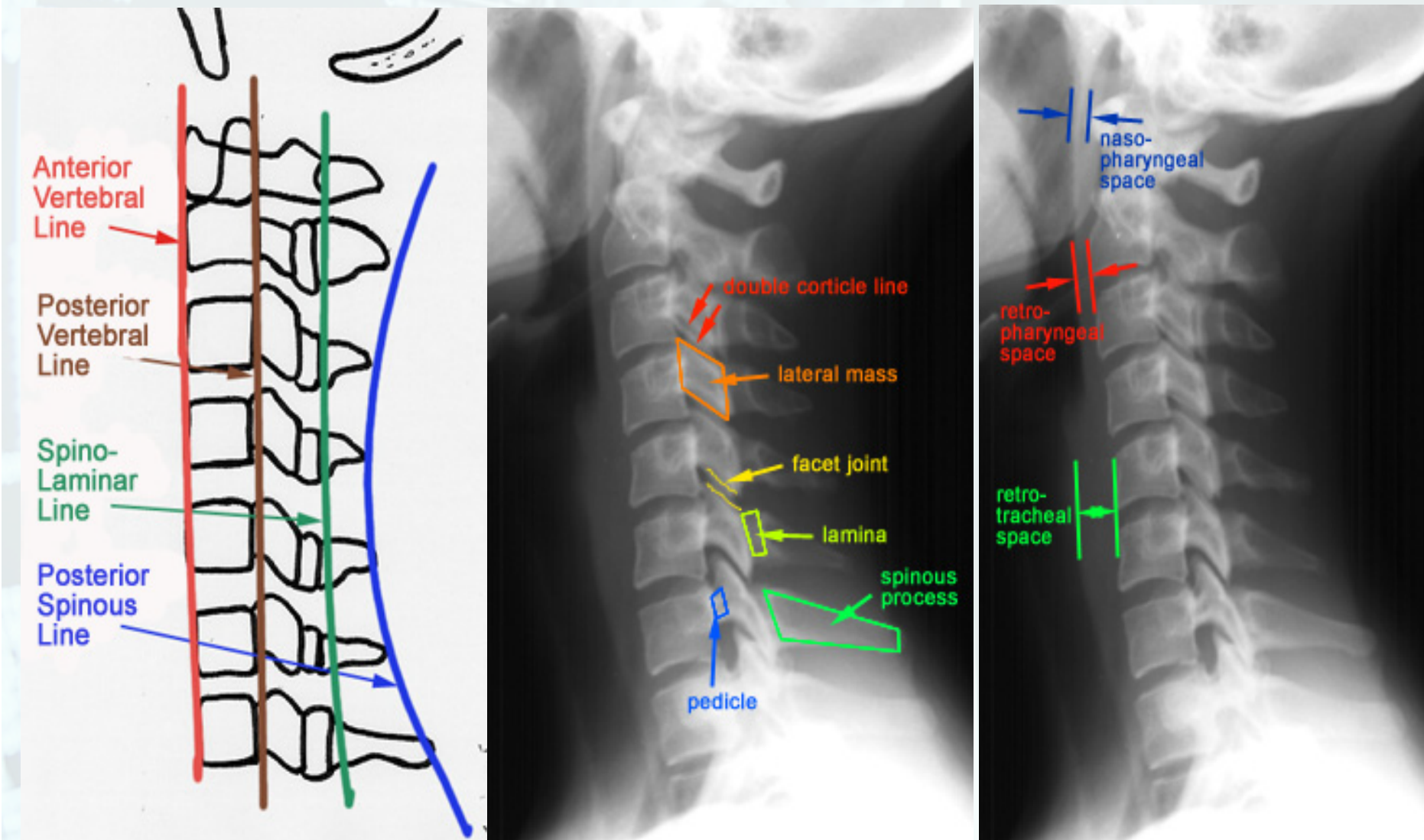
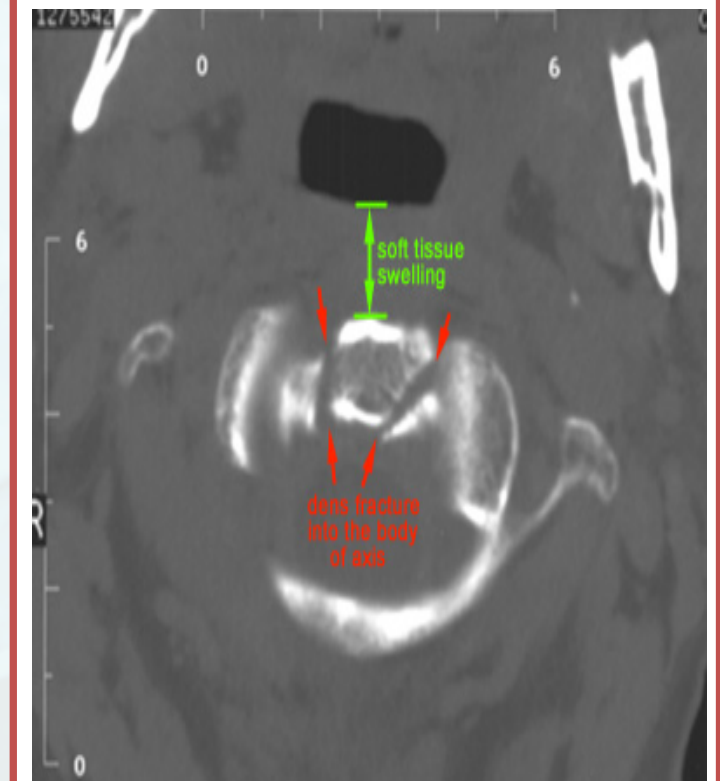
# Trauma

Patient with trauma, you have to look at :

- The alignment of vertebrae.
- Retropharyngeal space is about 2-3 mm.
- Retrotracheal space is about 6-7 mm.

