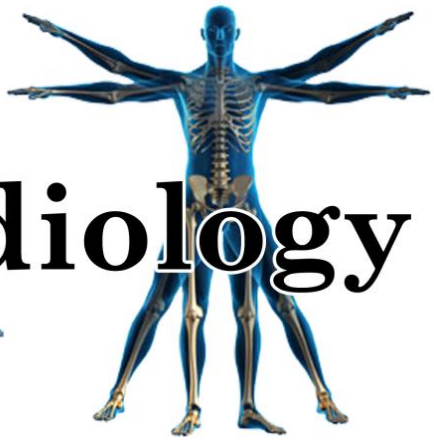

(10): Radiology of Spinal Diseases

* Many thanks to 431 team for their helpful notes *

Done By:
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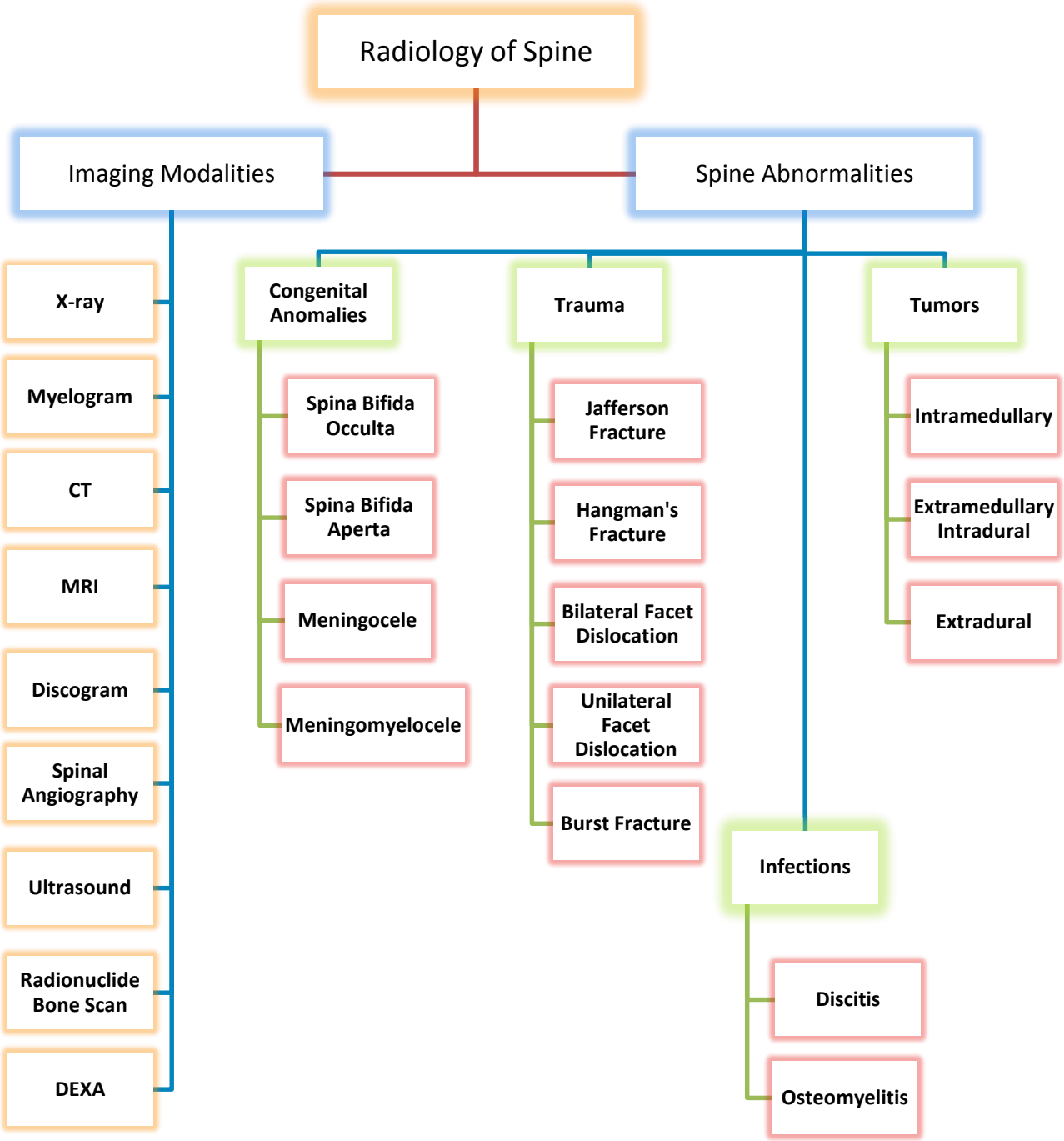
Reviewed By:
Eman AlBedaiea

COLOR GUIDE: • Females' Notes • Males' Notes • Important • Additional • 431 team

Objectives

Not Given ;(



From Slides | 431 Teams | Extra

A) Imaging Methods to Evaluate Spine

1) Plain X-Ray Films; it's usually the first used imaging modality
2) Myelogram – injection of contrast medium in CSF (within the thecal sac) followed by x-ray images. Rarely performed nowadays
3) Computed Tomography (CT Scan)
4) Magnetic Resonance Imaging (MRI)
   CT and MRI are very well established
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
   Discogram, spinal angiogram, and ultrasound are dedicated studies for certain questions
8) Radionuclide Bone Scan – intravenous injection of radioactive material bound to phosphonates which deposit in bones, followed by images by gamma camera. (performed to evaluate the whole skeleton)
9) DEXA – radionuclide scan for bone density (osteoporosis)

