MED437
King Saud University

RADIOLOGY TEAM 437

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Editting File

Radiology of spinal diseases

objectives:

- ➔ 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.

Sources

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Same 436 lecture Slides/Team:
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Imaging Methods to Evaluate the Spine

Imaging method	Explanation
Plain X-Ray Films	Bones eg. vertebral fracture (usually the first used imaging modality).
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 , spinal cord بالتحديد. - Preoperatively in spinal cases we do both CT and MRI.
Spinal angiography	To evaluate arteries and veins, eg. vascular malformations.
Ultrasound	More in children for example in congenital disease (Used in pediatrics because they have more cartilage unlike adults).
Radionuclide Bone Scan	- IV injection of radioactive material bound to phosphonates which deposit in bones, followed by images by gamma camera. - 1st choice for **malignancy & bone metastasis** and when multiple lesions are suspected.
DEXA (Dual-Energy X-ray Absorptiometry)	Radionuclide scan for bone density (Osteoporosis only).

X-Rays (Radiographs)

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

Can detect:

1. Spinal alignment and curvature (alignment means the vertebrae is aligned with the other vertebrae).
2. Spinal instability – with flexion & extension views, to assess displacement and subluxation.
3. Congenital (birth) defects of spinal column. ex: congenital scoliosis, congenital kyphosis, congenital lordosis and Klippel-Feil syndrome.
4. Fractures caused by trauma. (You must follow up with CT to confirm)
5. Moderate to severe osteoporosis (loss of Calcium from bone), but DEXA is better in osteoporosis (it is the gold standard)
6. Infections.
7. Tumors. infections and tumors are usually better assessed by other modalities.

Computerized Tomography (CT)

- Uses radiation to obtain 2D which can be processed to 3D images.
- 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, limited information about spinal cord and soft tissues.
- Entire spine can be imaged within a few minutes.
- Might need IV or intrathecal contrast for some areas.

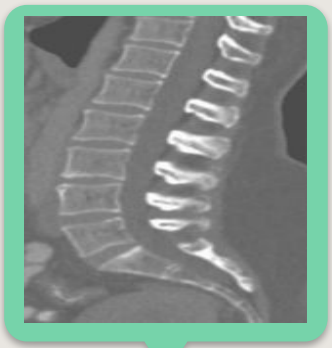
Better in visualizing:

1) Degenerative changes, Herniated discs. MRI is better
2) Spinal alignment (limited information). MRI is better
3) **Fractures and fracture patterns** (if there is trauma, CT is a must investigation). IMPORTANT
4) Congenital/childhood anomalies. especially anomalie of BONE
5) 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:

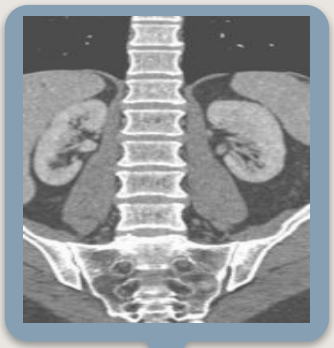
- Inner details of spinal cord (contents of spinal cord), the concentration is more on the bones.

3D Image



Sagittal Image

Axial Image



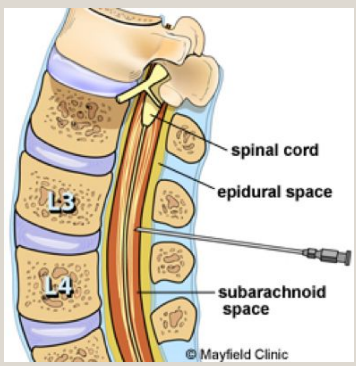
Coronal Image

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.

Procedure:
Under local anesthesia, a needle is placed into lower lumbar spinal canal (between L3-L4 to insure safety) then CSF flow is confirmed.
Contrast medium is then injected which mixes with CSF around spinal cord, making it visible on x-ray, the contrast is injected in the subarachnoid space.
Often a CT scan is performed after this.

White arrows: nerve root



Magnetic Resonance Imaging

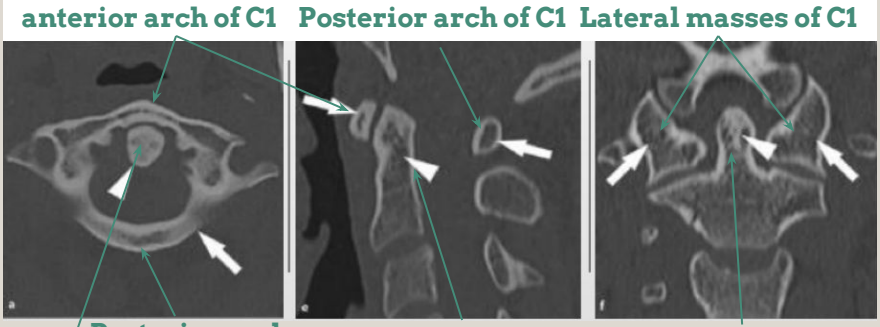
- **The gold standard for spinal disorders.**
- **Does not use ionizing radiation.**
- **Can identify abnormalities of bone, discs, muscles, ligaments and spinal cord.**
- **IV contrast is sometimes administered to better visualize certain structures or abnormalities. eg: infection, tumor but normally 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:

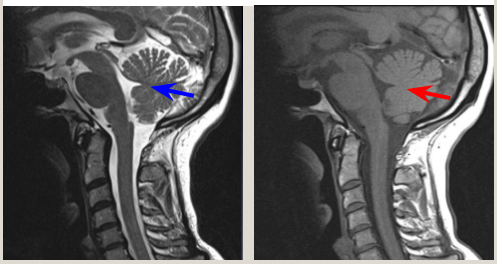
1. **Implanted devices e.g. cardiac pacemakers and all other electromagnetic devices.**
2. **Certain metal clips and stimulators (like aneurysmal clips, because if the clip moves it damages the artery).**
   - **Artificial joints & spinal hardware may still have MRI scans "will not be pulled out, but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