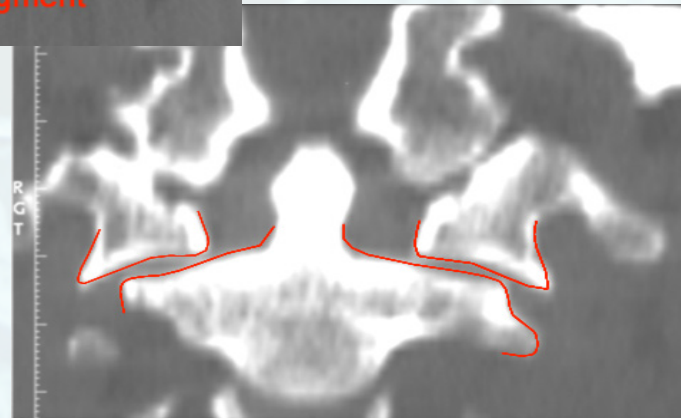
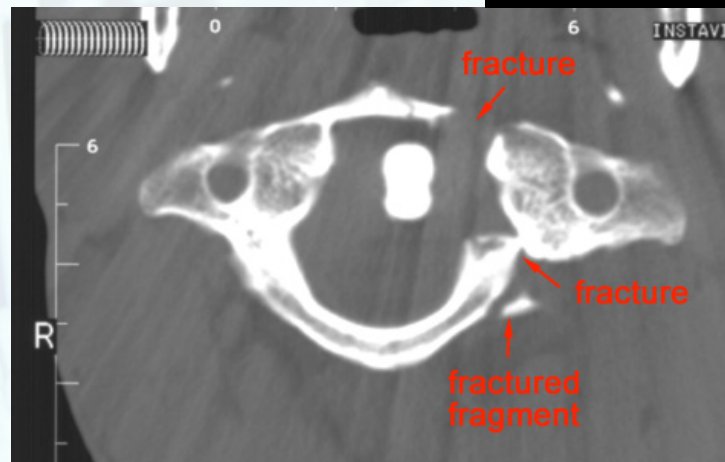
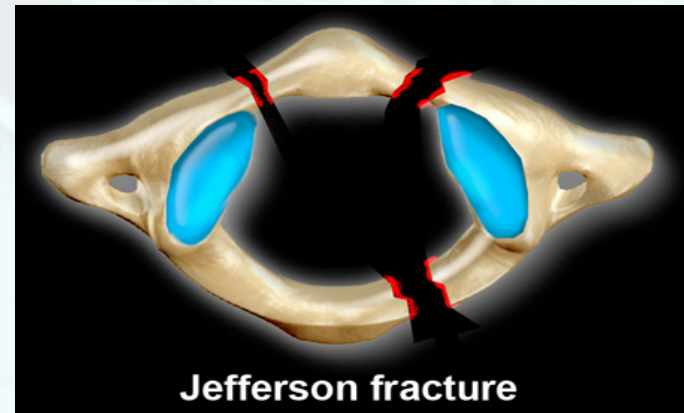
# Plain film assessment of trauma is the first imaging method

Soft tissue anterior to spine is very important



# Jefferson Fracture

- Lateral displacement of C1 in (**unstable fracture** )
- Dangerous because it could cause severe injury to the spinal cord which might lead to quadriplegia.
- Coronal reconstruction from a CT confirms the findings from the odontoid view
- Axial CT clearly shows the location of the fractures of C1