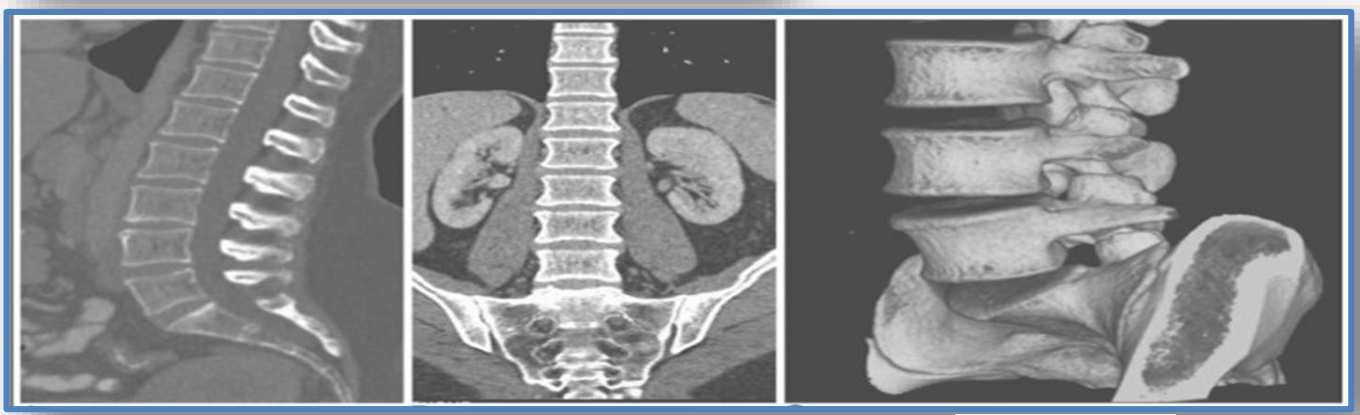
X-Rays (Radiographs)

- Often the first diagnostic imaging test, because it's quick, readily available and cheap
- Usually the method of choice when someone is having abnormality in the spine like back pain or trauma
- Small dose of radiation to visualize the bony parts of the spine
- Limitations: it doesn't show the muscular, ligaments, vascular and disc structure very well
- Can detect
  - Spinal alignment and curvature
  - Spinal instability – with flexion and extension views
  - Congenital (birth) defects of spinal column
  - Fractures caused by trauma
  - Moderate osteoporosis (loss of calcium from the bone)
  - Infections
  - Tumors
- All these will show an abnormality on plain films, but many times those "abnormalities" turn out to be normal. So, if there is some abnormality shown; do further evaluation with CT scan or MRI
- If there are no abnormal findings on x-ray but the patient has significant symptoms, we need further investigations. So it's not a very sensitive method; as it may miss many findings.
- X-ray images may be taken in different positions (e.g. the patient can bend forward and backward or bend laterally to left and right side) to assess for instability. Note that, this is not possible with CT and MRI, as the patient must be lying flat. So, if there are any abnormalities of the spine curvature in different stress positions like hyperflexion and hyperextension, they will not be seen.

COMPUTERIZED TOMOGRAPHY (CT SCAN)

- Uses radiation to obtain 2-D and 3-D images
- Patients must lie still on a table that moves through a scanner
- Cross-sectional images are obtained of the target areas
- Much detailed information regarding bony and soft tissues compared to plain films
- Better in visualizing:
  - Degenerative or aging changes, Herniated discs
  - Spinal alignment
  - Fractures and fracture patterns
  - Congenital / childhood anomalies
  - Areas of narrowing in spinal canal through which spinal cord and spinal nerve roots pass
- Poor in visualizing:
  - Inner details of spinal cord. So findings like edema, contusion, fracture, and hematoma will be missed, as it doesn't show the interior of the cord, only the outline.
- Entire spine can be imaged within a few minutes
- A contrast material may be injected intravenously (often) or intrathecally to make some areas clear

- **CT scanner** original images are usually in axial sections, but we can alter them. E.g. 3D

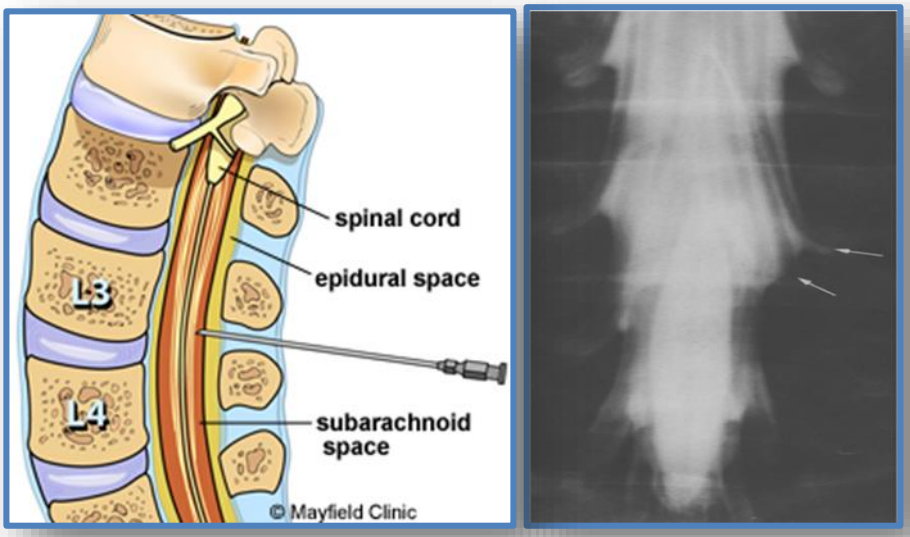


Sagittal Images | Coronal Images | 3D Images

3D images are very good qualities, on computer you can rotate these images and give much better information regarding fractures, tumor areas or other abnormalities.

Myelogram

- A contrast material is injected into CSF to better identify areas where spinal cord or spinal nerves may be compressed
- **Procedure:**
  - Under local anesthesia, a needle is placed into lower lumbar spinal canal (most often between L3 and L4 vertebral bodies between the spinous processes of the posterior aspects), and then CSF flow is confirmed. Contrast medium is then injected which mixes with CSF around spinal cord, making it visible on x-ray images
  - Often a CT scan is also performed after this
  - May be performed when MRI is contraindicated



- This plain film is called myelogram. And if we take CT after this, we call it CT myelogram.
- Better outline of the nerve routes; seen here as black lines.
- And outline of the thecal sac.
- Also spinal cord surface is shown.
- But MRI gives better visualization than myelogram.

