Radiology
Team 438

Radiology of spinal diseases

Lecture 24

Objectives

Reviewed By
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- To understand basic mechanisms of trauma to cervical spine.
- To evaluate findings on plain films of cervical spine trauma.
- To know basic differences between spine infections, tumors and trauma.
- To be able to localize spinal lesions in intramedullary, intramural and extradural compartments.

Color Index: Important | Doctor's Notes | Extra | Female slides | male slides

Team Leaders


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★ Red star: was mentioned to be **very important** *wink wink*

Imaging methods to evaluate the spine

	Explanation
Plain X-RAY films	• Bones eg. vertebral fracture (usually the first used imaging modality because it's cheap & available). e.g. Hx trauma, fracture, congenital fusion
★ **Myelogram**	• Injection of contrast medium in CSF followed by an X-ray. (to assess CSF surrounding space). • Rarely performed nowadays (because of risk of injury and infections. Only performed in selective cases that are contraindicated to MRI).
CT Scan	• Best modality for bone, very poor information about spinal cord.
MRI	• For intraspinal content , especially the spinal cord • Preoperatively in spinal cases we do both CT and MRI.
Spinal angiography	• To evaluate arteries and veins. E.g. suspecting vascular malformation, infarcts, and fistulas.
ULTRASOUND	• More in children (limited use except for neonate).
Radionuclides bone scan	• IV injection of radioactive material bound to phosphonates which deposit in bones, followed by images by gamma camera. • Used for malignancy & bone metastasis and when multiple lesions are suspected.
DEXA (Dual-Energy X-ray Absorptiometry)	• Radionuclide scan for bone density (Osteoporosis).

X-Rays (Radiographs)

- Often the 1st diagnostic test, quick & cheap,
- Small dose of radiation to visualize the bony parts of the spine.
- May be taken in different positions (flexion and extension) to assess for instability.

Can detect:

- Spinal alignment and curvature
- Spinal instability – with flexion & extension views
- Congenital (birth) defects of spinal column
- Fractures caused by trauma.
- Moderate osteoporosis (loss of Calcium from bone). Usually osteoporosis diagnosed with dexa, but these all as initial.
- Infections
- Tumor

Imaging methods to evaluate the spine

Computerized Tomography (CT)

- Uses radiation to obtain 2D which can be processed to 3D images.
- Contraindicated in pregnant women and children.
- Patient must lie still on a table, which moves through a scanner.
- Cross-sectional images are obtained of the target areas.
- Much detailed information regarding bony structures detecting fractures and bony abnormalities
- limited information about spinal cord and soft tissues. (Soft tissue are best evaluated using MRI)
- Entire spine can be imaged within a few minutes.
- Might need IV or intrathecal contrast for some areas

Better in visualizing:

- Degenerative or ageing changes, Herniated discs. MRI is better.
- Spinal alignment (limited information, MRI is better)
- **Fractures and fracture patterns** (The main indication for CT)
- Congenital/childhood anomalies. especially anomalie of BONE e.g . fusion anomaly
- Areas of narrowing in spinal canal through which spinal cord and spinal nerve roots pass, like spinal stenosis. (MRI can also be used).

Poor in visualizing

Inner details of spinal cord (contents of spinal cord), the concentration is more on the bones **(MRI is the gold standard of imaging for spinal cord diseases)**

3D Image

Sagittal Image

Axial Image

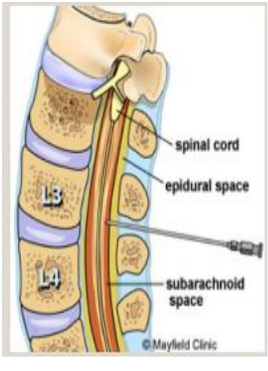
Coronal Image

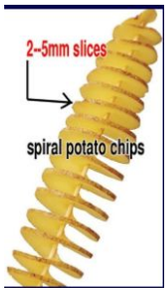
All these images are in the bone window, you can't see soft tissue details only bony anatomy.

Myelogram

- A contrast material is injected into CSF to better identify areas where spinal cord or spinal nerves are compressed. (Rarely used now, to assess the outline and not the cord itself).

White arrows: nerve root





Imaging methods to evaluate the spine

Magnetic Resonance Imaging

- The gold standard for spinal disorders.
- Does not use ionizing radiation. safe in pregnancy (without contrast) and children.
- Can identify abnormalities of bone, discs, muscles, ligaments and spinal cord.
- IV contrast is sometimes administered to better visualize certain structures or abnormalities. eg: infection, tumor but normally we do not use contrast.
- Patient lies still in a tunnel like structure for 25 mins.
- Claustrophobic patients may need sedation, and children often need general anesthesia.

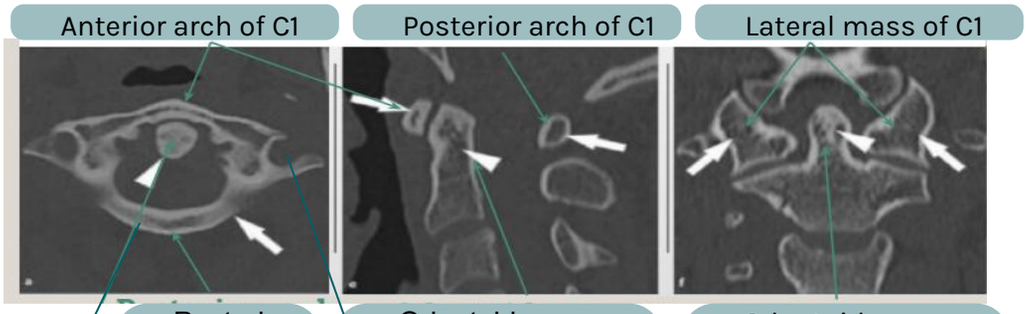
Contraindications include:

Extra

1. Implanted devices e.g. cardiac pacemakers and all other electromagnetic devices.
2. Certain metal clips and stimulators (like aneurysmal clips, because if the clip moves it damages the artery).
   - Artificial joints & spinal hardware may still have MRI scans "will not be pulled out, but the metal can get hard to the patient (they feel it)"

MRI features in contrast to CT

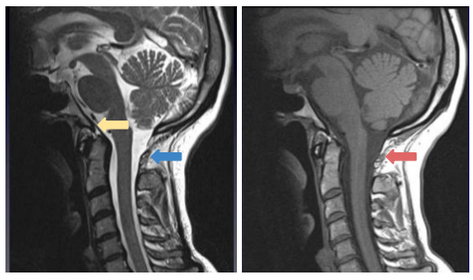
Craniocervical junction (C1 & C2)



odontoid process of C2 (anterior arch of C1 and this process articulates with each other)

Foramen transversum which contain **vertebral artery**

Spina bifida occulta at C1

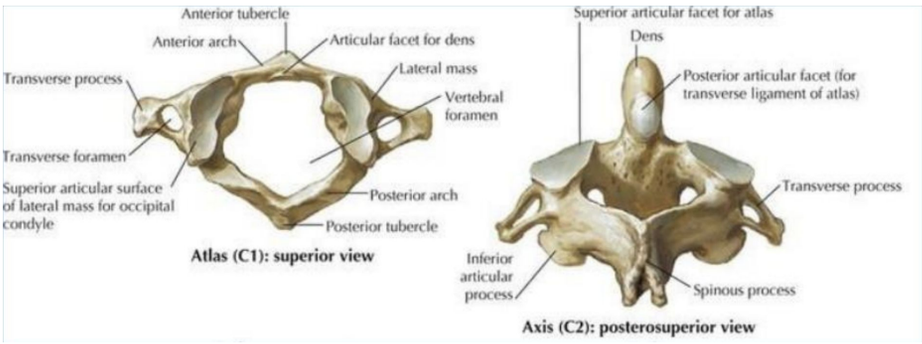


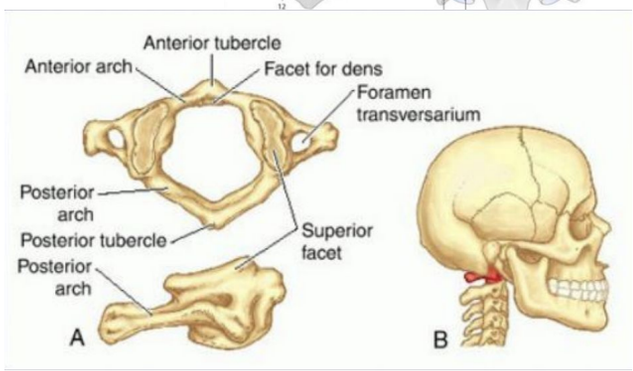
Blue arrow: normally we should see here a rounded structure which is the posterior arch of C1.
Red arrow: we do not see the arch here so this indicates spina bifida occulta and it is called occulta(hidden) because there is no soft tissue defect, it is only BONE.