MRI features in contrast to CT

Craniocervical junction (C1 & C2)

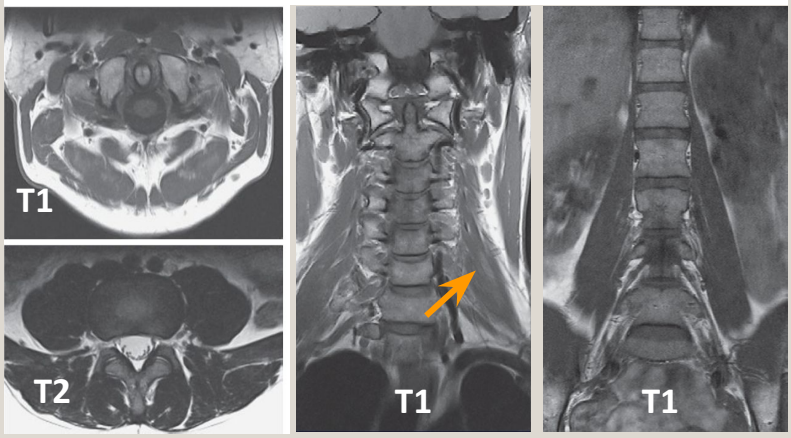


Spina bifida occulta at C1



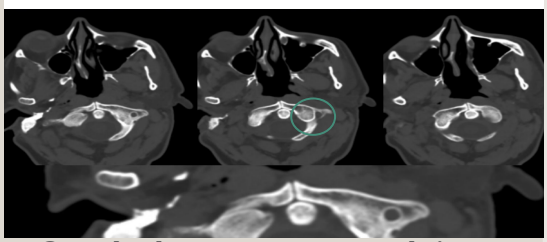
← normally we should see here a rounded structure which is the posterior arch of C1.
← we do not see the arch here so this indicates spina bifida occulta and it is called occulta because there is no soft tissue defect, it is only BONE.

MR images are Multi-planer



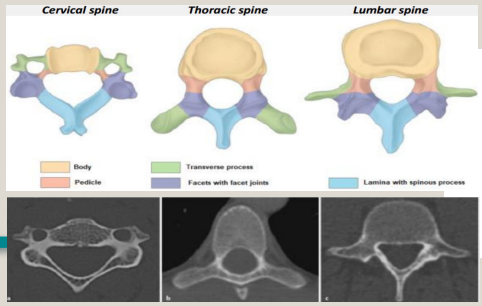
- **Orange arrow:** Psoas muscle.
- X-ray and CT show us only disc space.
- MRI not only shows us disc but the components of it.
- High signal intensity (bright disc) → T2 **Why?** due to collagenous water materials that why in degenerative disease the disc become hard and low water so it look little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

Fusion defect anterior arch at C1

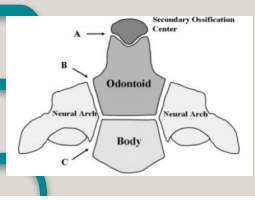


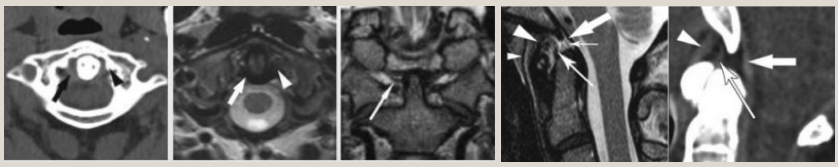
Occulta because no neural tissue or meninges herniating through.
Normally we should not see any space, the bone must be continuous

MRI features in contrast to CT

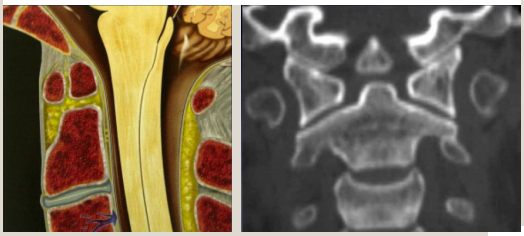


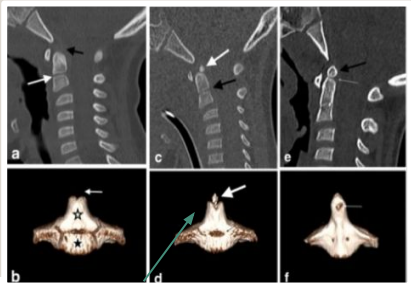
- Cervical vertebrae have foramen transversum which has vertebral artery and has small vertebral body
- Thoracic vertebrae have a bigger vertebral body
- Lumbar have triangular shaped canal and even bigger body