Discogram

- Discs are the cushions between the vertebral bodies
- Many patients refuse this modality because it produces pain and we can't give anesthesia
- While MRI and CT scans can provide structural information, discogram better identifies the relationship of disc to pain
- **Procedure:**
  - A needle is placed into center of the disc under fluoroscopy (continuous x-ray imaging)
  - A contrast material (dye) is injected
  - Radiologist then observes if patient experiences pain that is similar to his/her usual pain, and is increased by injecting contrast
- X-rays (+ CT scan) are then done to see if dye stays within the center of the disc or leaks to outer border of the disc indicating a tear in annulus fibrosus of disc which can be a source of pain

Magnetic Resonance Imaging (MRI)

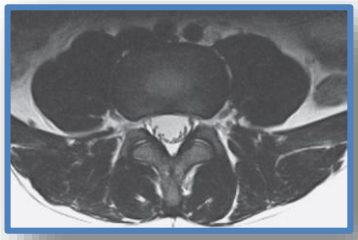
- The gold standard of imaging for spinal disorders
- Does not use ionizing radiation (it's magnetic based)
- Can identify abnormalities of bone, discs, muscles, ligaments & spinal cord (much better & clear details)
- Intravenous contrast is sometimes administered to better visualize certain structures or abnormalities
- Patient lies still in a tunnel like structure for about 25 minutes (can be done in 15-20 minutes)
- Claustrophobic patients may need sedation, and children often need general anesthesia (because they can't follow the instructions very well)
- MRI is considered as a gold standard for spine imaging, but fracture fragments are better seen in CT. So, when we have a trauma patient, we usually do both MRI & CT, because we need to evaluate the spinal cord, the nerve roots and the fracture fragments.
- Contraindications include:
  - Implanted devices e.g. cardiac pacemakers and other electromagnetic devices
  - Certain metal clips and stimulators
  - Artificial joints and spinal hardware may still have MRI scans
- Patients with artificial joints and spinal hardware, metallic bars and surgery scrolls may still have MRI scans. Because they are fixed and not electromagnetic.
- Nowadays in surgery they use titanium or other materials that are not magnetic.
- If there's a foreign metal body like a bullet or small metal fragments inside the brain, eyes or in some vital locations we cannot do MRI because that metal fragment will move and do more damage to the patient

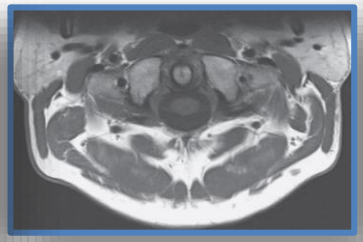
MRI Scanner (Closed Type) magnetic field is all around

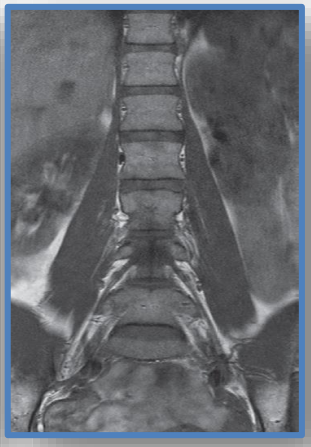
MRI Scanner (Open Type)

- Width of the closed type is much smaller than width of the opened type.
- Why don't we use the open type for claustrophobic people?
  - Because it gives very low quality images compared to the closed type, the magnetic strength is 10 times lower.

MRI Images are multi-planar (axial, coronal, sagittal, oblique planes) we can also do the whole spine it may take 5 minutes more (25 to 30 minutes) you can join the images together to look as a whole body MRI