Very imp:
Yellow arrow:tectorial membrane

Imaging methods to evaluate the spine

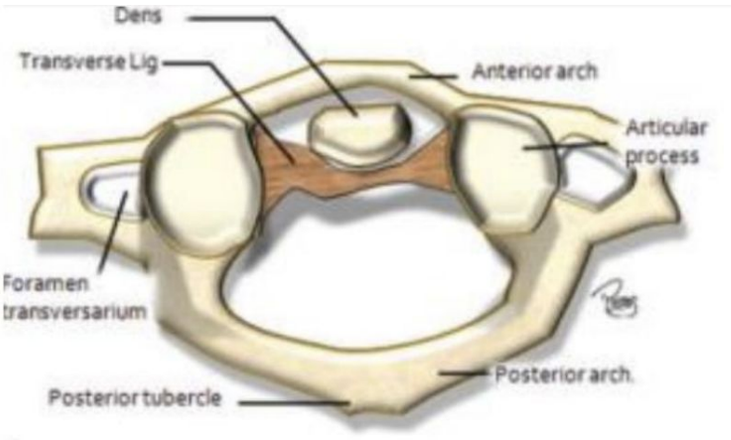
Craniocervical junction (C1 & C2)

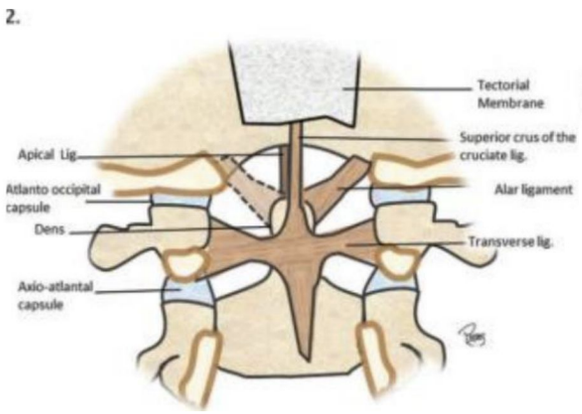




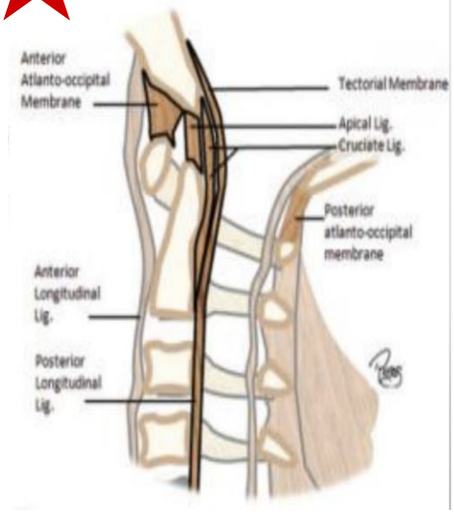
- Atlas was the primordial titan who supported the heavens
- (C1) is of Anterior arch, Posterior arch, and 2 bulky lateral masses

Ligamentous Anatomy Craniocervical junction (C1 & C2)





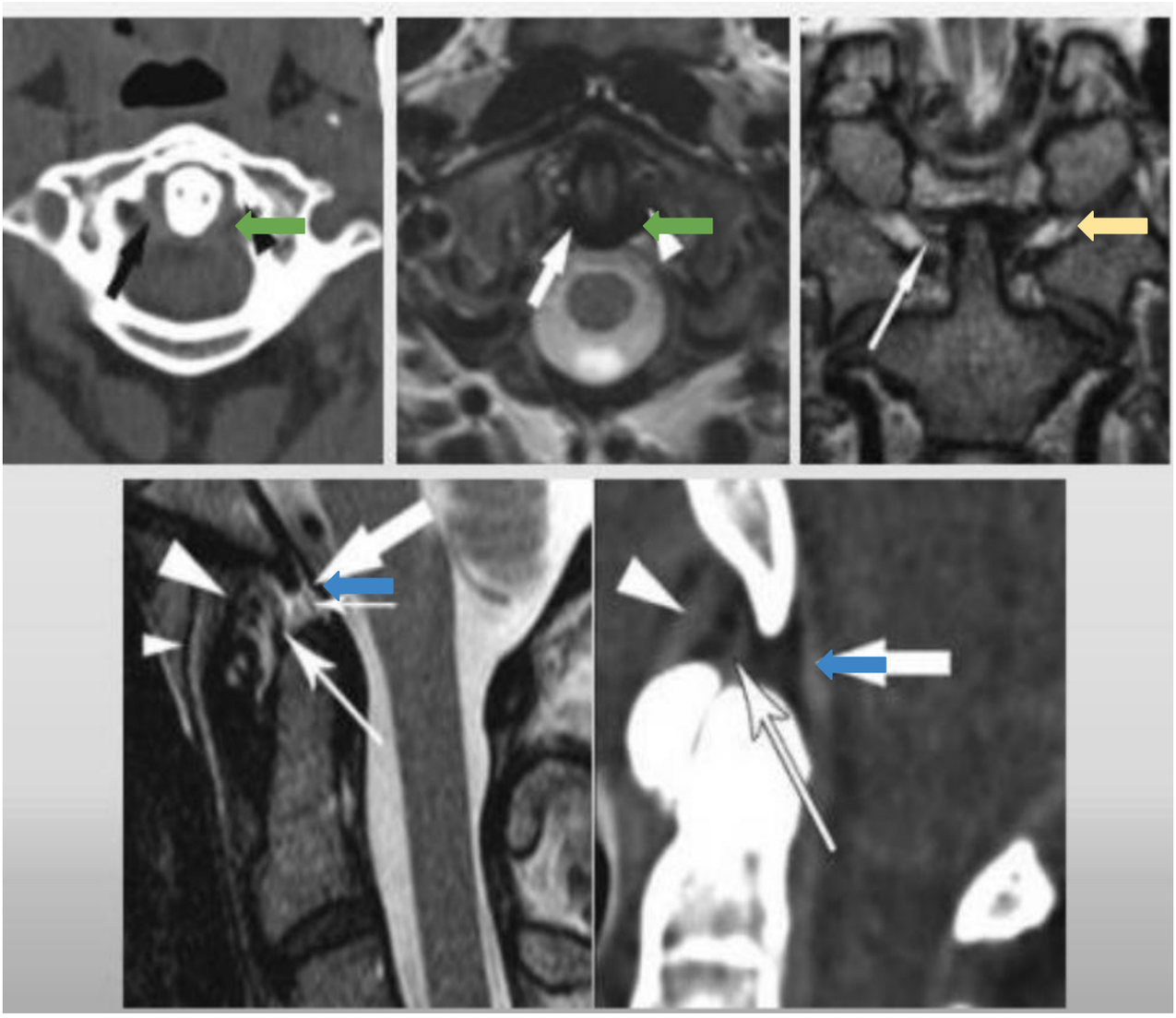
- Posterior to the Dens is the transverse ligament which is attached on either side to a small tubercle on the medial surface of the lateral mass of the Atlas.
- The anterior atlanto-occipital membrane is a thin membrane that joins the upper border of the anterior arch of the atlas (C1) to the anterior inferior surface of the foramen magnum. It is a continuation of the anterior longitudinal ligament above the C1 level. It is immediately posterior to the prevertebral muscles.



- Apical ligament connects the tip the odontoid process with the anterior margin of foramen magnum. Posterior to it lies the cruciate ligament from anterior margin of the foramen magnum to the posterior aspect of c2. And posterior to that lies the tectorial membrane from the anterior margin of foramen magnum to c2 and its continuation called the posterior longitudinal ligament
- Posteriorly we have posterior atlanto-occipital membrane, its continuation called posterior ligamentum flavum

- lateral masses of c1 and c2 should be aligned, if not you may suspect fracture.
- The vertebral artery passes through foramen transversarium, so if you have fracture along the foramen transversarium you should do vascular imaging to detect any injury to the vertebral artery.

Craniocervical junction (C1 & C2) cont..