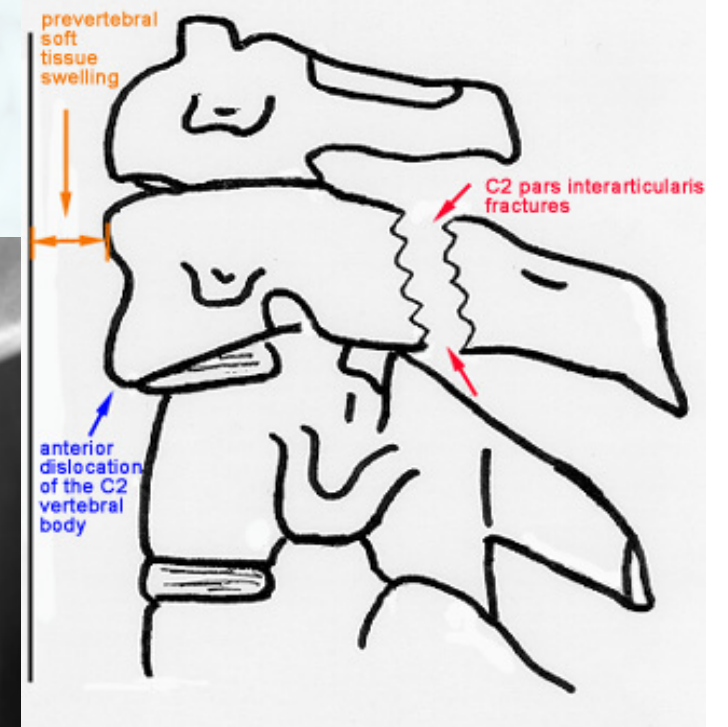
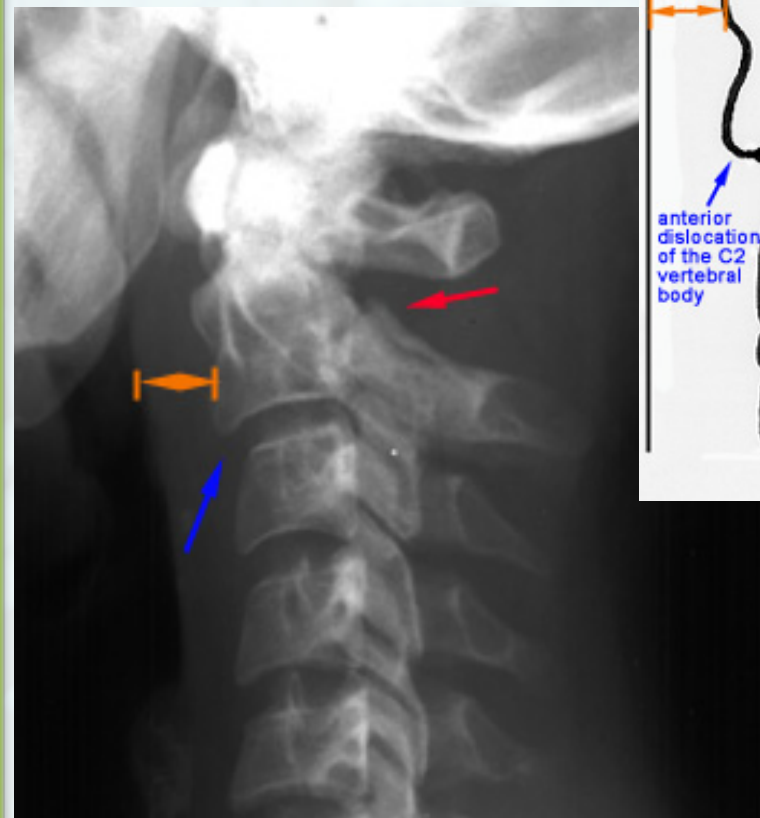


# Hangman's Fracture

**Unstable fractures** through the pars interarticularis of C2 resulting from hyperextension and distraction (e.g. hanging, chin hits dashboard in road accident)

**Radiographic features:** (best seen on lateral view)

1. Prevertebral soft tissue swelling.
2. Anterior dislocation of C2 vertebral body.
3. Bilateral C2 pars interarticularis fractures.
4. Avulsion of anterior inferior corner of C2 associated with rupture of anterior longitudinal ligament.



# Bilateral Facet Dislocation

Complete **unstable anterior dislocation** of vertebral body resulting from extreme hyperflexion injury. Associated with a very high risk of cord damage (**emergency**)

Mentioned by female doctor



Bilateral interfacetal dislocation.

50% anteroposition C5C6 as a result of the dislocation.

In unilateral dislocation the anteroposition is usually only 25%.

Widened space between spinous processes C5 and C6 due to ligament rupture.

Ruptured disc space.

**CT-images of the same patient, which confirm the bilateral dislocation.**

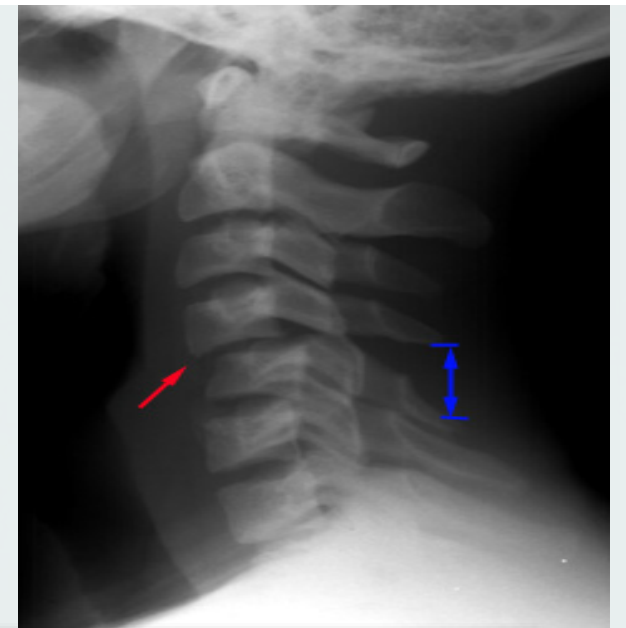
**Near one of the facets there is a small fleck of bone, but there is no major fracture, so this is basically just a hyperflexion soft tissue injury.**

The MRI-findings are:

- Soft tissue swelling anteriorly
- Disruption of the disc
- Non-hemorrhagic cord injury