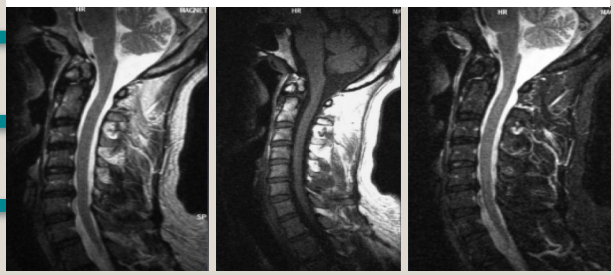
Odontoid bone



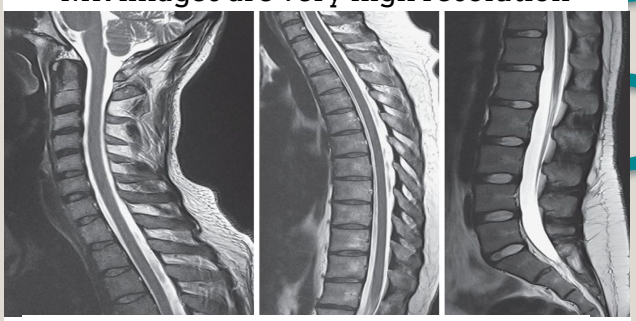


Arrow shows non-fused ossification centers mimicking fracture

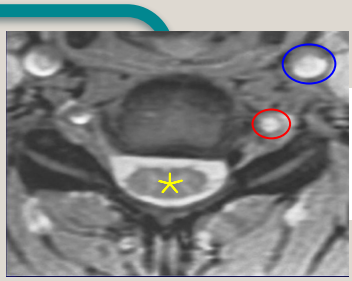
Os odontoideum



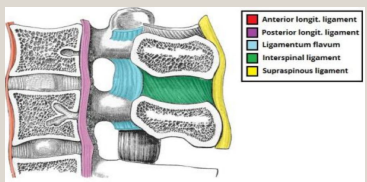
MR images are very high resolution

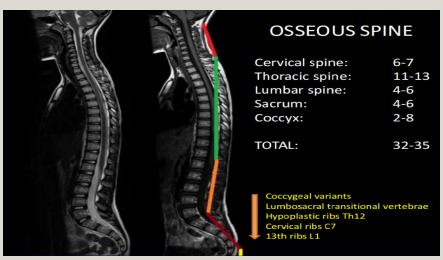


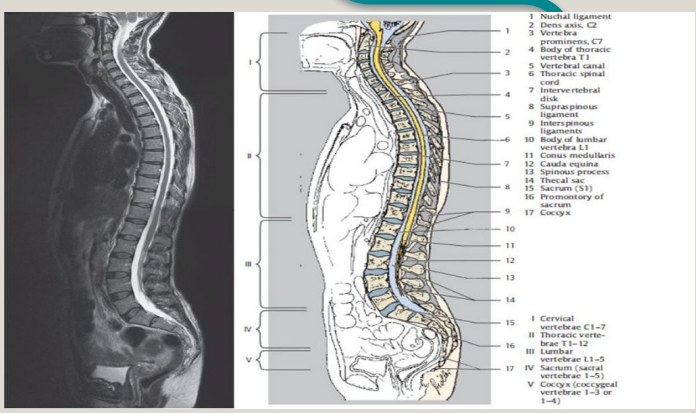
Cervical Thoracic Lumbar

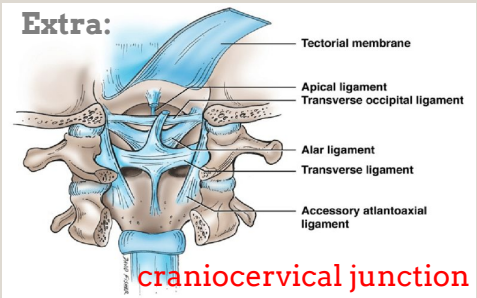


- **Yellow star:** spinal cord.
- **Red circle :** vertebral artery.
- **Blue circle :** carotid artery.









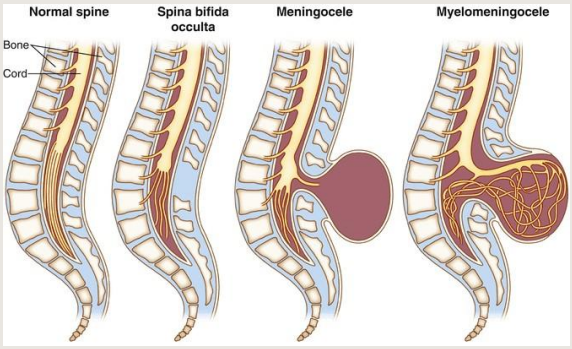
craniocervical junction

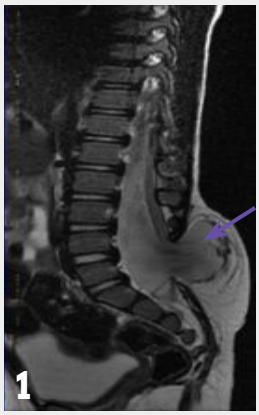
Doctor talked about the ligaments in the craniocervical junction and said just know their names

Spinal Abnormalities Assessment:

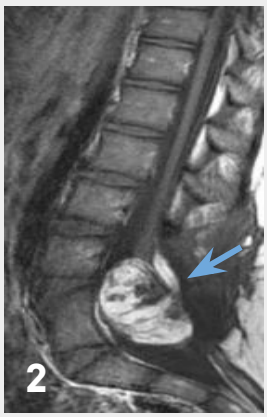
1) Congenital Anomalies:

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.





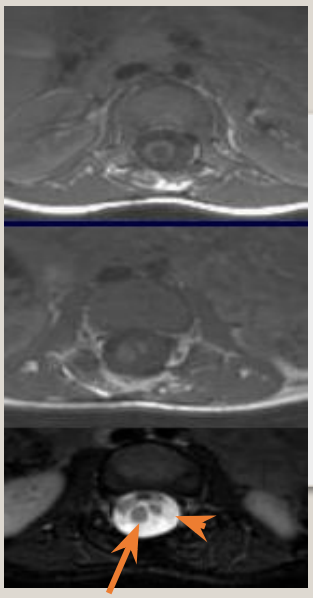
Meningocele



Low lying cord tethered to large lipoma

- **Pic 1:** T2 because the disc is bright.
- **Pic 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)
- Orange arrow: Low lying cord.
- Blue arrow: Lipoma.

Multiple fusion abnormalities of vertebra on plain film, loss of disc space.