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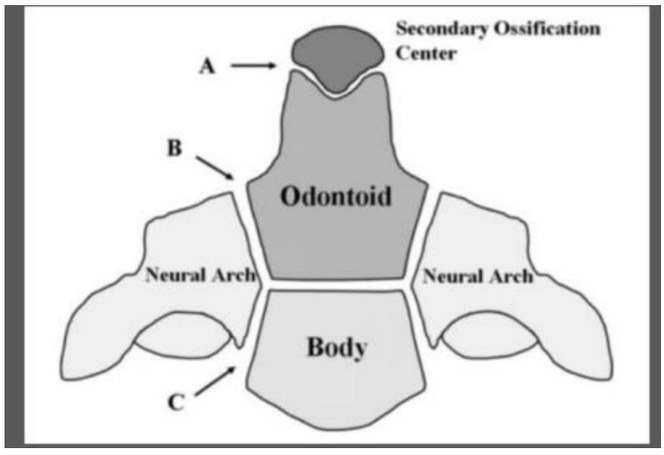
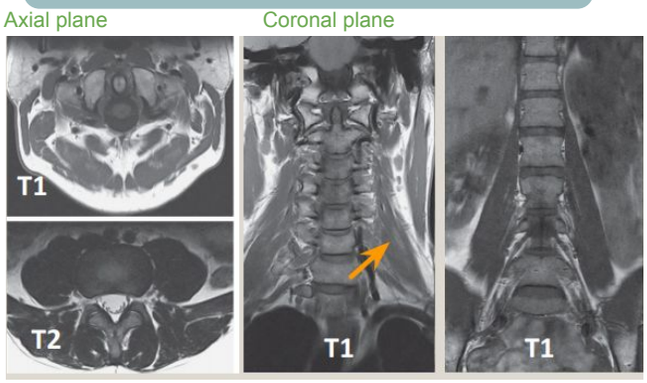
Yellow arrow: alar ligament
Green arrow : transverse ligament
Blue arrow : tectorial membrane



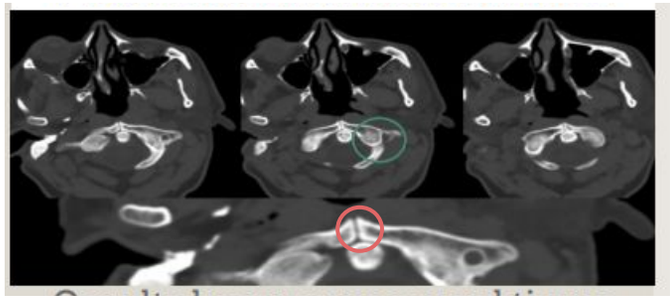
MRI features in contrast to CT

- Orange arrow: Psoas muscle.
- X-ray and CT show us only disc space.
- MRI not only shows us disc but the components of it.
- High signal intensity (bright disc) → T2 Why? due to collagenous water materials that why in degenerative disease the disc become hard and low water so it look little bit dark + narrow disc space

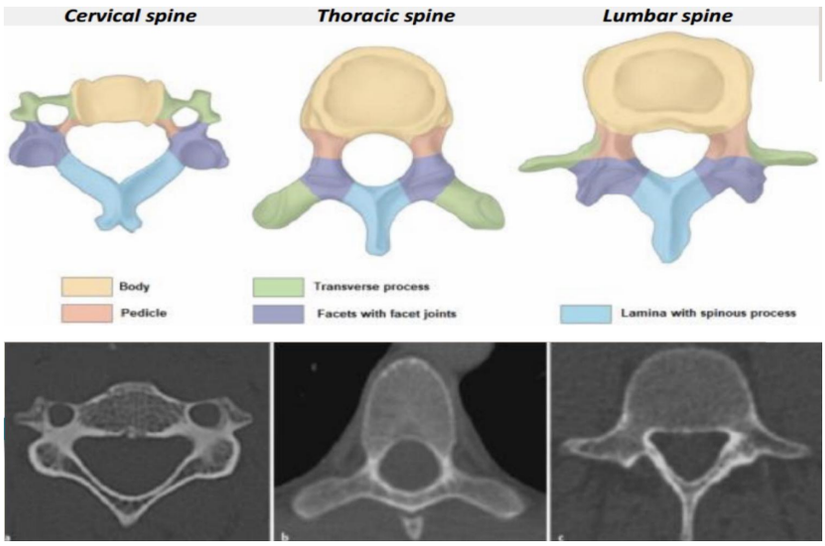
MR images are Multi-planer



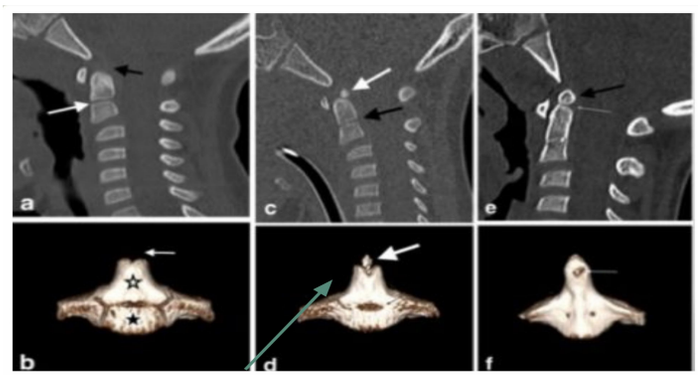
Fusion defect anterior arch at C1



- Normally we should not see any space, the bone must be continuous. Better detected by ct, because it shows you the cortex very well
- How to differentiate between fusion defect and fracture? The periosteum here continues with the defect that is seen in the anterior arch(defect surrounded by sclerotic margin)

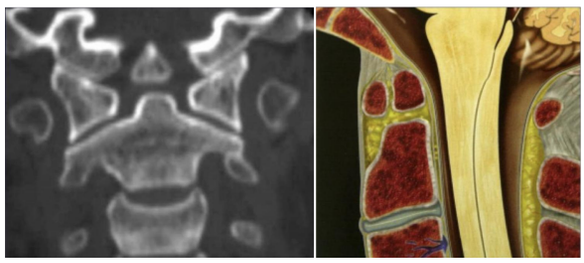


- Cervical vertebrae have foramen transversum which has vertebral artery and has small vertebral body
- Thoracic vertebrae have a bigger vertebral body, no foramen transversum.
- Lumbar have triangular shaped canal and even bigger body



Arrow shows non-fused ossification centers mimicking fracture

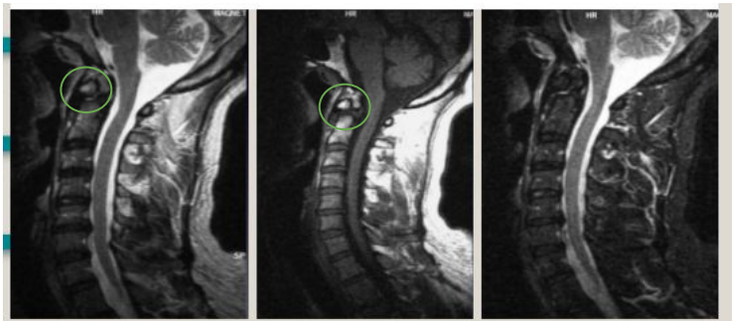
Odontoid bone (Os odontoideum)



How to differentiate between odontoid fusion defect and fracture? The fusion defect usually well corticated bone and it considered normal variation.