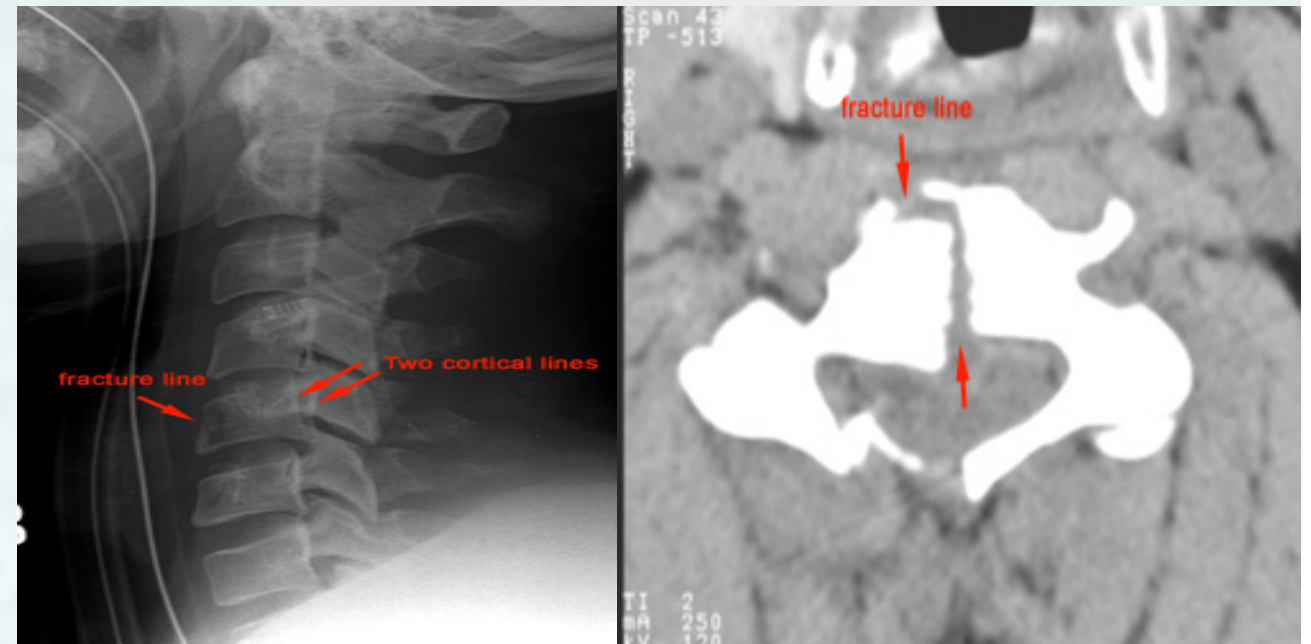
# Unilateral Facet Dislocation

- **stable fracture**
- Facet joint dislocation and rupture of the apophyseal joint ligaments resulting from rotatory injury
- **Mechanism:** simultaneous flexion and rotation



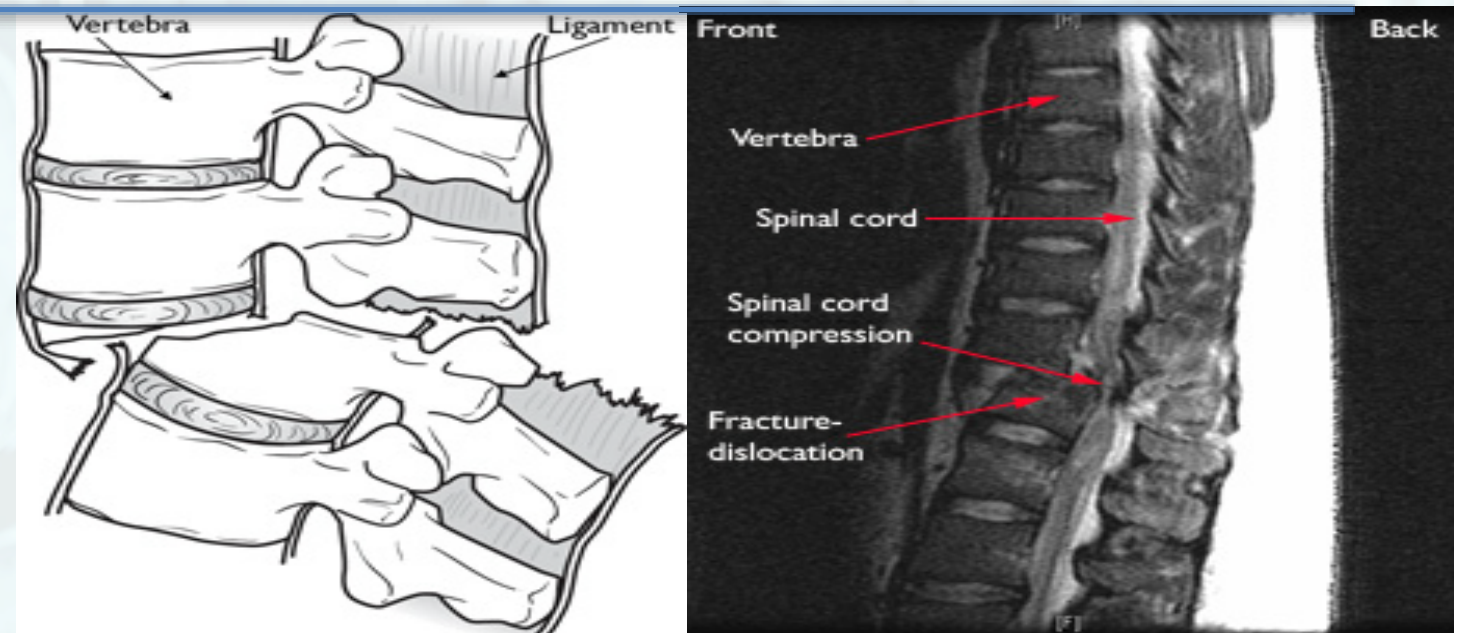
# Burst Fracture

- Results from axial compression
- Injury to spinal cord is common due to displacement of posterior fragments
- CT is required for all patient to evaluate extent of injury



# Fracture-dislocation

This is an unstable injury involving bone and soft tissue in which a vertebra may move off an adjacent vertebra (displaced). These injuries frequentl