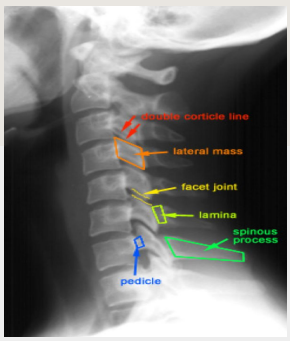


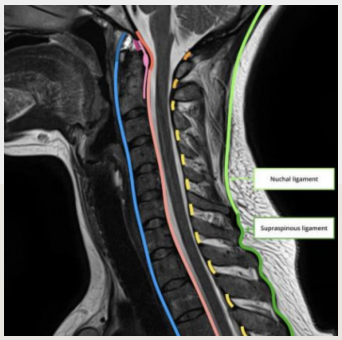
Arrows: represents the splitting cord into two part separated by bone element it's hard to see it by the sagittal view.
Circle: cyst.

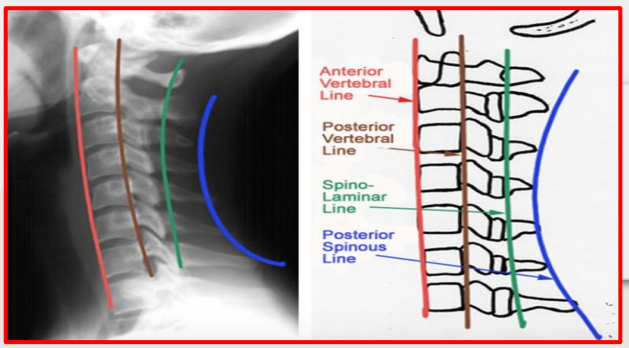
Split low lying cord (diastematomyelia)

2) Trauma

- Plain film is the first imaging modality in assessment of trauma.
- All vertebrae were developed from notochord.
- 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.

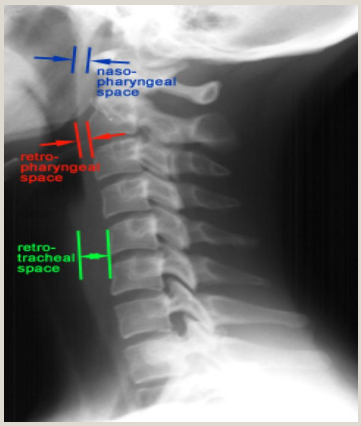


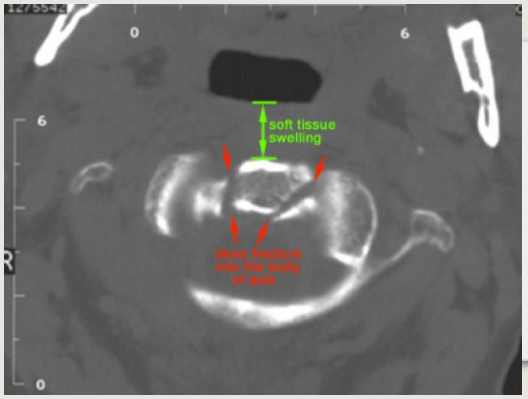




Alignment should be normal – check by drawing lines to assess displacement and subluxation.

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.



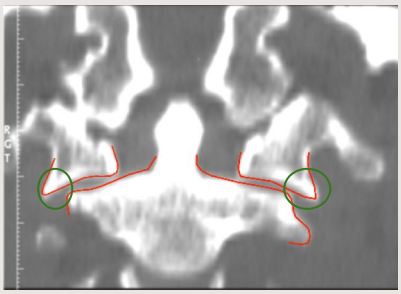


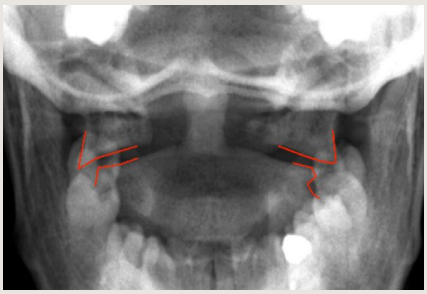
Increased soft tissue space anterior to upper cervical vertebrae indicates hemorrhage from fractures (hematoma).
No need to repeat, just get the patient to CT scan to assess the site of injury.

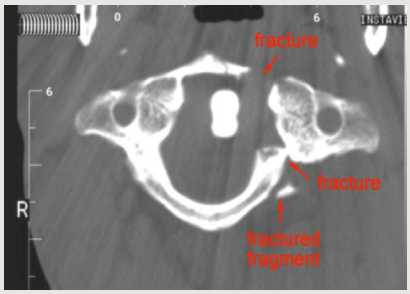
Jefferson Fracture (C1 fracture): (Important)

- There is a lateral displacement of C1 in plain film.
- Coronal reconstruction from a CT confirms the findings from the odontoid view.

- Axial CT clearly shows the location of the fractures of C1.
- Fractures in both anterior and posterior arches of the C1 flexion is called **jefferson fracture**. But, if the fractures only in the anterior or posterior arches is called anterior or posterior arch fractures, not jefferson.



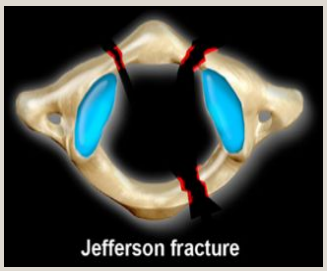




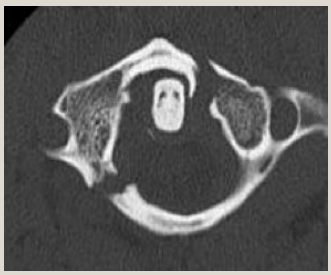
YOU SHOULD COMMENT ON DISPLACEMENT.
The green circles show lateral displacement and loss of the alignment.