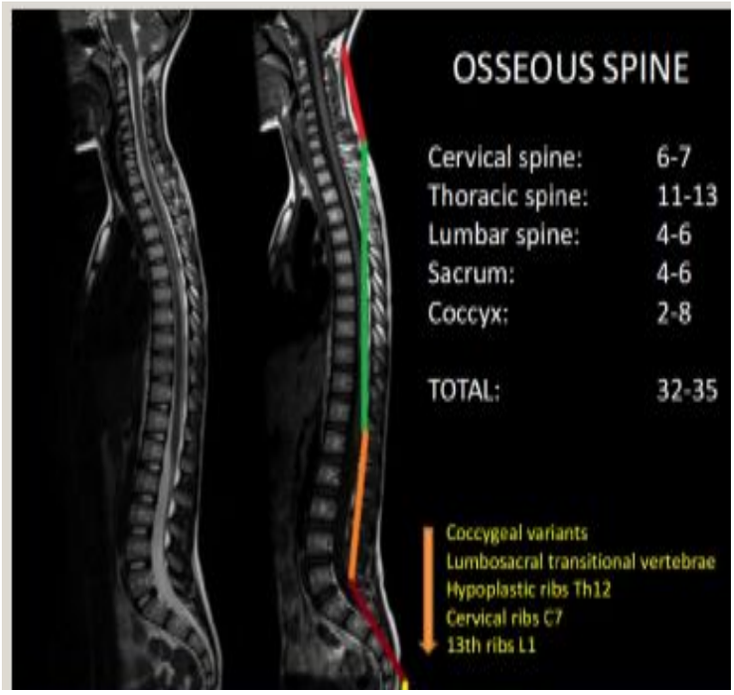
MRI features in contrast to CT

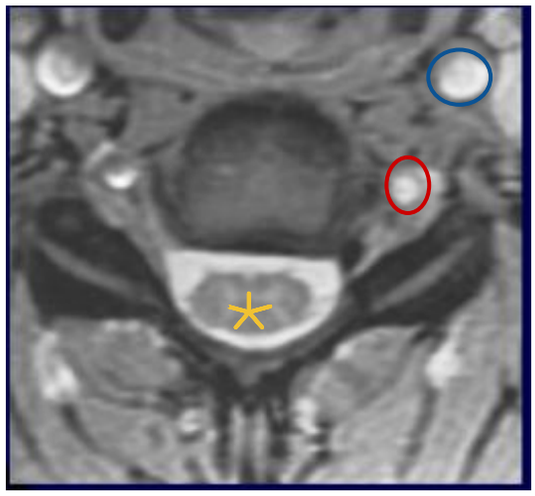
Os odontoideum



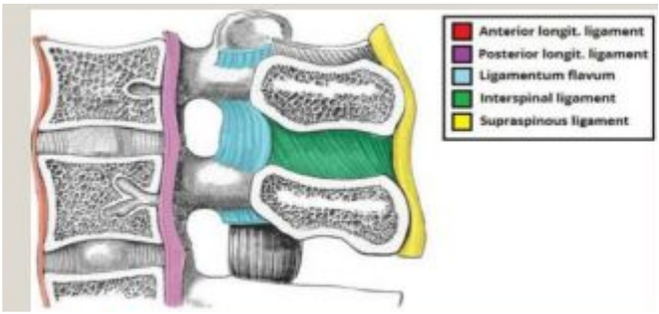
MR images are very high resolution

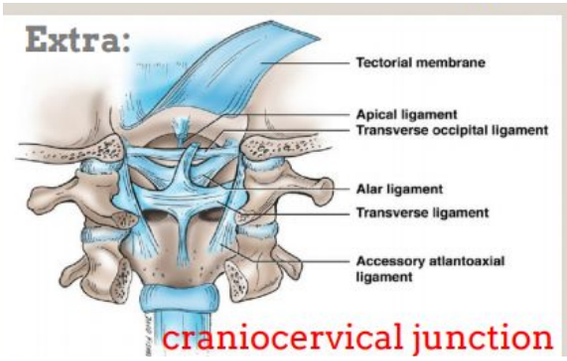
Cervical | Thoracic | Lumbar

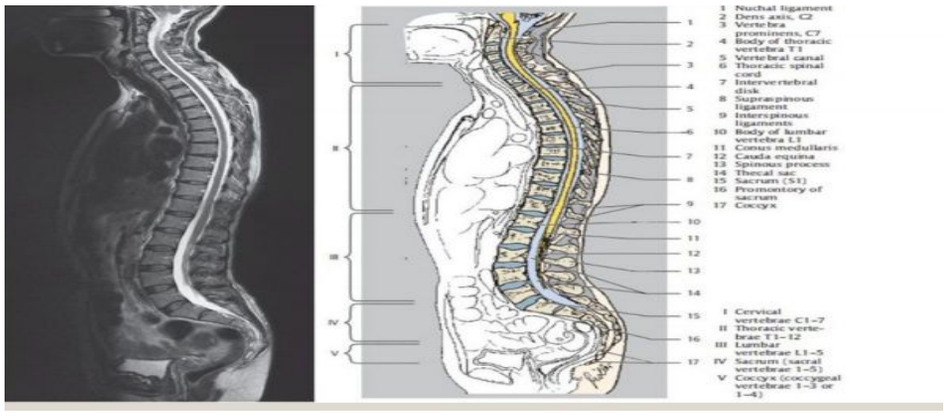




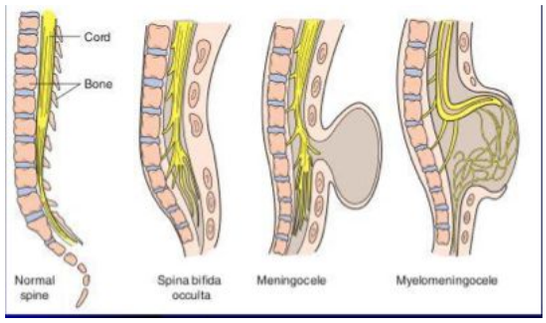
Yellow star: spinal cord.
Red circle : vertebral artery.
Blue circle : carotid artery.





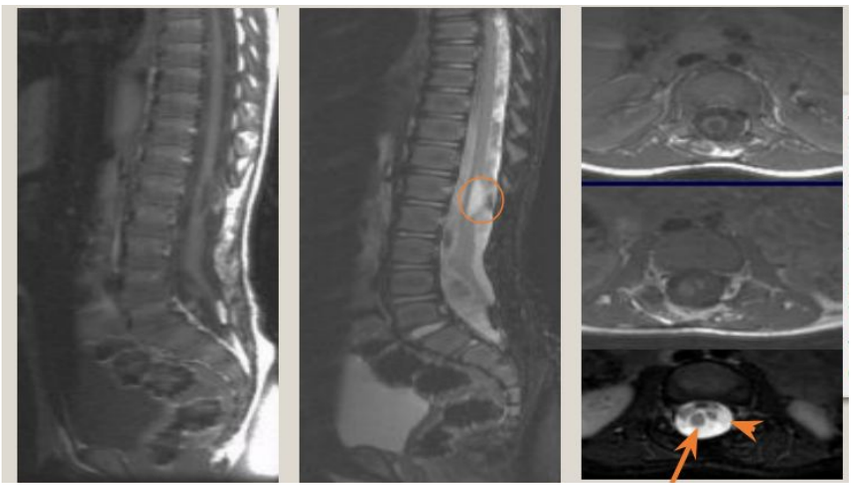


Congenital Anomalies

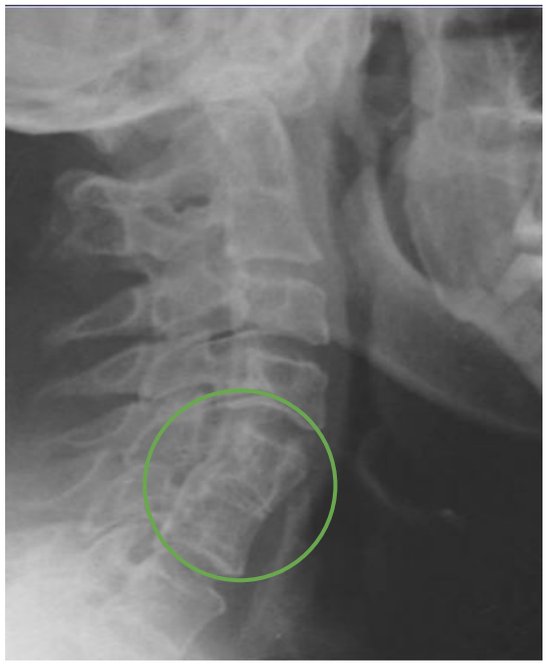


- MRI is the best to assess the contents of the cavity, extent of abnormalities, and the spinal cord. CT shows bony structures the best and is often used before surgery. If the patient has bony defect and soft tissue swelling so the best way to assess it is using MRI, allow you to assess the content of the cavity

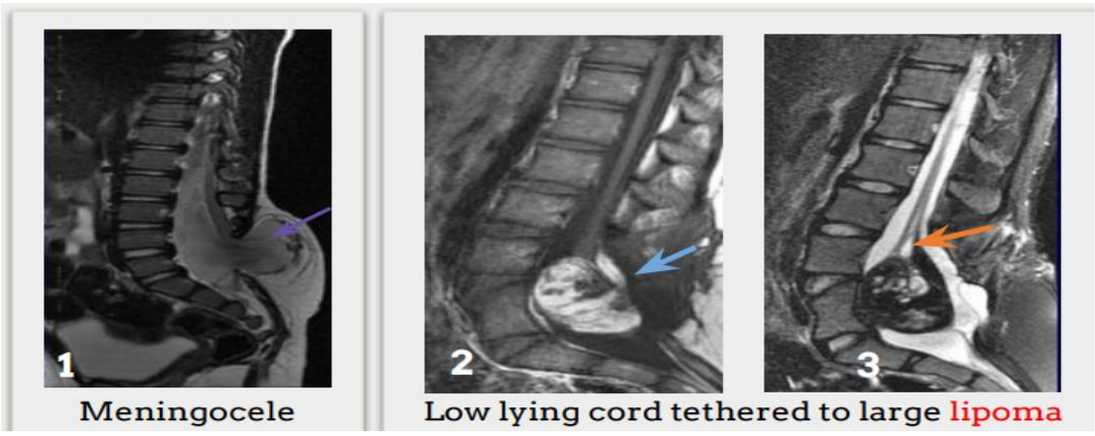
Split low lying cord (diastematomyelia)



Arrows: represents the splitting cord into two part separated by bone element. it's hard to see by sagittal view.
Circle: cyst. And the spinal cord lower than normal



Multiple fusion abnormalities of vertebra on plain film, loss of disc space. In c5 and 6

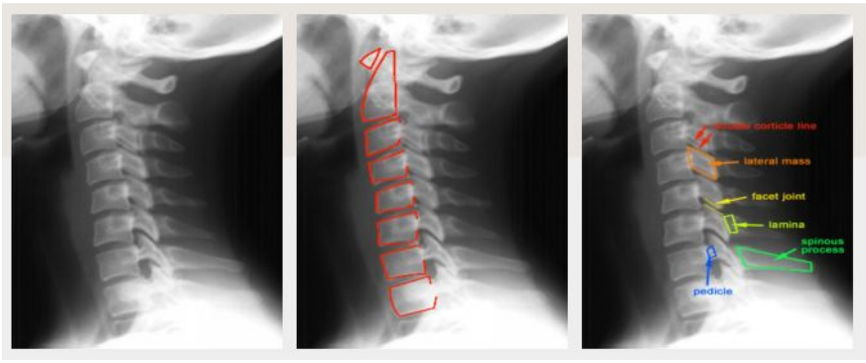


Orange arrow: Low lying cord.
Blue arrow: Lipoma.