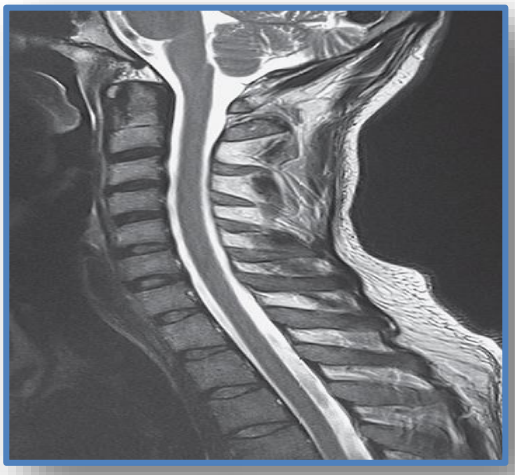


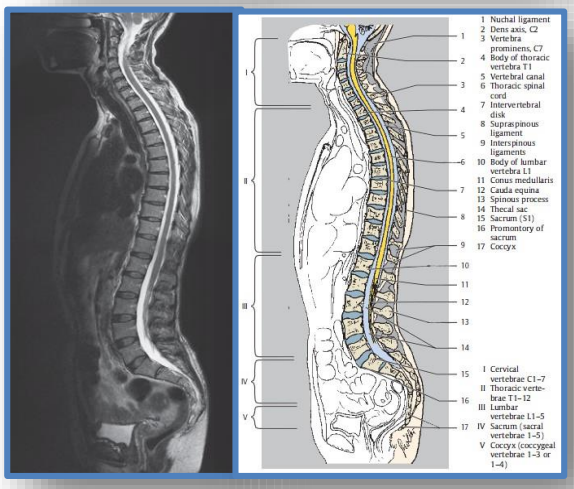




The details of structures are very good, you can see the vertebral body here

MRI Images have very high resolution





The outline and inner details of the cord and CSF

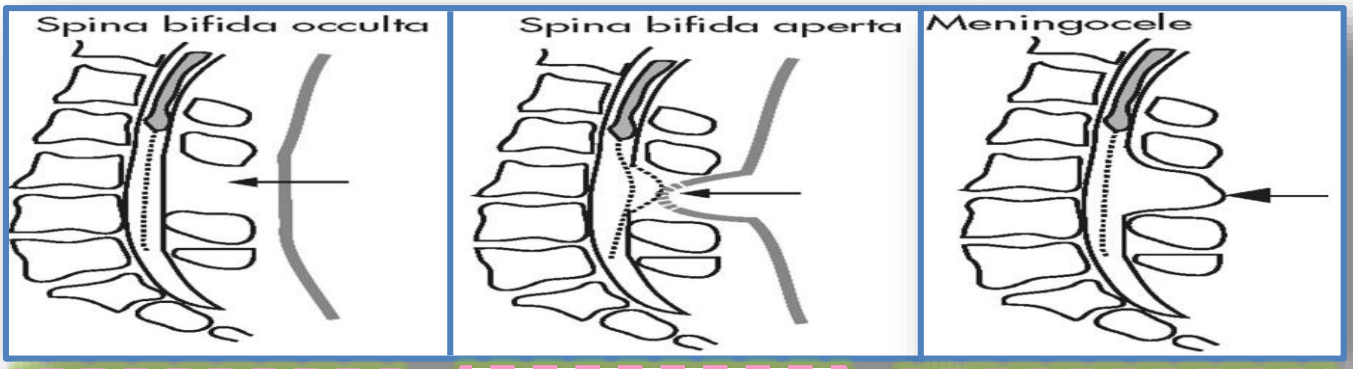
2 Black Arrows:
You can see inside spinal cord such as white matter (dark color) grey matter (grey/little whitish)

Blue Arrow:
You can see the facet joints here like a burger

B: Spine Abnormalities

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
- MRI is the best modality to investigate these abnormalities



The Spina Bifida means overlying skin.

If the overlying skin is intact, very clear, and you don't see abnormality in the skin surface >> then call it spina bifida occulta

Occulta means something hidden

Here there is also skin defect, so call it spina bifida aperta

Aperta means something obvious

Fluid filled thecal sac with meninges and CSF it comes out like a balloon >> called meningocele.

Sometimes even spinal cord comes out >> called meningomylocele.

There is a defect here. The whole thecal sac even spinal cord is protruding. This is meningomylocele.

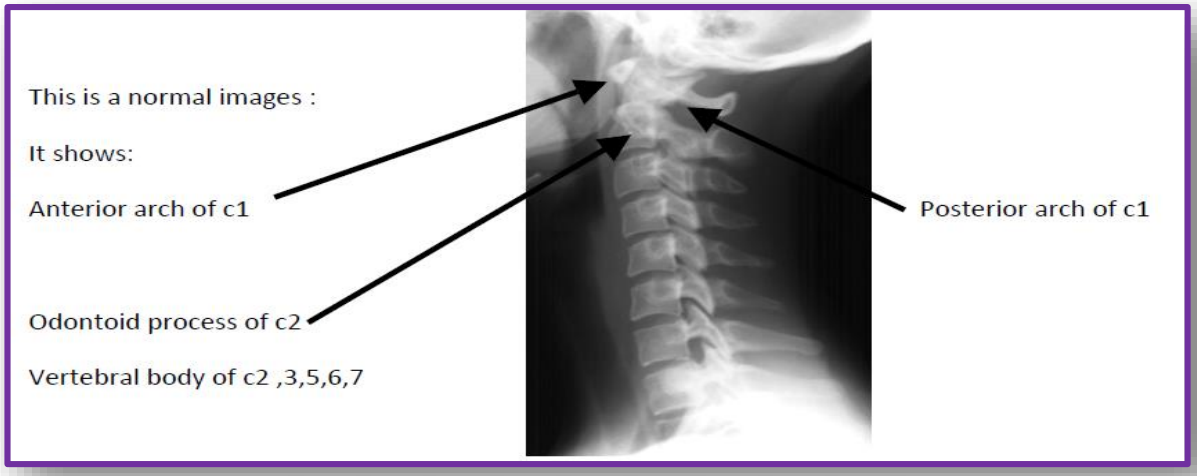
Multiple fusion abnormalities of vertebrae on plain film

- Adjacent vertebral body fused with each other. (*Black arrow:* partial fusion)
- Investigating with plain film is usually enough because surgical intervention is not needed. It'll not be operated on to separate them. This is just screening evaluation.

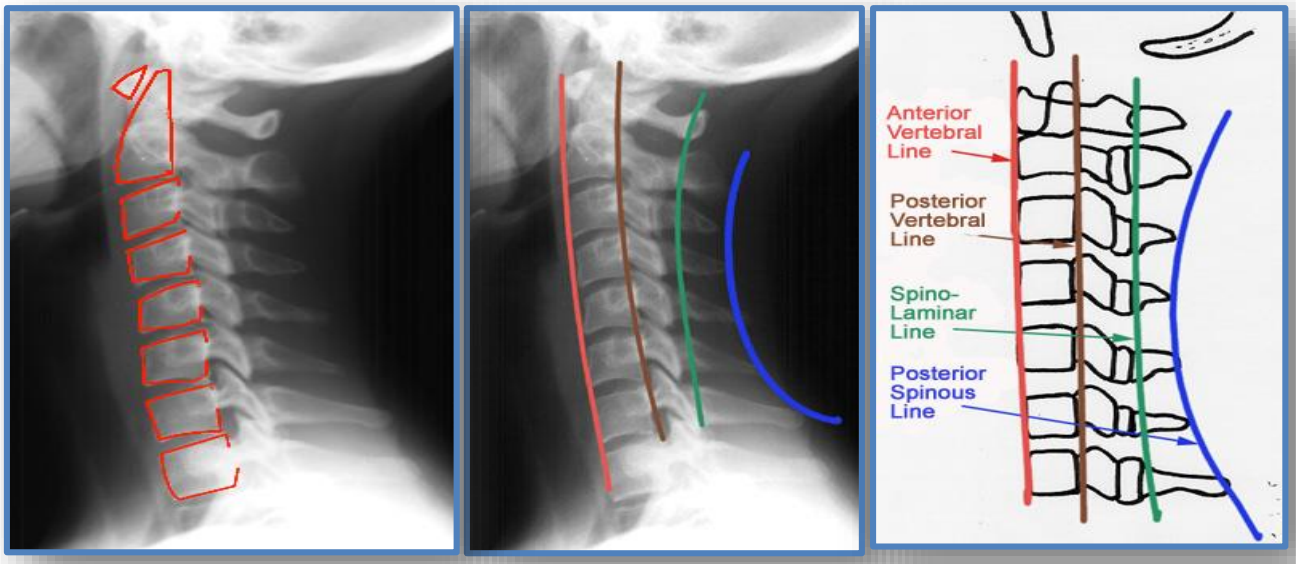
Trauma (very important)

- When assessing trauma the cervical spine injuries are the most crucial because they can cause sudden death.
- WHY? Because it disrupts the innervations to the diaphragm and intercostal muscles (diaphragm gets nerve supply from lower cervical region)
- When a patient comes to the hospital with minor injury to this region, don't move him when doing the X-ray. Instead, put a film under the board where the patient is lying and get an AP image, also put a film in the side and take a lateral view.
- Two views to assess if there are more injuries. We can do farther evaluation later on.