Mechanism of trauma is Axial Loading:

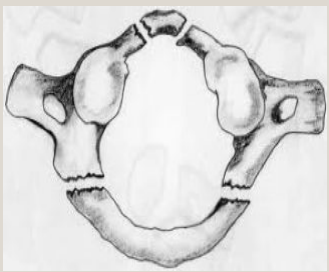
1) Object hitting the head.
* E.g. when a hard brick falls on the head of a worker. (Workers should wear helmets, but they still aren't fully protected because the helmet protects against the direct head injury, but the ultimate weight will transmit to the whole craniocervical junction) but if the worker doesn't wear a helmet he will have a head injury, which is more lethal than cervical spine injury.
2) Head hitting a surface or object.
* E.g. Jumping into a swimming pool with shallow water will cause the head to hit the floor directly.



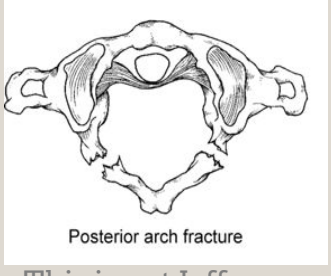
2 anterior and
1 posterior fracture



1 anterior and
1 posterior fracture

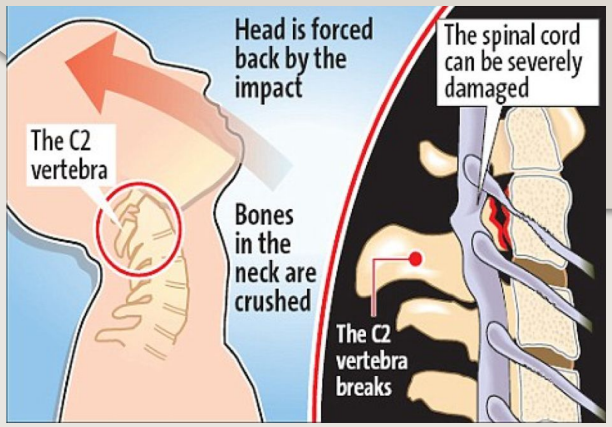


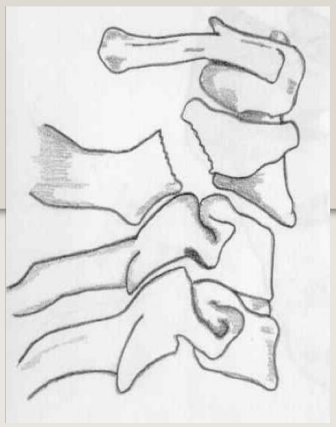
2 anterior and
2 posterior fracture

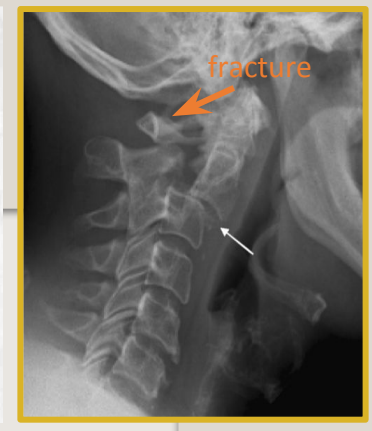


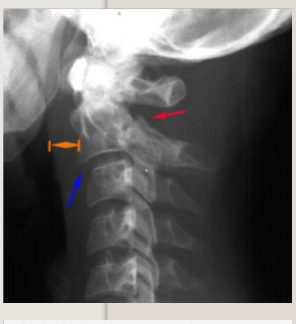
This is not Jefferson fracture

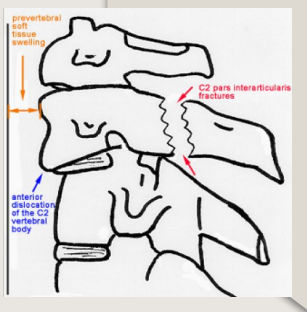
Hangman's Fracture (C2 fracture): (Important) can cause death











- Fractures through the pars interarticularis of C2 (between vertebral Body and posterior element) resulting from **hyperextension and distraction.**
- Sudden Hyperextension e.g. hanging (death sentence) or when chin hits dashboard in road accident.

Radiographic features: (best seen on lateral view).

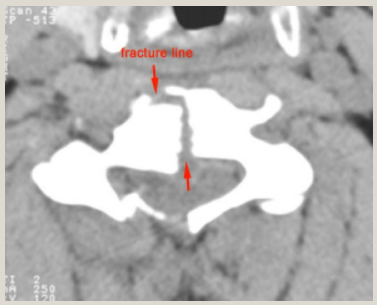
1. Prevertebral soft tissue swelling
2. Fracture (Avulsion) of anterior inferior corner of C2 associated with rupture of anterior longitudinal ligament.
3. Anterior dislocation of C2 vertebral body. (white arrow)
4. Bilateral C2 pars interarticularis fractures.
    - if injury is in C2 > hemiplegia.
    - if below C5 > quadriplegia and breathing is intact.
    - if C3 and below, patient can't breathe because the diaphragm is supplied by C3,C4,C5.

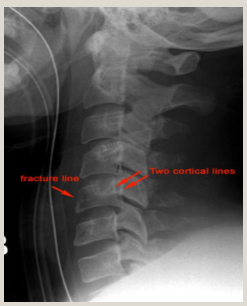
Burst Fracture: For more details, click HERE.

- 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..

Retropulsed fragments.

Cord edema





Fracture of vertebral body + spinal cord compression.