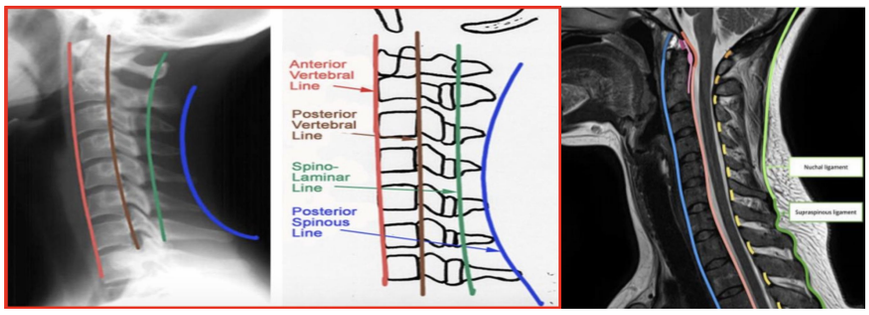
- Figure 1: T2 because the disc is bright. Missing spinous processes and herniation of meninges and CSF
- Figures 2 & 3: Post meningocele repair, the spinal cord lower than the normal (normally it ends at L2, but in low lying cord it goes down to L4 or L3!) and it could be with free end or attached (tethered) to fat like this pic (the cyst removed & the fat is lift)
- Fat bright in pic 2 while in pic 3 dark by using fat saturation technique which suppress the fat (to make sure if it is really fat or not)

Trauma

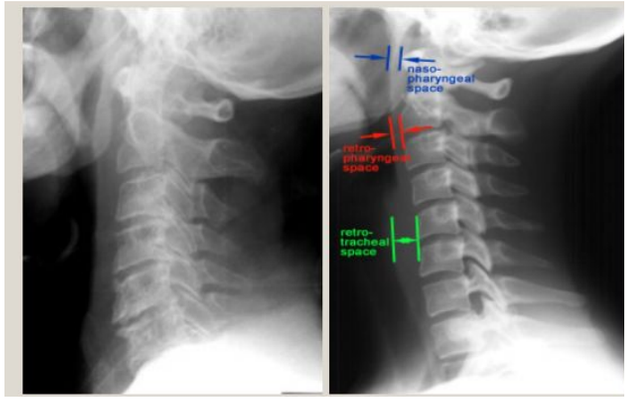
- Plain film is the first imaging modality in assessment of trauma. Assess alignment and cortex on x ray. Prevertebral soft tissue shouldn't exceed more than half of epi diameter bone vertebral body in c 1,2 and 3. When we go down it could be thicker.
- Cervical spine trauma is more likely to have fracture because it is uncovered part of the spine a little bit compared to thoracic and lumbar
- To assess trauma, usually we do plain films, unless the patient is severely traumatized (head injury, skull laceration or multiple bone fracture) we do CT trauma survey from head to thigh.



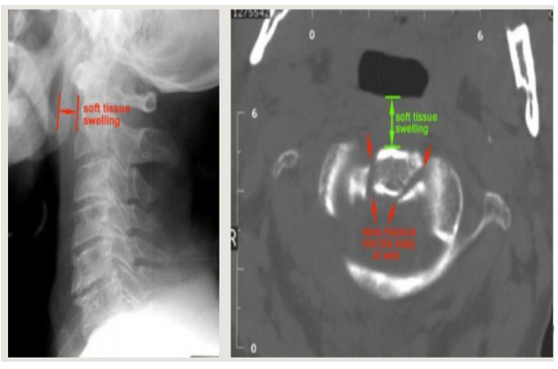
Alignment should be normal – check by drawing lines (to assess displacement and subluxation)



Normally the thickness increase when we go down from nasopharyngeal to retrotracheal but it should not exceed specific numbers.
Anterior soft tissue start from nasopharyngeal until C4 which is the level of retropharyngeal space the thickness of this area should not exceed 3-5 mm if it more than that it will be abnormal eg: hematoma, abscess, metastasis tumor, while the thickness of the anterior soft tissue below C4 which is the level of retrotracheal space should not exceed the width of the vertebral body.
Prevertebral soft tissue swelling may indicates fracture, hematoma, retropharyngeal abscess or infection.

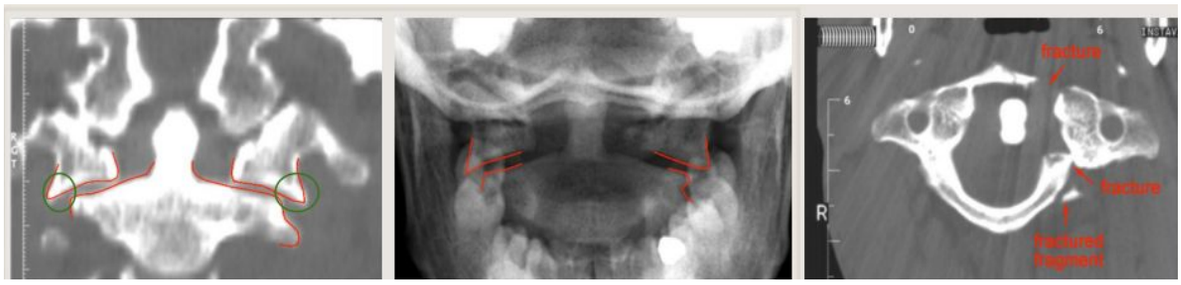


- Soft tissue anterior to spine is very important
- Increased soft tissue space anterior to upper cervical vertebrae (swelling)
- indicates hemorrhage from fractures (hematoma). No need to repeat, just get the patient to CT scan to assess the site of injury.

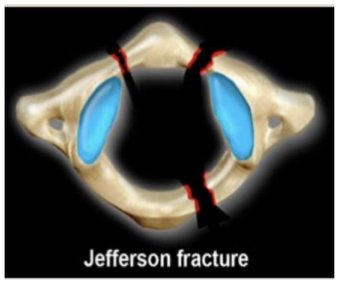


Jefferson Fracture (C1 fracture)

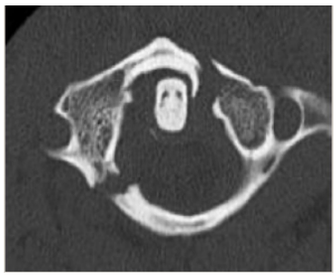
- There is a lateral displacement of **C1** lateral masses in plain film. And malalignment.
- Coronal reconstruction from a CT confirms the findings from the odontoid view.
- Axial CT clearly shows the location of the fractures of C1.



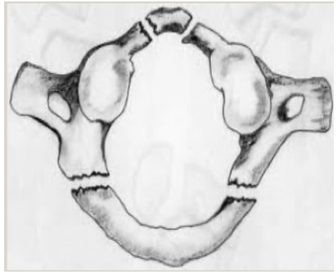
you should comment on the displacement.
The green circles show lateral displacement and loss of the alignment.



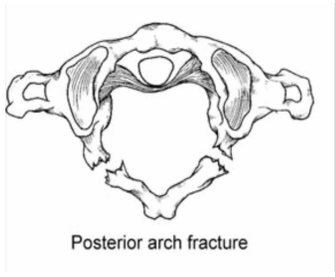
2 anterior and 1 posterior fracture



1 anterior and 1 posterior fracture



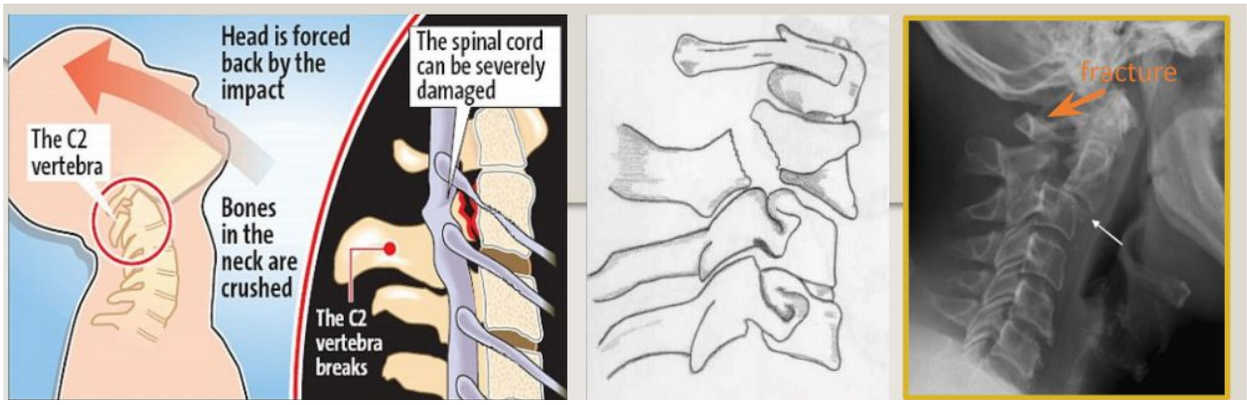
2 anterior and 2 posterior fracture



Not Jefferson fracture

wow, such empty

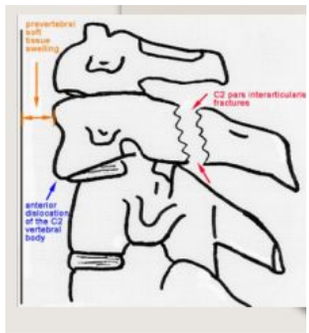
Hangman's Fracture (C2 fracture)