Plain film assessment of trauma the first imaging method



Alignment should be normal - check by drawing lines



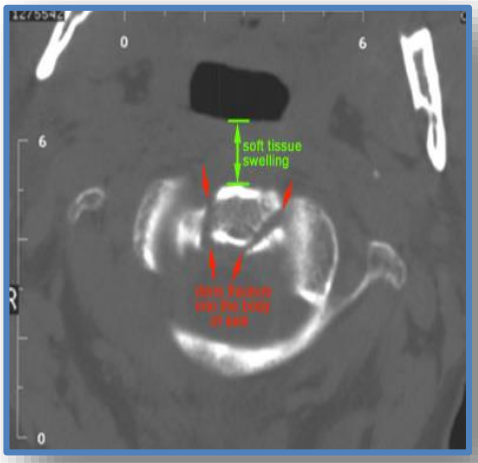
- Draw a line anterior to the vertebral body, 2nd line posterior vertebral, 3rd line over the facet joints and 4th line over the spinous process.
- If these 4 lines are good in alignments that means the patient has no significant injury. Although some minor fractures or dislocation injury might be present.

Air in airway (black) Trachea
There is a space between
Spine and Airway (white)
We call this free vertebral soft tissue space.
So it is **soft tissue** anterior to the spine. In upper part up to the larynx it is less than 4 or 5 mm and in lower part is less than 10 or less than the diameter of the vertebra.

Soft tissue anterior to spine is very important

- In trauma whenever there are bony fractures involving cervical spine or skull base there will be hemorrhage, because bones are very vascular structures, the patient can bleed a large amount of blood.
- In the spine it is not that vascular but the patient can still bleed significantly to cause abnormality in these areas.

CT scan showing the fracture in C2 vertebra. We see the increased space.



If we drew a line here we will not see obvious fractures.

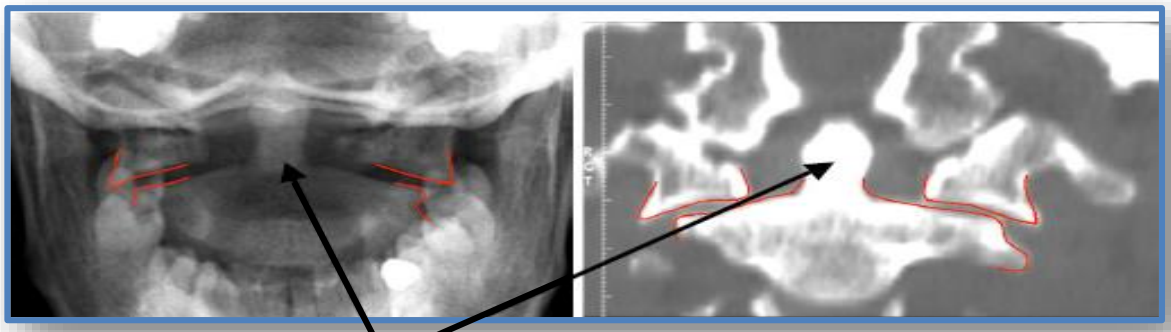
So, this increase in space indicates blood clot.

The space can also increase in tumors and abscess, but here in case of trauma we consider it a hemorrhage.

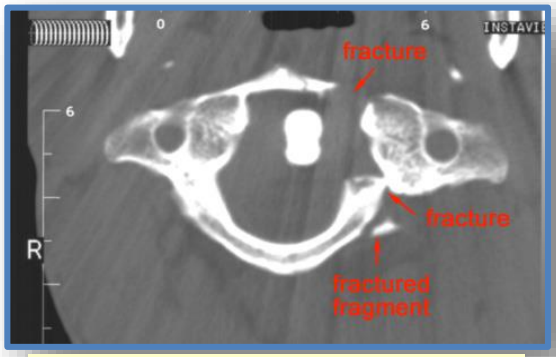
That means this patient needs further imaging.

Jefferson Fracture

- Lateral displacement of C1 in plain film (A)
- Coronal reconstruction from a CT confirms the findings from the odontoid view
- Axial CT clearly shows the location of the fractures of C1



- C2 vertebra with the odontoid process.
- The lateral aspect of C1 (red lines)
- C1 here is sitting on a sloping surface so this not a straight. If something presses on the superior aspects like this it will press laterally because it's a sloping surface. So vertebra C1 is like a ring, it usually breaks down with one side in the anterior and one in posterior.



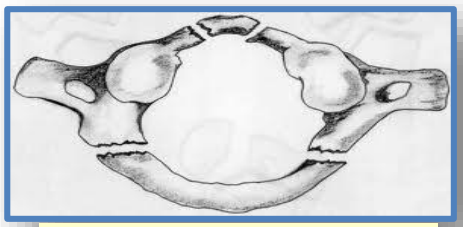
Fracture in the anterior and posterior aspects. This is called **Jefferson Fracture**

Mechanism of trauma: (Axial Loading)

1) Object hitting the head.
   - E.g. when a hard block falls on the head of a worker.
   - Nowadays workers wear helmets, but they are still not fully protected. The helmet will protect the direct head injury, but the ultimate weight will transmit to the whole cervical spine. But if the worker didn'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/diving into a swimming pool with shallow water will cause the head to hit the floor directly.