3) Infections

Discitis & Osteomyelitis

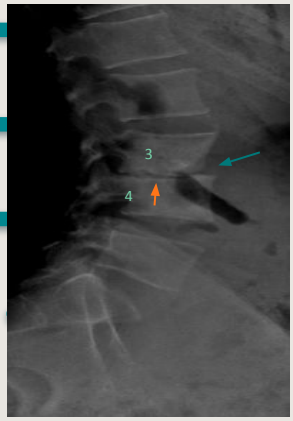
- **Usually the result of blood–borne agents** (hematogenous spread), especially from the lungs and urinary tract.
- Most common pathogen is **staphylococcus**, Streptococcus is less common.
- Gram-negative rods in **IV drug abusers or immunocompromised patients:**
  - E. Coli.
  - Proteus.
  - Non-pyogenic (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.

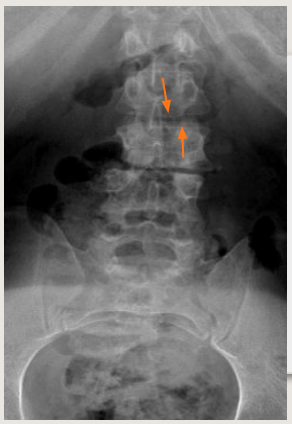
Imaging Findings:

Plain Films	MRI
• 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.

Spondylodiscitis

Spondylo = vertebral body , discitis = inflammation of disc so there is involvement of the disc and vertebral body.





Narrow and destruction of L3-L4 disc space with irregular erosions of opposing end plates.

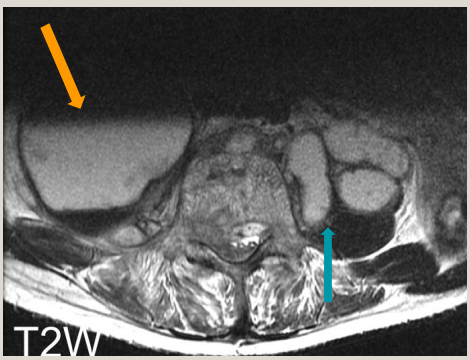
Blue arrow: loss of the corner > erosion

Sagittal T1WI shows decreased signal of vertebral bodies and disc with end plate destruction lost L3-L4 due to infection materials inside the bone marrow.

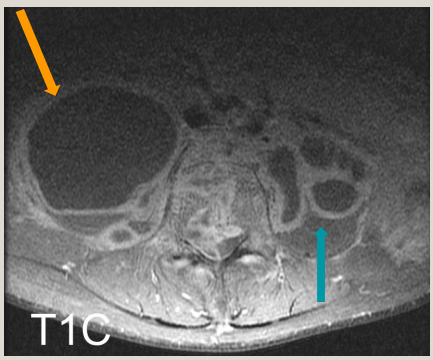
Sagittal T2WI shows increased signal in corresponding areas with anterior subligamentous and intraspinal epidural abscess. we can see also paravertebral component + compression of spinal cord (arrow).

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
Treatment:
drainage + antibiotic.
Symptom:
fever + back pain + urinary incontinence.



Orange arrows: Large abscess.



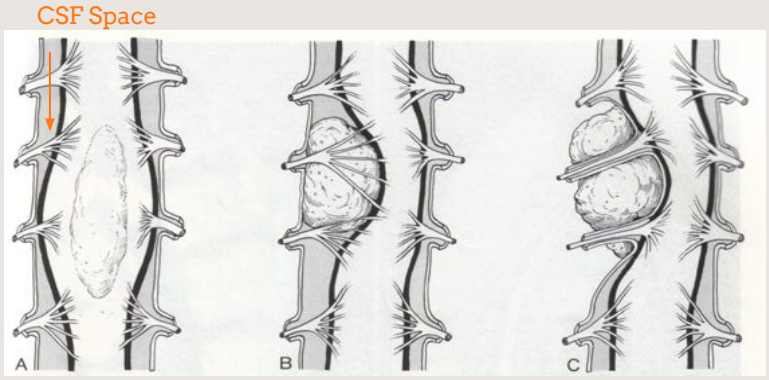
Blue arrows: Multi abscesses.

4) 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.



Intra medullary | Intradural extramedullary | Extra dural

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

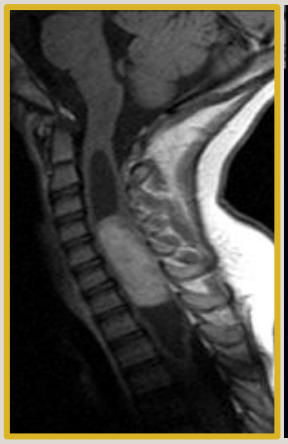
this is Intramedullary tumor. (very limited treatment options) (we can't do surgery)

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

this is Intradural extramedullary eg: meningioma , schwannomas.

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

this is Extradural eg: lymphoma, metastasis.

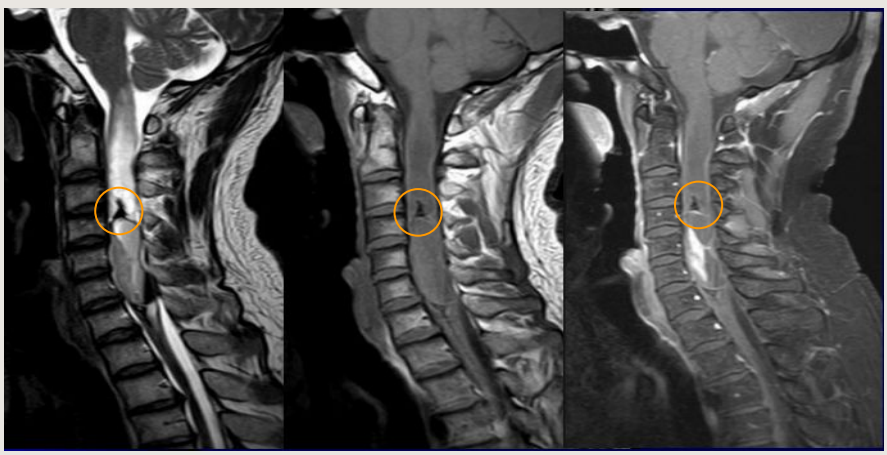


Intraspinal intramedullary tumor > expansion of the spinal cord

Intraspinal Intradural extramedullary

Extra dural

a) Ependymoma:

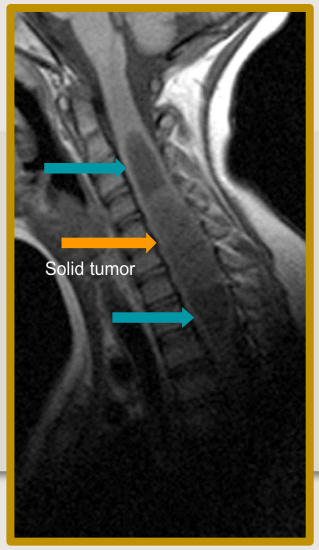


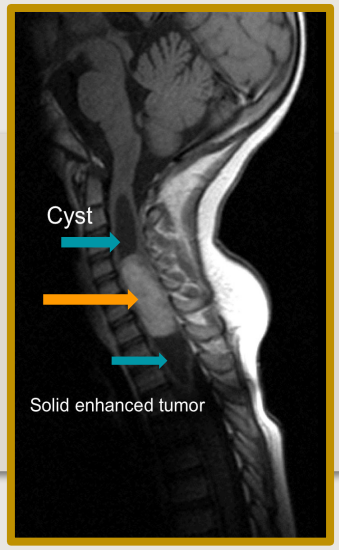
1. Intraspinal intramedullary mass > spinal cord expansion.
2. Hemosiderin deposition (orange circle) indicate blood component (hemosiderin cap) by itself good sign to tell you this is ependymoma because ependymomas cause hemorrhage.

b) 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).

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





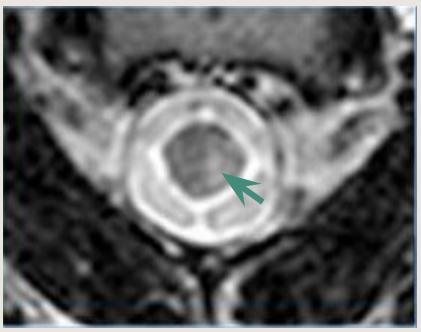
5) Inflammatory

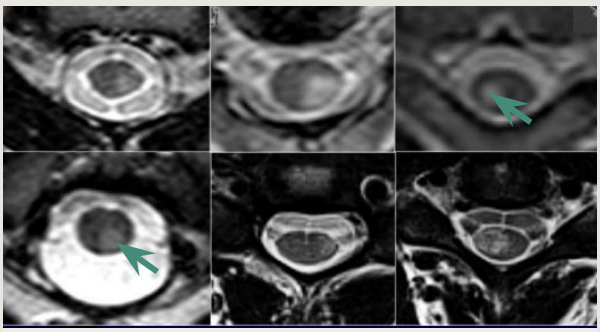
1a) Multiple Sclerosis

- 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.
  - The partial form of transverse myelitis.

2b) 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 (short segments).
- 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.





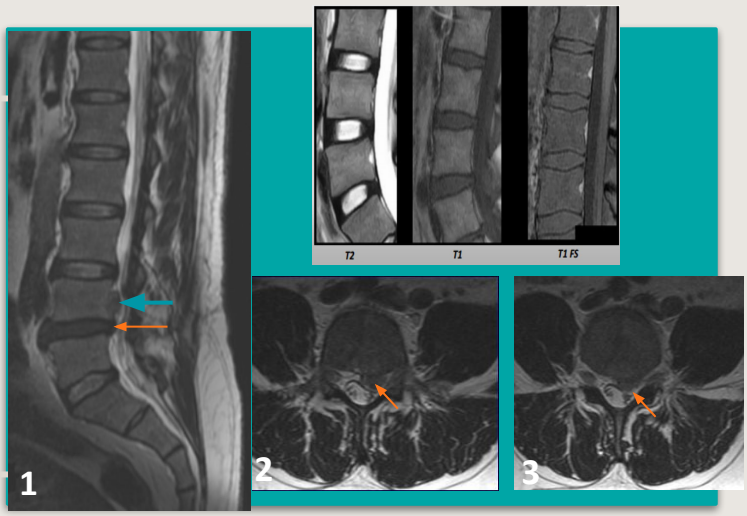
On transverse images MS lesions typically have a round or triangular shape and are located posteriorly or laterally. (arrows)

2) Disc disease:

Disc herniation with sequestered disc fragment.

- **Pic1:** space between L3-L4 there is loss of signal intensity.
- We call it disc dehydration if it was in young person instead of degenerative diseases.
- **Pic3:** shows compression on the cord and nerve number 3 and 4.