- Fractures through the pars interarticularis of **C2**
  - (part of a vertebra located between the inferior and superior articular processes of the facet joint) resulting from hyperextension and distraction
- Hyperextension (e.g. hanging, chin hits dashboard in road accident)

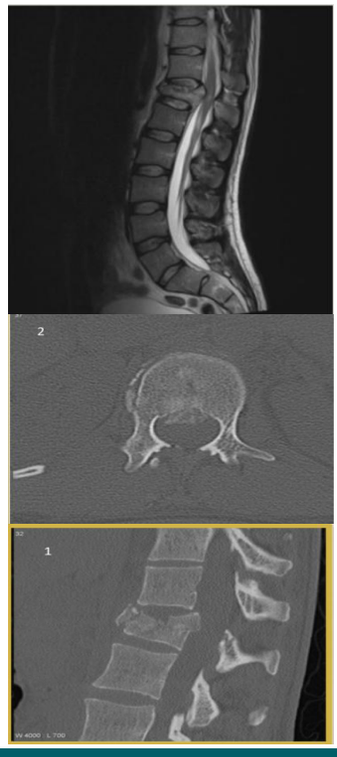
Radiographic features **(best seen on lateral view).**

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



Burst Fracture

- Are a type of compression fracture related to high-energy axial loading spinal trauma that results in disruption of the posterior vertebral body cortex with retropulsion into the spinal canal.
- Injury to spinal cord is common due to displacement of posterior fragments (if it reaches to the posterior cortex of vertebra, its called burst fracture).
- CT is required for all patient to evaluate extent of injury.
- Occurs due to hyperflexion and axial compression
- Hyperflexion is more stable than hyperextension injuries..
- Radiographic feature: disruption of the posterior vertebral body and some bony fragments that extend into the spinal canal.
- If you see this in ct scan do MRI to make sure that there is no injury to the spinal cord.



Infections

Discitis & Osteomyelitis

- Usually the result of blood-borne agents (hematogenous spread), especially from the lungs and urinary tract
- Most common pathogen is staphylococcus, Streptococcus is 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 disk to adjacent vertebral endplate.
- Infection classically starts in vertebral body but it extend quickly to the disc, if it is only in the vertebra it is usually tumor because tumor needs blood to survive and the disc has no blood supply.
- Infection from UTI can go to the spine.

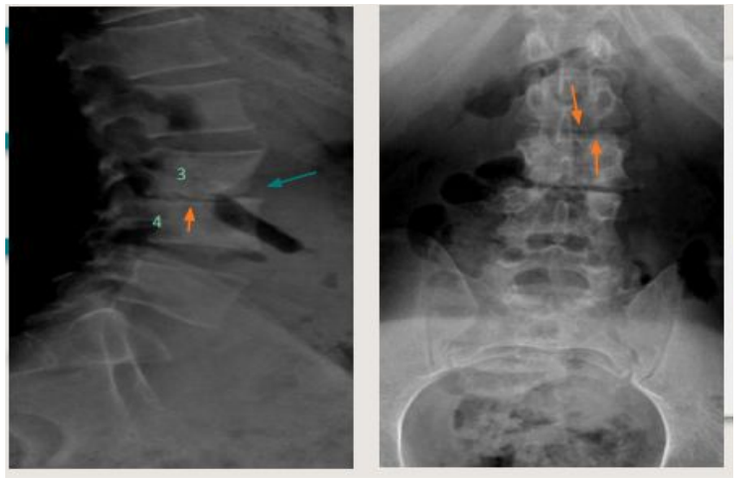
Imaging Findings

Plain Films (not specific)	MRI (more imp and sensitive)
• Narrowing and destruction of an intervertebral disk (Earliest plain film sign). • Indistinct adjacent endplates with destruction. • Often associated with bony sclerosis of the two contiguous vertebral bodies. • Paravertebral soft tissue mass. • Endplate sclerosis (during healing phase beginning anywhere from 8 weeks to 8 months after onset). • Bone fusion after 6 months to 2 years.	• Bone marrow edema in infected vertebrae, discs and paraspinal soft tissues. • (Dark on T1 and bright on T2 images) • Enhancement of inflamed tissue after contrast. • Fluid collections (abscesses) are common this is indication for MRI WITH contrast. • Used to assess progression of the disease & treatment response

Spondylodiscitis

Spondylo = vertebral body , discitis = inflammation of disc

Narrow and destruction of L3-L4 disc space with irregular erosions of opposing end plates.
Blue arrow: loss of the corner > erosion
All these findings are nonspecific so you need to do MRI next



Sagittal T1WI shows decreased signal of vertebral bodies and disc with endplate destruction lost L3-L4 due to infection materials inside the bone marrow.
Loss of the intervertebral disc, and bone marrow edema (thos appear as low signal intensity in T1W, and high intensity in T2W)

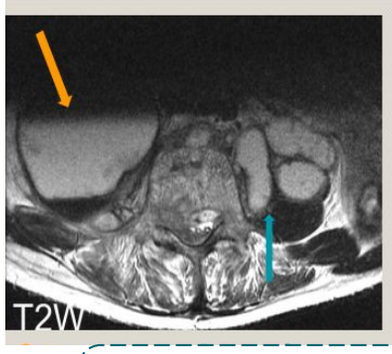
Sagittal T2WI shows increased signal in corresponding areas destruction of the intervertebral disc) with anterior subligamentous and intraspinal epidural abscess(green arrow). we can see also paravertebral component + compression of spinal cord (orange arrow).

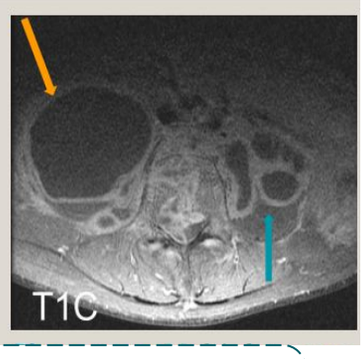
Sagittal contrast-enhanced T1-fat sat shows intense enhancement the involved area. there is erosion of the endplate.

- Axial T2WI and axial contrast-enhanced T1 fat sat show the paraspinal large abscesses.
- there is multi abcesses in the left side in both pics

1) **Treatment:**
drainage + antibiotic

2) **Symptom:**
fever + back pain + urinary incontinence.





Orange arrow: Large abscess.
Blue arrow: Multi abscesses..

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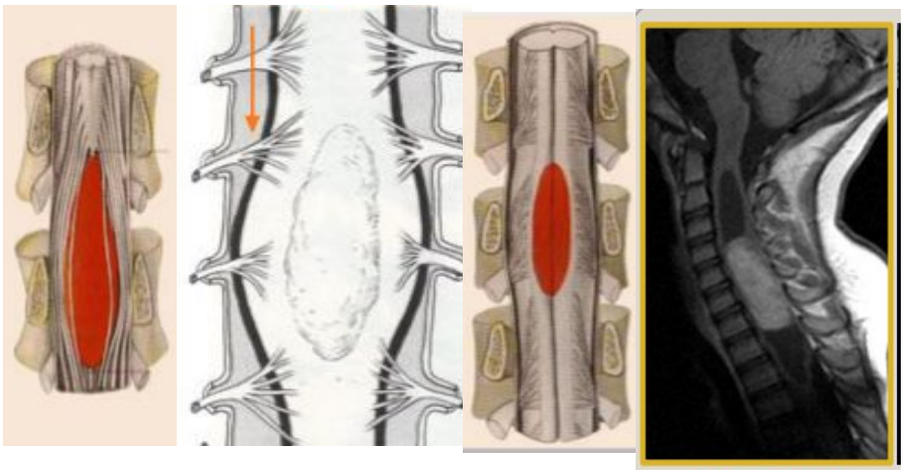
Tumors

We should answer this question:

- **Is this tumor from the spinal cord or outside the cord?** Spinal cord tumors can not be removed unless If the tumor is outside the spinal cord it can be removed.