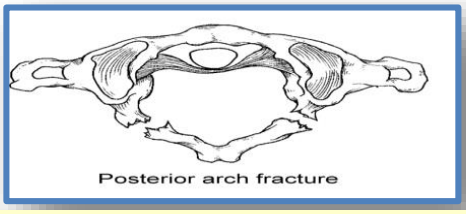
These Images are C1 (Jefferson Fracture)

It can break at 2 sites in anterior and



Or multiple sites like this image

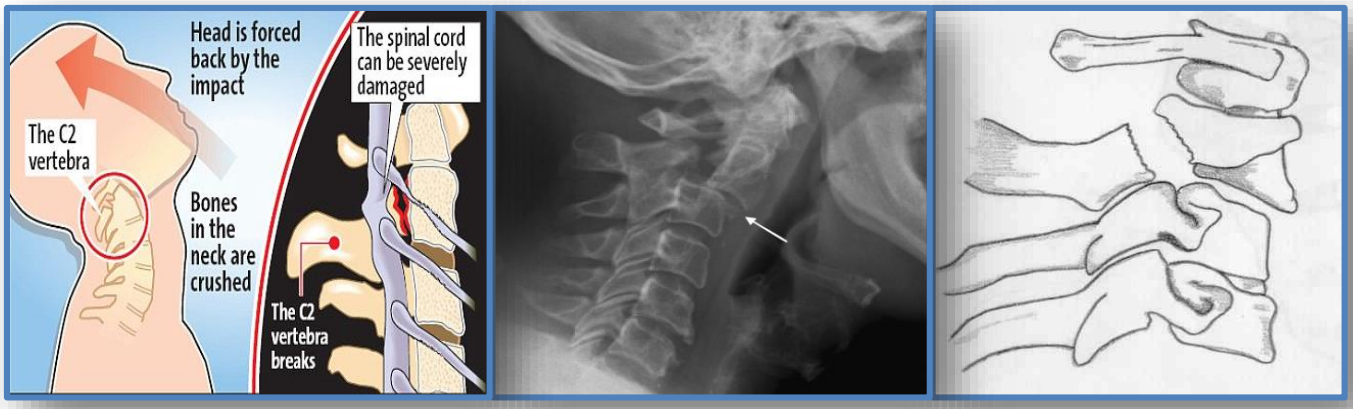
Here 2 anterior and 1 posterior

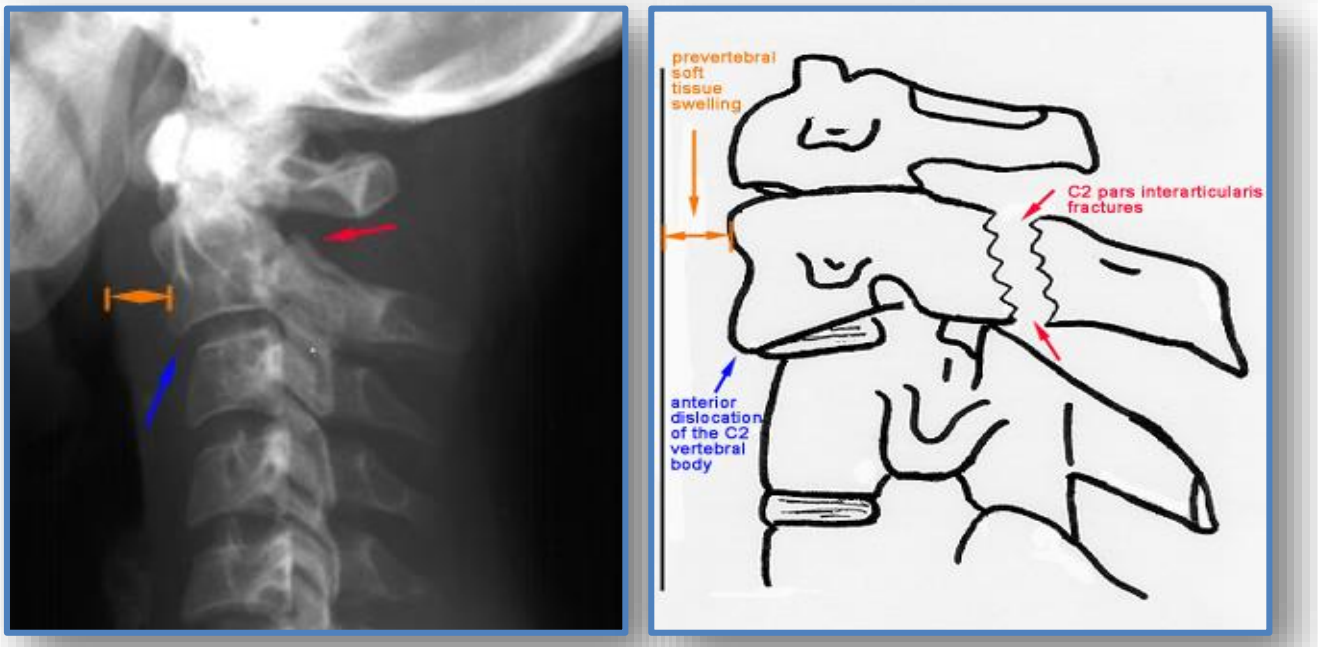


This is NOT Jefferson: it is posterior arch fracture

Hangman's Fracture

- The mechanism is Hyperextension:
- It breaks the posterior parts like intermediate part of C2. This fracture is called Hangman's Fracture.
- This was common when the hanging was a death sentence punishment. Nowadays it often happens due to motor vehicle accidents. If someone is sitting in the front seat with no seat belt and the vehicle crashes or suddenly stops, the person will hit the dashboard and it will cause this hyperextension.