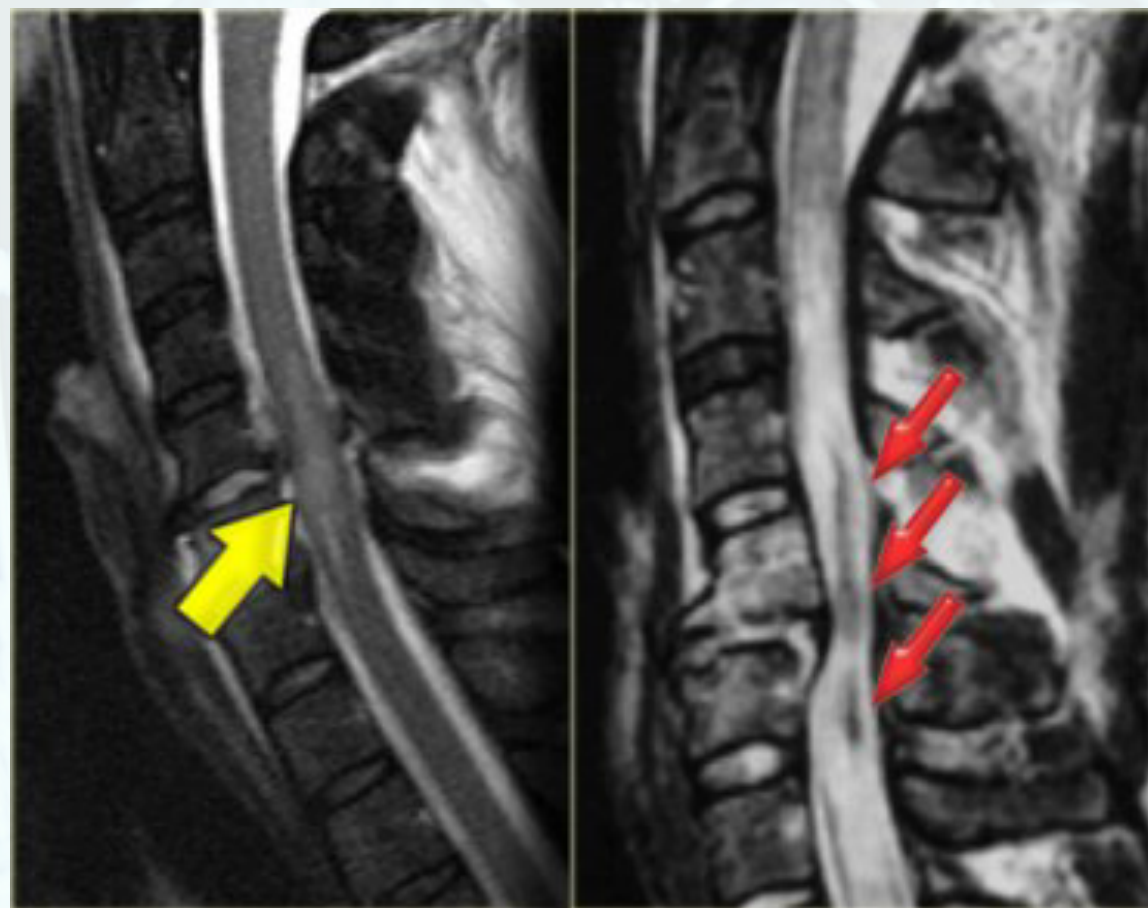




## Spinal cord injury

There are two types of injury to the spinal cord:

- Non-hemorrhagic with only high signal on MR due to edema.
- Hemorrhagic with areas of low signal intensity within the area of edema.

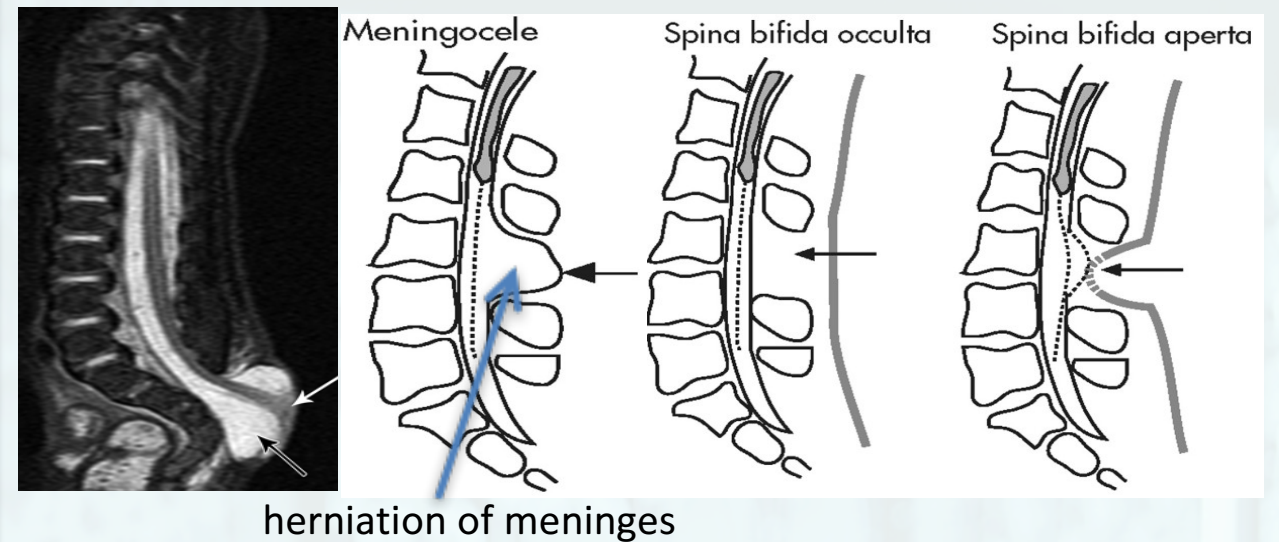


Non-hemorrhagic

hemorrhagic

## Congenital Anomalies

- Skin covered defects and Open skin defects
- **MRI** is the best to assess the contents of the cavity, extent of abnormalities, and **spinal cord**.
- **CT** shows **bony structures** the best and is often used before surgery