Spinal compartments

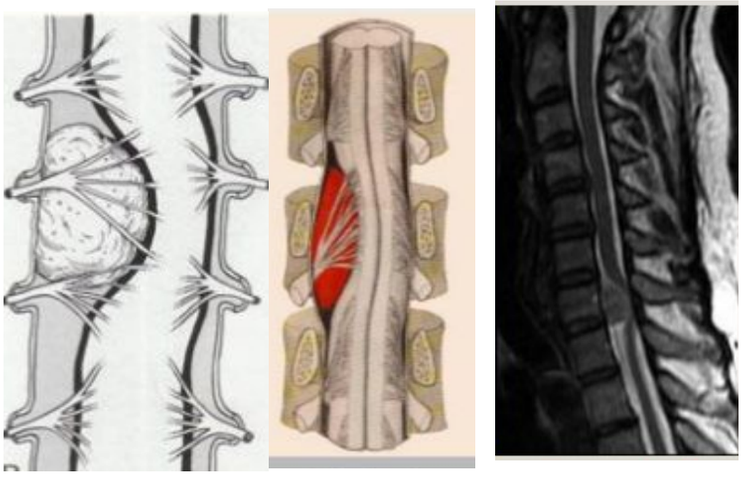


Intramedullary

Usually malignant
Ex: ependymomas, astrocytomas, and hemangioblastomas

If the CSF space is narrowed and the spinal cord diameter becomes bigger

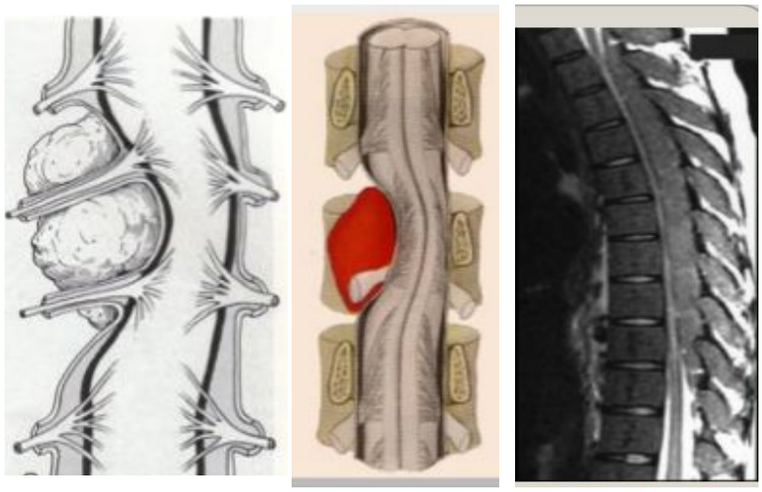
(very limited treatment options)
(we can't do surgery)



Intradural extramedullary

E.g. Meningiomas and schwannomas.

If the CSF space is larger and the spinal cord diameter becomes smaller



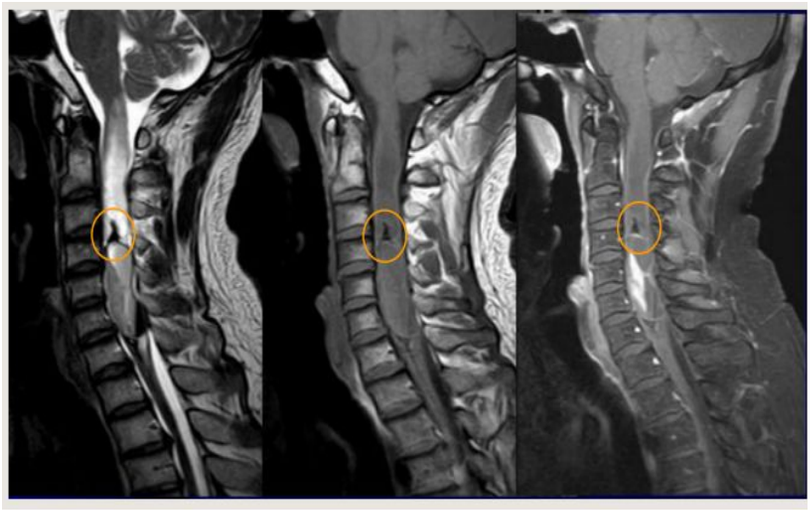
Extradural

E.g. Lymphoma, Metastasis

If the CSF space is narrowed and the spinal cord diameter becomes smaller

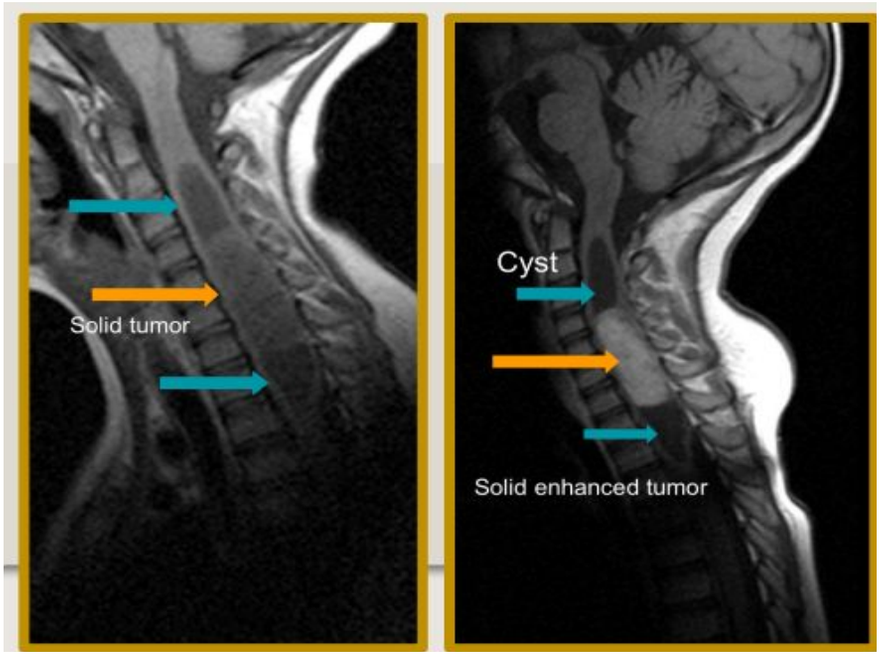
Ependymoma

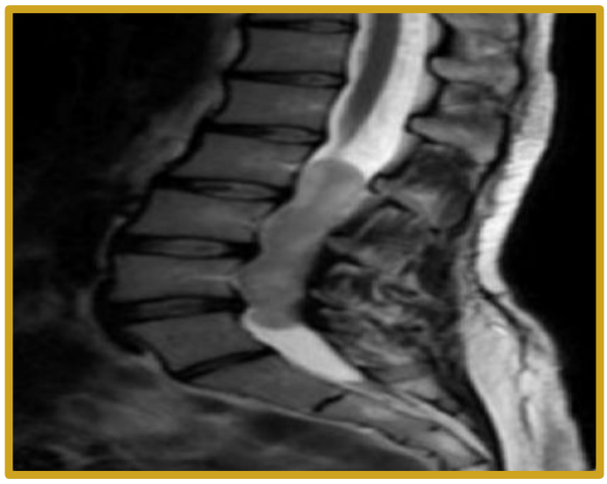
1. Intramedullary mass > spinal cord expansion. Usually located in the cervical region.
2. Hemosiderin deposition (orange circle) indicate blood component (hemosiderin cap) by itself good sign to tell you this is ependymoma because ependymomas cause hemorrhage.



Astrocytoma

- Intraspinal intramedullary > expansion of the cord.
- There is solid tumor (orange arrow) which is enhanced in the second picture and cystic component (blue arrows).





intramedullary tumor > expansion of the spinal cord

Syringomyelia means cyst inside the spinal cord. These are two pictures of the same patient with different MRI windows

Inflammatory

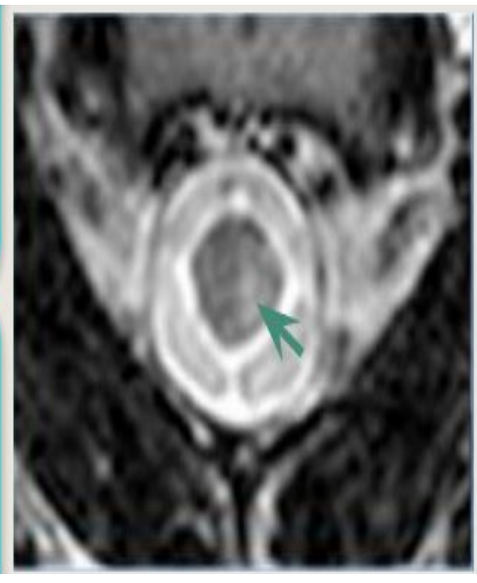
Multiple Sclerosis (Common in young females)

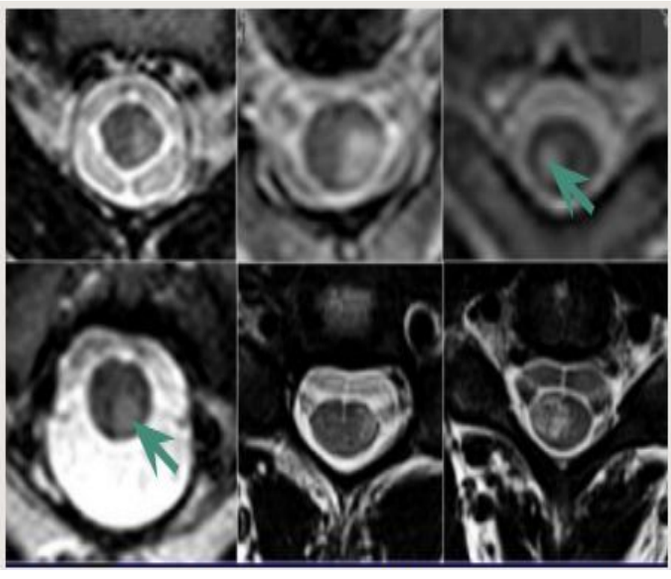
- MS is an immune-mediated inflammatory demyelinating disease of the brain and the spinal cord
- MS is the most common demyelinating disease and there is overlap between these diseases:

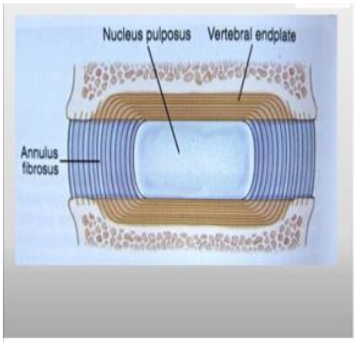
● NMO (Neuromyelitis optica) was first thought to be a form of MS, but is now considered to be a distinct form
● ADEM (Acute disseminated encephalomyelitis) can relapse and progress to MS. (Commons in pediatric)
● The partial form of transverse myelitis.