← sequestered disc fragment

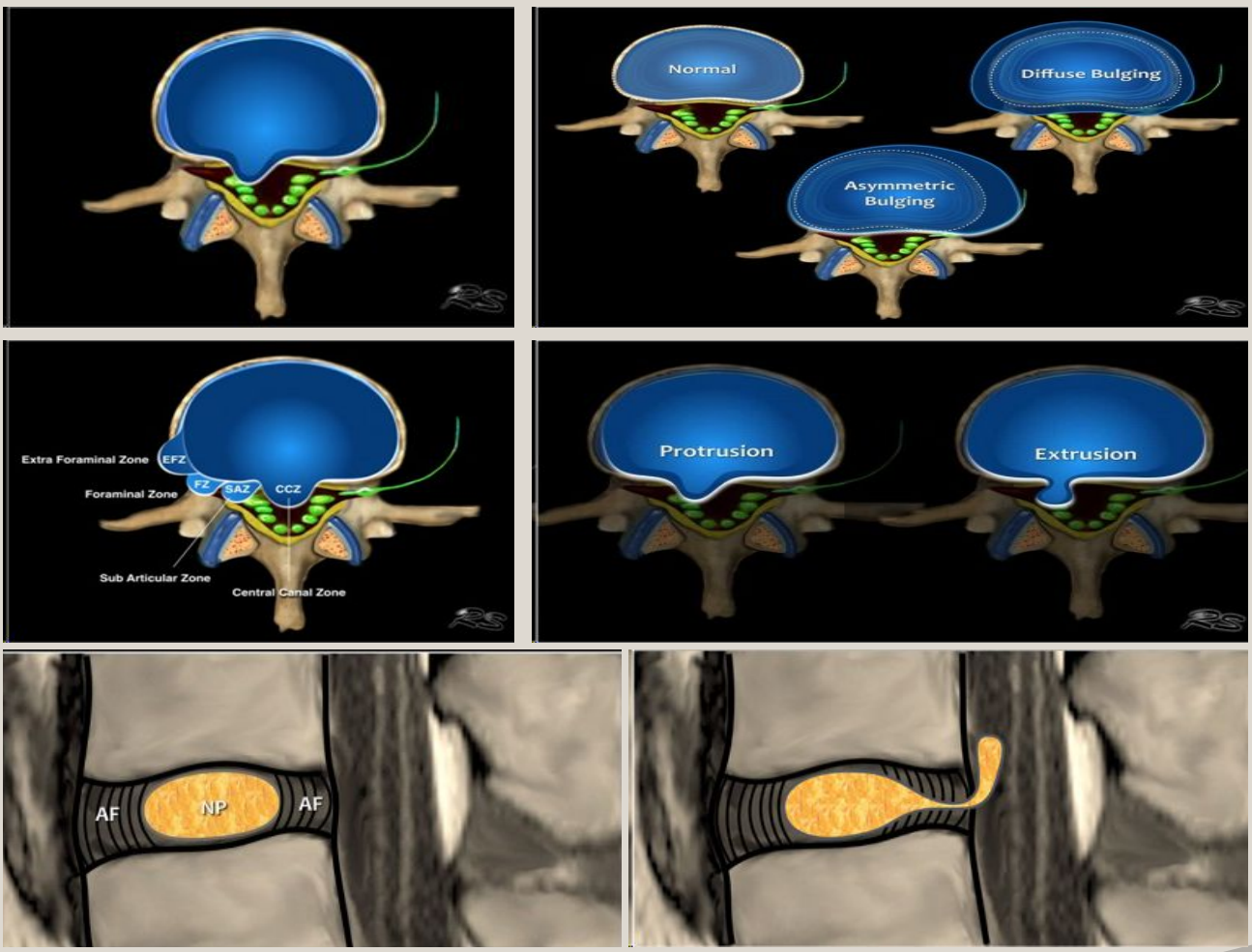


How to differentiate between MS and Intramedullary tumor?

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.



Protrusion = wide neck.
Extrusion = narrow neck

SUMMARY

Imaging method to Evaluate the Spine

Plain X-Ray Films	Myelogram	CT Scan	MRI	Spinal angiography	Ultrasound	Radionuclide Bone Scan	DEXA
		We do both preoperatively					
First for bones Detect spinal alignment, instability	Rare Contrast followed by x-ray	The best for bones, poor for spinal cord -confirms Trauma	Gold standard Spinal cord -identify abnormalities of bone, discs, muscles, ligaments and spinal cord.	Evaluate vessels	Congenital diseases	1st choose for malignancies , or metastasis	Osteoporosis

Abnormalities

Congenital Anomalies

MRI is the best to assess

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 flexion Findings: • loss of alignments and lateral displacement
Hangman's Fracture (C2 fracture)	• Can cause death • 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

Discitis & Osteomyelitis	• The most common pathogen is **staphylococcus,**Gram-negative rods in IV drug abusers or immunocompromised patients • Plain Xray:Narrowing and destruction of an intervertebral disk (Earliest plain film sign). • MRI:Enhancement of inflamed tissue after contrast.

Tumors

- Is this tumor from the spinal cord or outside the cord?
- 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	Solid with cystic component

Inflammatory

Multiple sclerosis	Spinal cord lesions

Disc diseases

QUESTIONS

1. What do you see in the X-Ray:

a) Normal spine.

c) Increased soft tissue space anterior to upper cervical vertebrae

b) Jefferson Fracture.

d) Multiple fusion abnormalities.

2. What is the name of fracture seen in the X-Ray:

a) Hangman's Fracture.

c) Burst Fracture.

b) Jefferson Fracture.

d) there is no fracture

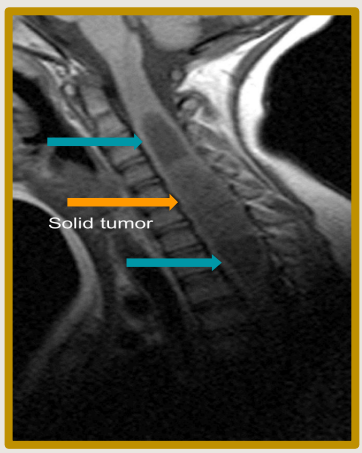
3. What is seen in MRI:

a) Astrocytoma

c) schwannomas

b) Ependymoma

d) diastematomyelia



4. If the CSF space is narrowed and the spinal cord diameter becomes big this is ?

a) Normal spinal cord

c) Intraspinal Intradural extramedullary

b) intraspinal intramedullary tumor

d) extra dural

1-D
2-A
3-A
4-B

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References

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