- Multiple fusion abnormalities of vertebrae on plain film



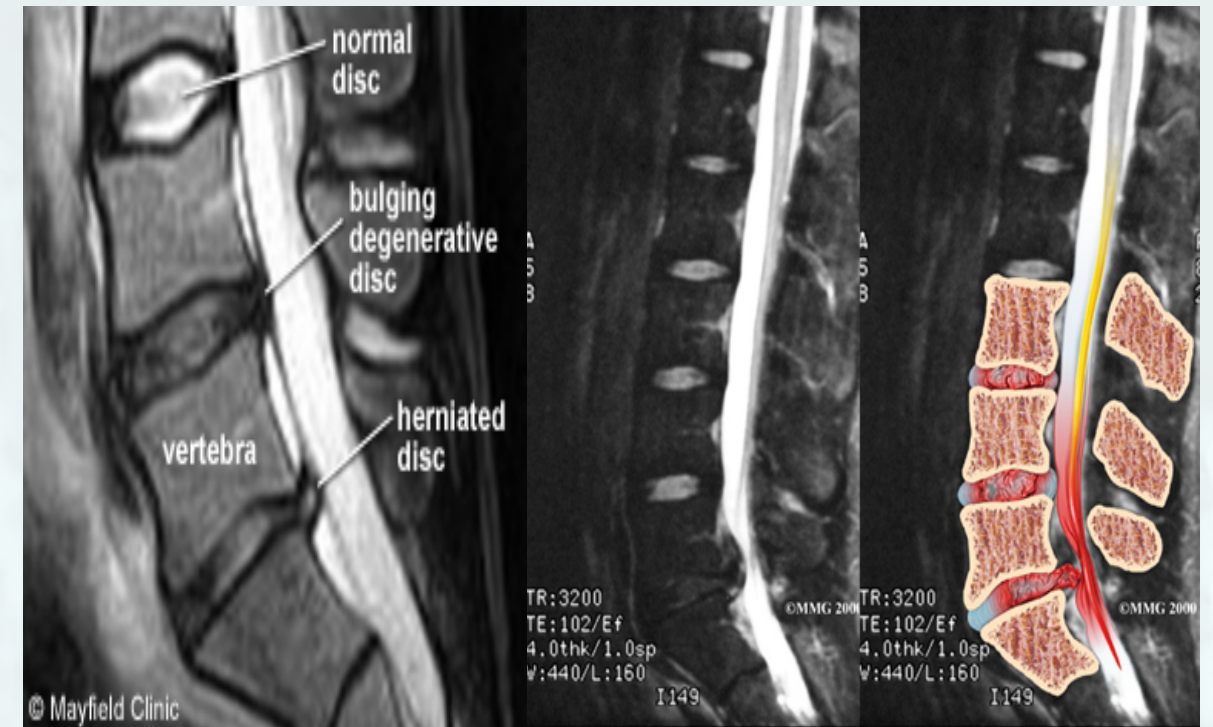
# TUMORS

- Tumors inside the spinal cord are intramedullary tumors, and out of the spinal cord are extramedullary tumors.
- Extramedullary tumors are either intradural or extradural.
- intramedullary tumors are mostly malignant (astrocytoma or ependymoma).
- extramedullary are benign (schwannoma or meningioma).