- Fractures through the pars interaticularis of C2 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
    4. Bilateral C2 pars interarticularis fractures (called pars interarticularis because it's between two joints)

Bilateral Facet Dislocation

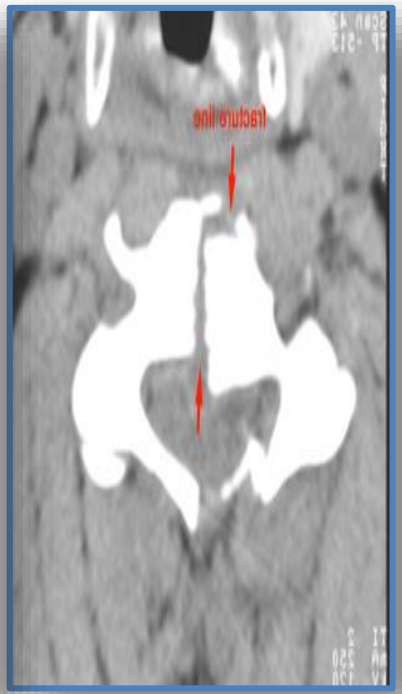
- Complete anterior dislocation of vertebral body resulting from extreme hyper flexion injury
- Associated with a very high risk of cord damage (red arrow)
- (Too much vertebral bodies movement over each other), we call it (hyper flexion compression fracture).
- Usually involves anterior vertebral bodies and becomes like a wedge v-shaped because posterior height is maintained and the anterior is compressed so this height is lost

Unilateral Facet Dislocation

- Facet joint dislocation and rupture of the apophyseal joint ligaments resulting from rotatory injury
- Mechanism: simultaneous flexion and rotation
- There will be very little movement, but still it one vertebral body will be over the other

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



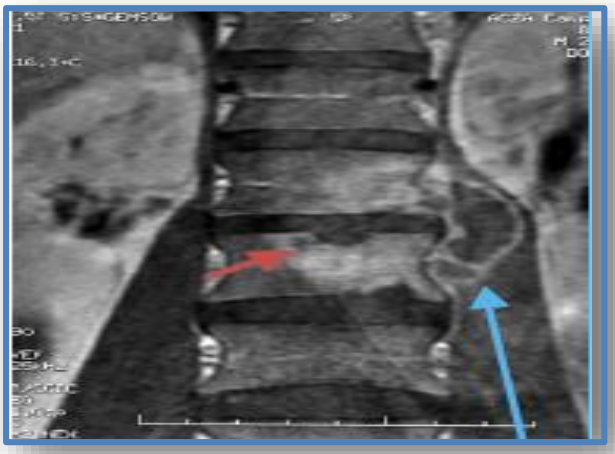
Infections

Discitis and Osteomyelitis

- Usually the result of blood-borne agents
- Especially from lung and urinary tract
- Most common pathogen is staphylococcus
- 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 adjacent vertebral
- In adults, in anterior inferior corner (it can go quickly to adjacent disc then to next vertebra) of vertebral body with spread across disk to adjacent vertebral endplate
- Other causes: surgical, radiological when inserting a needle (lumbar puncture), penetrating objects like knives and bullets.
- **Site of involvement :**
    - L3/4
    - L4/5
    - Unusual above T9
    - Usually involvement of one disk space (occasionally 2)
- **Imaging Findings:**
    - Plain Films
        - 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
    - 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

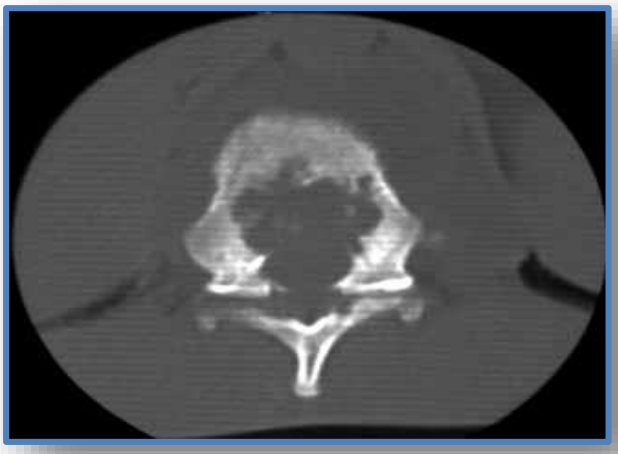
Note:

- Tumors don't cross the disc
- Osteomyelitis >> vertebral bone Discitis >> the disc (Both are usually combined)

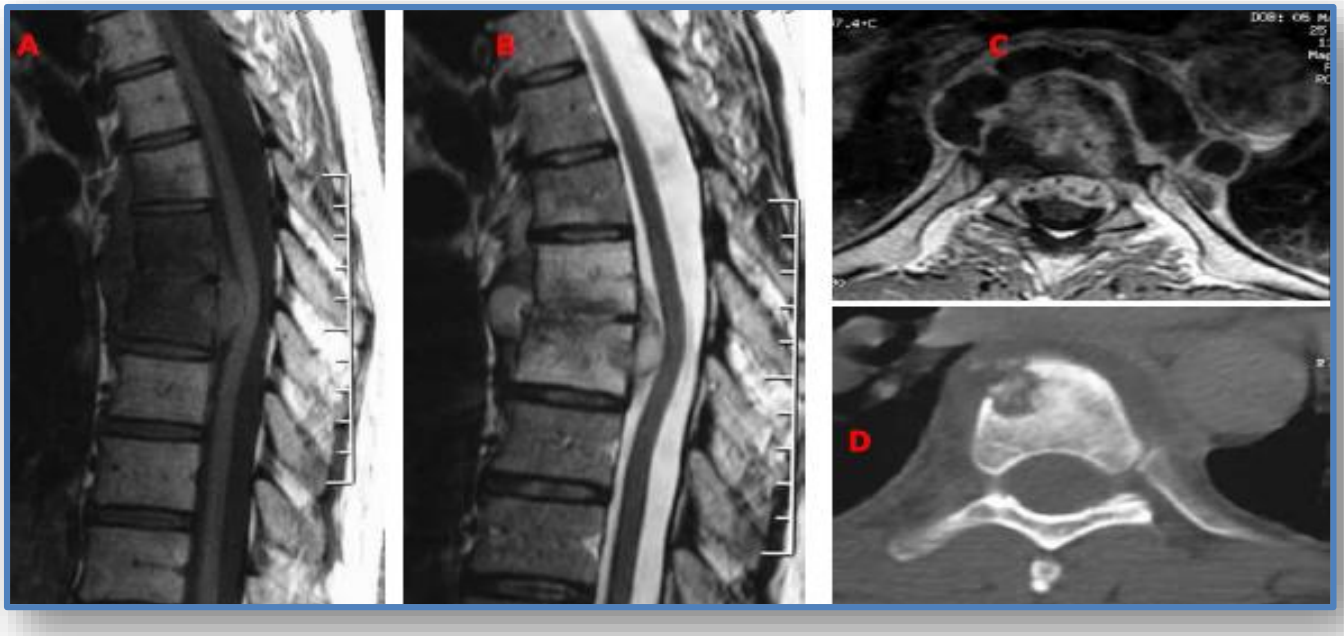


Pus Bucket

Abnormality and irregularity on the vertebral body (red arrow)