Spinal cord lesions

● Mostly in cervical cord (60%) and conus.
● Less commonly in thoracic region.
● More than 1 lesion in 55%
● <2 segments (2-60 mm) in craniocaudal length
● Eccentric in the posterior or lateral, not midline because the white matter is posterior or lateral and MS is a disease of the white matter.
● No or very little mass effect or cord swelling.
● Lesions only in spinal cord in 5-24%.
● May result in cord atrophy leading to disability.

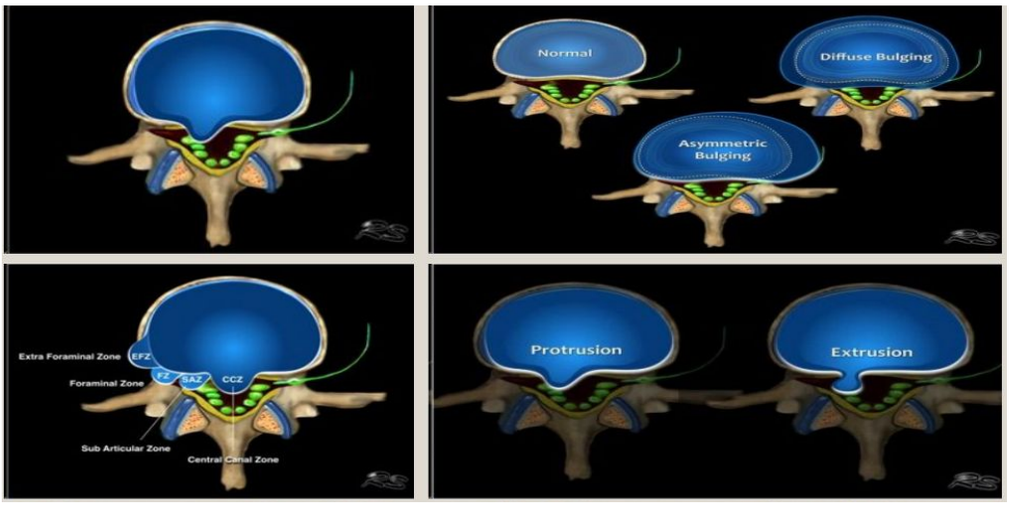


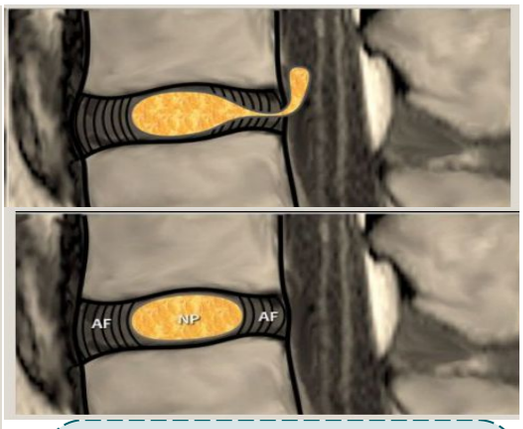




Intervertebral disc

Disc disease:





Protrusion = wide neck.
Extrusion = narrow neck

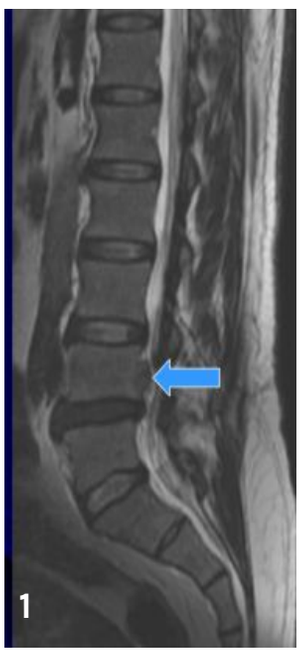
- Diffuse bulging: diffuse swelling involving more than 90 degree or 25% of the disc circumference.
  - It could be also asymmetric.
- Protrusion: bulge less than 25%.
- Extrusion: protrusion + herniated neck.
  - There could be superior or inferior migration of this material.

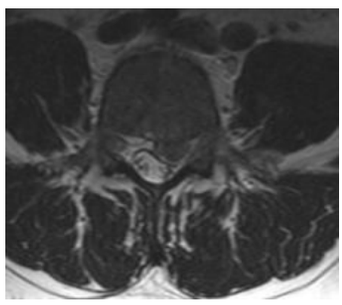
- **Disc herniation with sequestered disc fragment.**

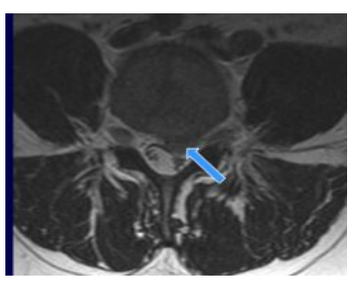
❖ Pic1: space between L4-L5 there is loss of signal intensity. (Nerve root L5 is affected). There is disc herniation, why? Bc it is less than 25%. With sequestered fragment.

How to differentiate between MS and Intramedullary tumor?
1. MS: Spinal cord has same size proximal to lesion as distal
2. Intramedullary tumor: Spinal cord becomes bigger.

How to differentiate between disc herniation and tumor?
A disc herniation won't enhance after contrast unlike the tumor

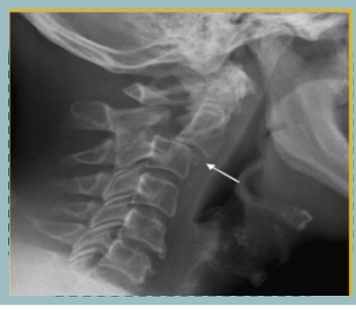






	Abnormalities
Congenital Anomalies	❖ MRI is the best to assess the contents of the cavity
Trauma	• Plain film is the first imaging modality in assessment of trauma. • Cervical trauma is more likely to cause fracture • We do CT in case of Head injury , skull lacerations, multiple bone fractures
Jefferson Fracture (C1 fracture)	Fracture of anterior and posterior arches of the C1 flexio Findings: • loss of alignments and lateral displacement
Hangman's Fracture (C2 fracture)	Destruction as a result of a sudden hyperextension (road accident) Findings: • Anterior dislocation of C2 vertebral body. • Bilateral C2 pars interarticularis fractures.
Burst Fracture	• Occurs due to hyperflexion and axial compression. • Injury to spinal cord is common.
Infections	• The most common pathogen is staphylococcus,Gram-negative rods in IV drug abusers or immunocompromised patientsPlain Xray:Narrowing and destruction of an intervertebral disk (Earliest plain film sign). • MRI:Enhancement of inflamed tissue after contrast.
Tumors	• CSF space is narrowed and the spinal cord diameter becomes big ->this is Intramedullary tumor. • If the CSF space is larger and the spinal cord diameter becomes small ->Intradural extramedullary. • If the CSF space is narrowed and the spinal cord diameter becomes small ->Extra dural.
Ependymoma	ependymomas cause hemorrhage, look for hemosiderin cap.
Astrocytoma	there is solid component and cystic component.

1-What is the name of fracture seen in the X-Ray?
a. Hangman's Fracture.
b. Burst Fracture.
c. Jefferson Fracture.
d. there is no fracture



2-Locate the following abnormality
a. Intramedullary
b. Extramedullary intradural.
c. Extradural
d. Normal

3-What is seen in MRI?
a. Astrocytoma
b. schwannomas
C. Ependymoma
d. diastematomyelia

4- If the CSF space is narrowed and the spinal cord diameter becomes big this is ?
a. Normal spinal cord
b. intramedullary tumor
c. Intradural extramedullary
d. extra dural

5-Which one of the following is the best to assess the contents of the cavity, extent of abnormalities, and spinal cord IN CONGENITAL ANOMALIES
a.MRI
b.CT
c. X-rays
d.Myelogram

6-What is the etiology of Jefferson Fracture?
a. lateral displacement of C1
b. Fracture of pars interaticularis
c. TB of spine
d. Disc prolapse of C3

Answers
1)a
2)a
3)a
4)b
5)a
6)a