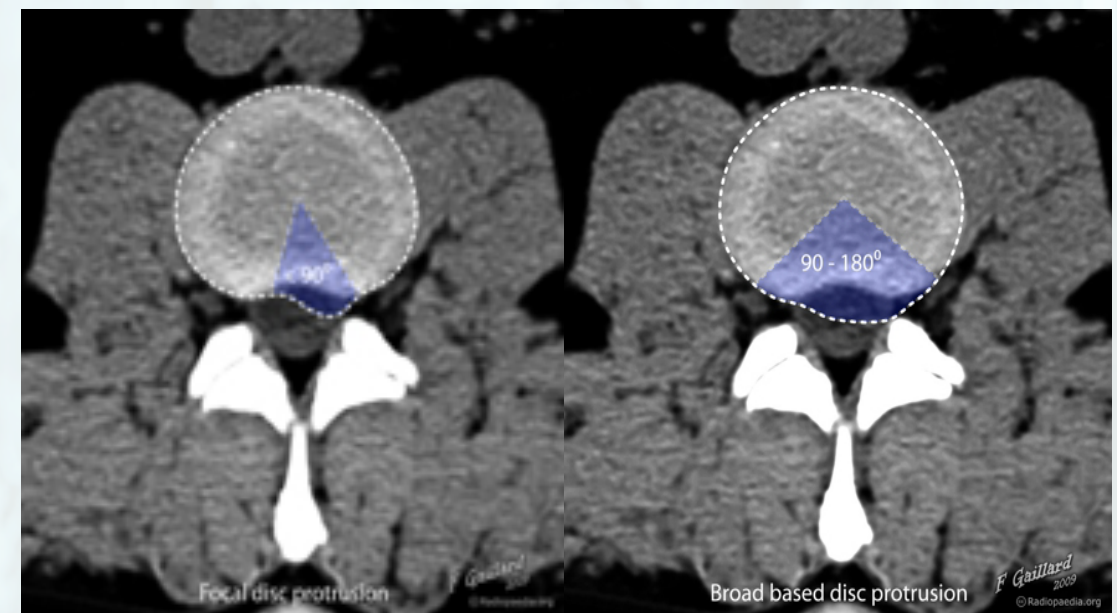
# Lumbar disk herniation

Myelogram shows extradural lesion



90°  
focal herniation

>90° Broad based  
herniation



# INFECTIONS:

- Discitis, Osteomyelitis and less commonly intraspinal infections.
- hematogenous route, Adjacent focus, Direct inoculation.
- Usually the result of blood-borne agents, Especially from lung and urinary tract
- Most common pathogen is **staphylococcus** (pyogenic ) Streptococcus less common
- Gram-negative rods in IV drug abusers or immunocompromised patients
- (E. Coli , Proteus ,Non-pyogenic ,**Tuberculosis** ,Coccidioidomycosis )
- May occur after invasive procedure like Surgery, Discography, Myelography
- In children, infection begins in vascularized disc
- In adults, in anterior inferior corner of vertebral body with spread across disc to adjacent vertebral endplate
- **Site of involvement**
  - L3/L4
  - L4/L5
  - Unusual above T9
  - Usually involvement of one disc (occasionally 2)

Spondylitis : infection in the vertebrae.

Discitis : infection in the intervertebral disc.

Infections mostly starts from disc > body.

Metastasis starts from body > disc .

# Discitis and Osteomyelitis

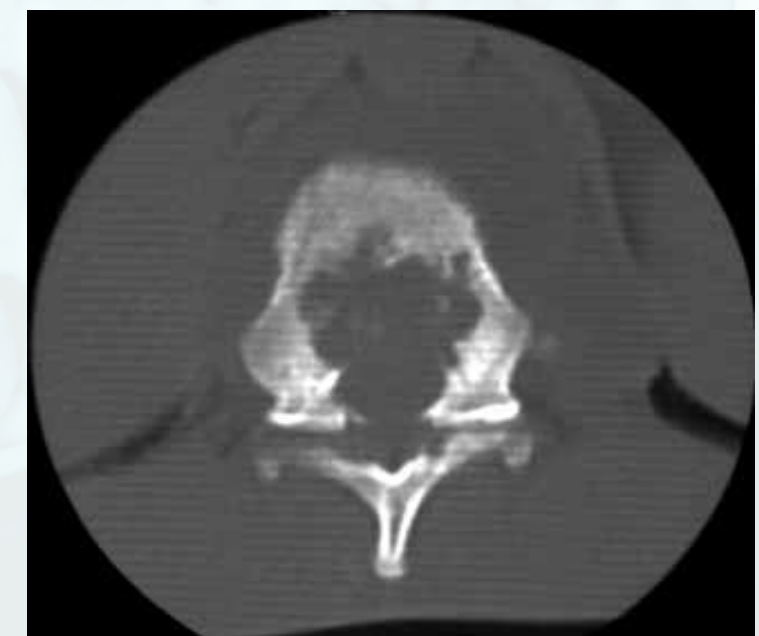
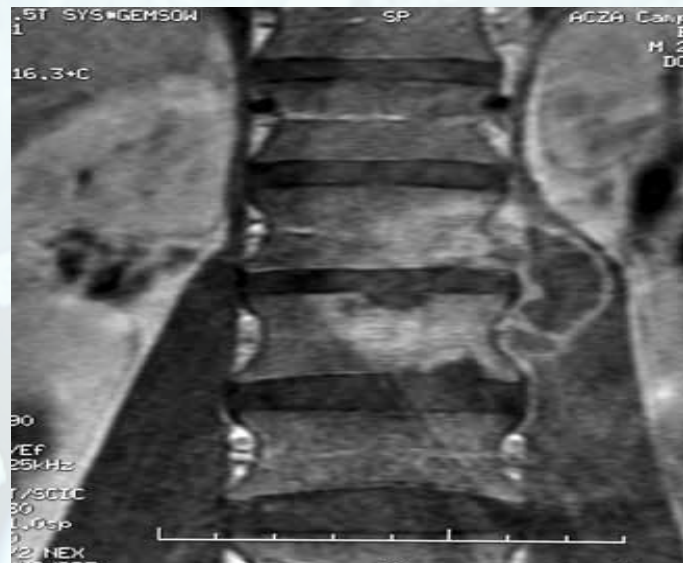
## IMAGING FINDINGS:

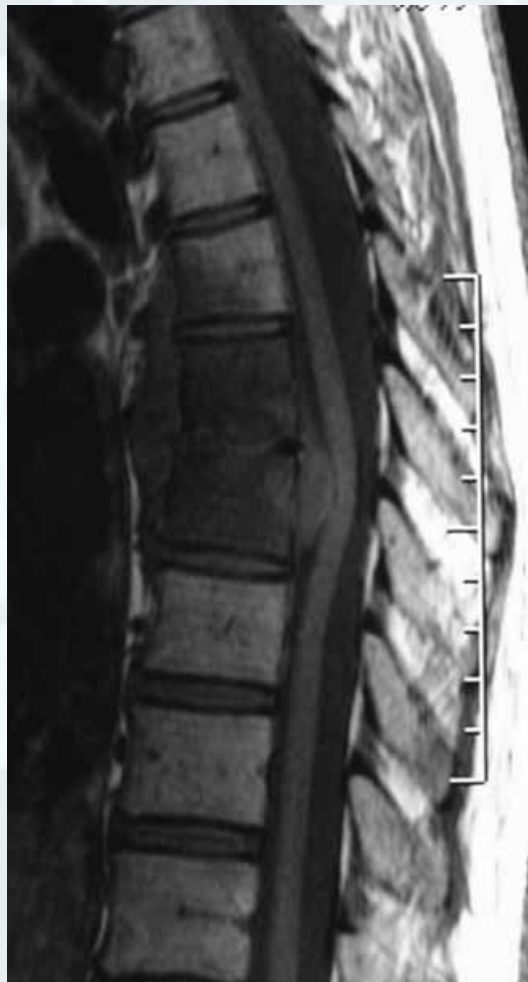
### 1. PLAIN FILMS:

- Narrowing and destruction of an intervertebral disk (Earliest plain film sign )
- Indistinct adjacent endplates with destruction of vertebral body.
- Often associated with bony sclerosis of the two contiguous vertebral bodies
- Paravertebral soft tissue mass (mass)
- Endplate sclerosis (during healing phase beginning anywhere from 8 weeks to 8 months after onset)
- Bone fusion after 6 months to 2 years

### 2. MRI:

- Bone marrow edema in infected vertebrae, discs and paraspinal soft tissues
- Dark on T1 and bright on T2 images
- Enhancement of inflammed tissues after contrast
- Fluid collections (abscesses) are common
- (We can see the infection as a round white circle)





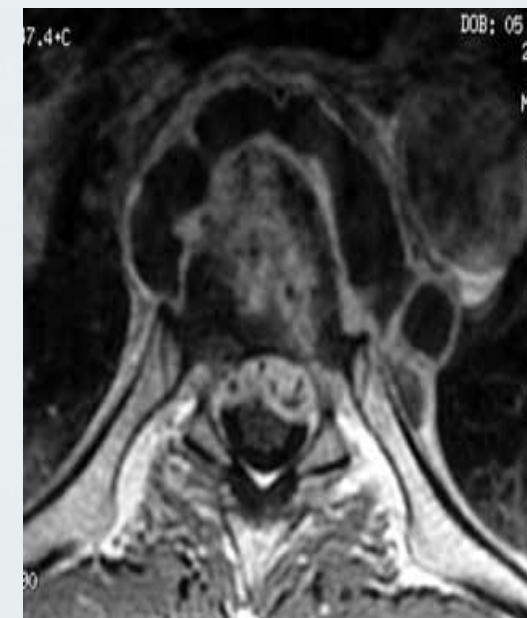
Sagittal T1 MRI shows:  
decreased signal of  
vertebral bodies and  
disc with end plate  
destruction



Sagittal T2 MRI shows:  
increased signal in  
corresponding areas  
with anterior  
subligamentous  
abscess, epidural  
involvement and  
extension of  
inflammation in T6  
with preserved  
endplate



Axial contrast-enhanced  
T1 MRI shows:  
peripheral enhancement  
of paravertebral abscess  
and marked  
enhancement of epidural  
tissues causing  
displacement of spinal  
cord



CT shows:  
lytic lesion in vertebral  
body and paravertebral  
abscess with  
calcifications

# Questions:

Q1- The first choice for any examination is :

- A- x-Ray
- B- MRI
- C- CT
- D- x-Ray Myelogram

Q2- To assist a bone examination we use :

- A- MRI
- B- CT
- C- x-Ray
- D- CT Myelogram

Q3- to assist soft tissues examination we use :

- A- MRI
- B- x-Ray
- C- CT

Q4- Spinal cord extend to :

- A- L4
- B- L1
- C- S2
- D- L2

Q5- The spinal cord have ..... pairs of spinal nerves :

- A- 31
- B- 30
- C- 32
- D- 34

Q6- The space which contain the CSF is :

- A- subarachnoid space
- B- subdural space
- C- epidural space

Q7- Myelogram is a diagnostic tool use ( Dye ) that is injected into :

- A- BV
- B- muscles
- C- CSF

Q8- Myelogram is the addition of dye to assist ..... examination :

- A- CT & x-Ray
- B- CT
- C- x-Ray
- D- MRI

Q9: Puncture of dye injection is made at the space of :

- A- L2 - L3
- B- L4 - L5
- C- L1 - L2
- D- T12 - L1

Answers: 1) A 2) b 3) A 4) D 5) A 6) A 7) C 8) A 9) A

Q10- In MRI , we can see the CSF in black color at :

- A- T3 sequence
- B- T1 sequence
- C- T2 sequence
- D- T4 sequence

Q11- The position of OdP ( Odontoid Process ) is always in :

- A- C1
- B- C3
- C- C2
- D- C5

Q12- When a patient comes with herniation , one of the sign we can see is :

- A- can't sit down
- B- can't lie on bed
- C- can't bow

Q13- Epidural abscess begin in the ..... then moves to the vertebral body :

- A- disk
- B- CSF
- C- BV

Q14- When The infection reaches the vertebral column it usually goes to

- A- disk then to the body
- B- body then to the disk
- C- stays in the disk

Q15- So if we suspect a lesion that has been traveled from the disk into the body , this lesion might be:

- A- cancer
- B- infection
- C- damaged
- D- died

Q16: If we saw a hole in the image this indicates:

- A- cancer
- B- mass
- C- blood clot
- D- infection

Answers: 10) B 11) C 12) C 13) A 14) A 15) B 16) D



We really hope that we made it easy and informative ,,

**Done By :**

Faisal S. AlGhamdi

Falwah AlHarthi

Basmah AlDoghaither

Alanoud AlBogami

Barah AlQarni

Afnan AlMutawa

Munira AlMehsen

**Revised by:**

Faisal S. AlGamdi

Haifa AlOtaibi

Contact us : [433radiology@gmail.com](mailto:433radiology@gmail.com)