Normal Image



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

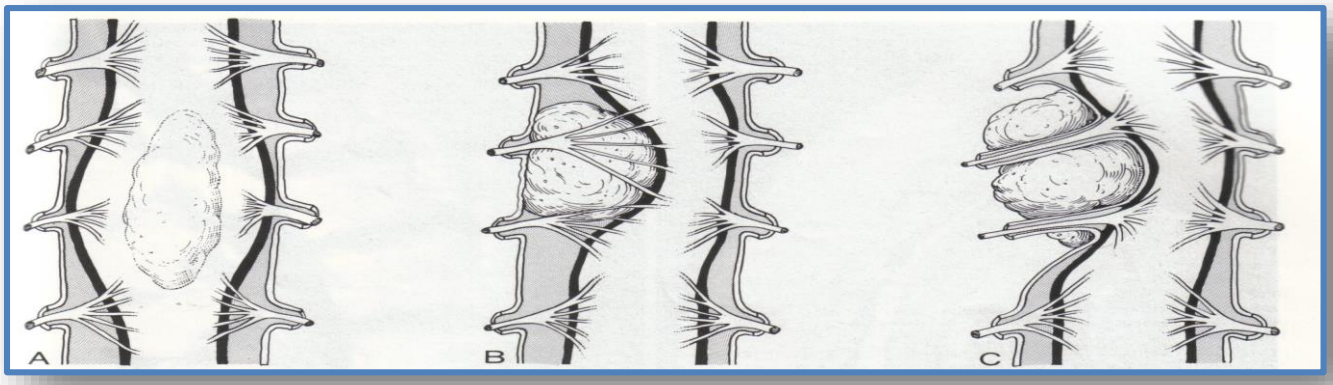
B. Sagittal T2 MRI shows increased signal in corresponding areas with anterior sub-ligamentous abscess (it can go back and cause cord compression), epidural involvement and extension of inflammation in T6 with preserved endplate

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

(Whenever you see 2 vertebral abnormalities with intervening disc abnormality this is much classified for infection and usually there are pus bucket).

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

Tumors



Inside the cord (intramedullary)

Outside cord but still inside the spinal canal (extramedullary intradural)

Outside spinal canal (extradural)

Tumor inside the cord >> the cord will be big and expanded

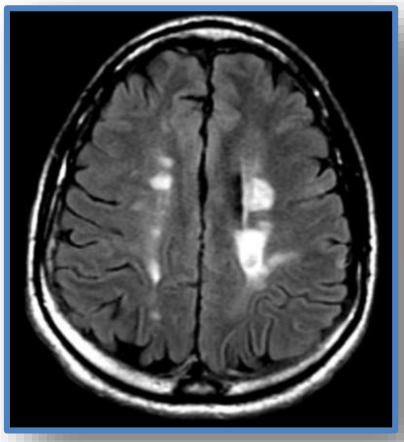
Tumor outside the cord >> the cord will be displaced and thin

Where is this tumor located?

(Extramedullary intradural)

You can see the cord has been displaced and compressed

Here it's from the cord (intramedullary)



Multiple lesions in the brain

This is MS

This is intramedullary but it's not a tumor because the cord size has not changed

SUMMARY

1. Imaging Modalities:
    - X-ray the first diagnostic imaging test
    - Myelogram: injection of contrast medium in CSF (rarely performed, but maybe performed if MRI is contraindicated)
    - CT scan gives detailed information regarding bony and soft tissues, but poor in visualizing inner details of spinal cord
    - MRI: the gold standard of imaging for spinal disorders, but fracture fragments are better seen in CT
    - Discogram: better identifies the relationship of disc to pain
    - X-ray images may be taken in different positions, and this is not possible in CT and MRI
2. Congenital Anomalies
    - overlying skin is intact, very clear, and abnormality is not seen in the skin surface >> Spina Bifida occulta
    - there is skin defect >> Spina bifida aperta
    - Fluid filled thecal sac with meninges and CSF, it comes out like a balloon >> meningocele
    - if even spinal cord comes out >> meningomyelocele
3. Trauma
    - Plain film assessment of trauma – the first imaging method
    - Alignment should be normal – check by drawing lines
    - Soft tissue anterior to spine is very important
    - Jefferson Fracture: Lateral displacement of C1
        - Object hitting the head
        - Head hitting a surface or object
    - Hangman's Fracture:
        - Fractures through the pars interaticularis of C2 resulting of hyperextension and distraction
        - radiologic features best seen on lateral view
4. Infections (Discitis & Osteomyelitis)
    - usually results from blood-borne agents
    - Children > begins in vascularized disc adjacent vertebral
    - Adults > in anterior inferior corner
5. Tumors
    - Intramedullary > inside the cord
    - Extramedullary Intradural > outside cord but still inside spinal canal
    - Extradural > outside spinal canal

Questions

1) A 48 years old male patient comes to orthopedic department complaining of back pain radiating to right leg. What is the BEST imaging method to evaluate him ?
   a. Plain Films
   b. CT scan with intravenous contrast
   c. Myelogram
   d. MRI

2) 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

A good website for extra images: http://www.radiologymasterclass.co.uk/index.html

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Answers:

1st Questions: D

2nd Questions: A