431

Radiology Team

Leader: Lama AlShwairikh

Sub-leader: AbdulazizAlmutair

Lecture 9: Radiology of Spine Diseases

Done By: Randa Bin Madhi

Revised By: Lama AlShwairikh

◆Important ◆Doctor's notes ◆Team's notes

We thank 430 Team for their helpful notes

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 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 US 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 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.

It 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 farther evaluation with CT scan or MRI.
- If there are no abnormal findings on x-ray but the patient has significant symptoms we need farther investigations. So it's not a very sensitive method as it can miss many findings.

X-ray image 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 film.
- Entire spine can be imaged within a few minutes.
- A contrast material may be injected intravenously (more often) or intrathecally to make some areas clear.

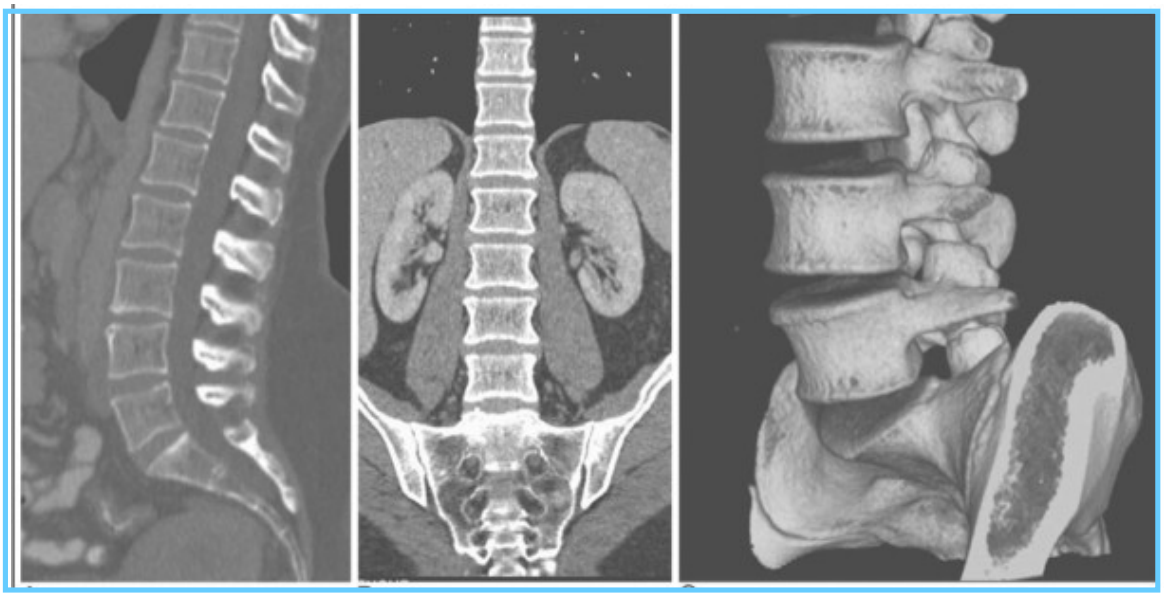
Better in visualizing:

- 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.

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



Sagittal images **coronal images** **3D images**

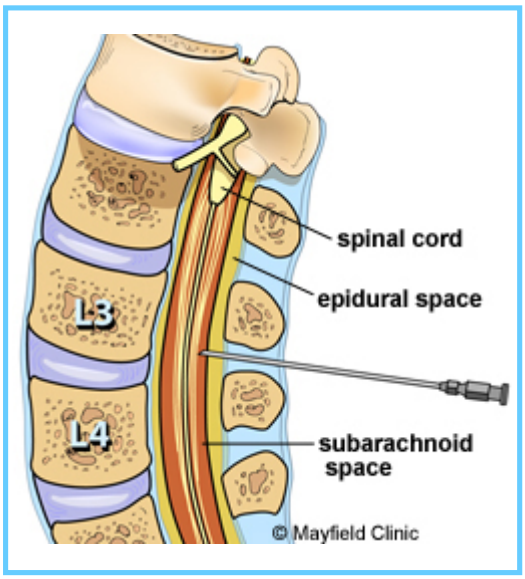
3D images are very good qualities, on computer you can rotate these images and give much better information regarding fractures, tumor areas or other abnormalities

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 is plain film .we call it 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.

Magnetic Resonance Imaging (MRI)

- The gold standard of imaging for spinal disorders.
- Does not use ionizing radiation (its magnetic based)
- Can identify abnormalities of bone, discs, muscles, ligaments and spinal cord (much better and 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 (it can be done in 15 -20 minutes)
- Claustrophobic patients may need sedation, and children often need general anesthesia (because they cannot follow the instructions very well)
- MRI is considered it as a gold standard of imaging for spine, but fractures fragments are better seen in CT. So when we have a trauma patient we usually we do both CT and MRI 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.

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)

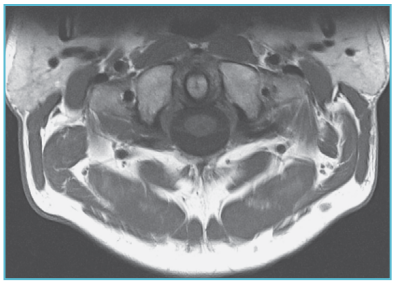
- Width of the closed type is much smaller than width of the opened type.

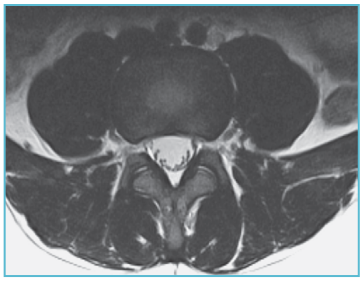
- Why don't we use the open type for claustrophobic people?

Because it gives very low quality images compared to the closed type, the magnetic strength is 10 times lower.

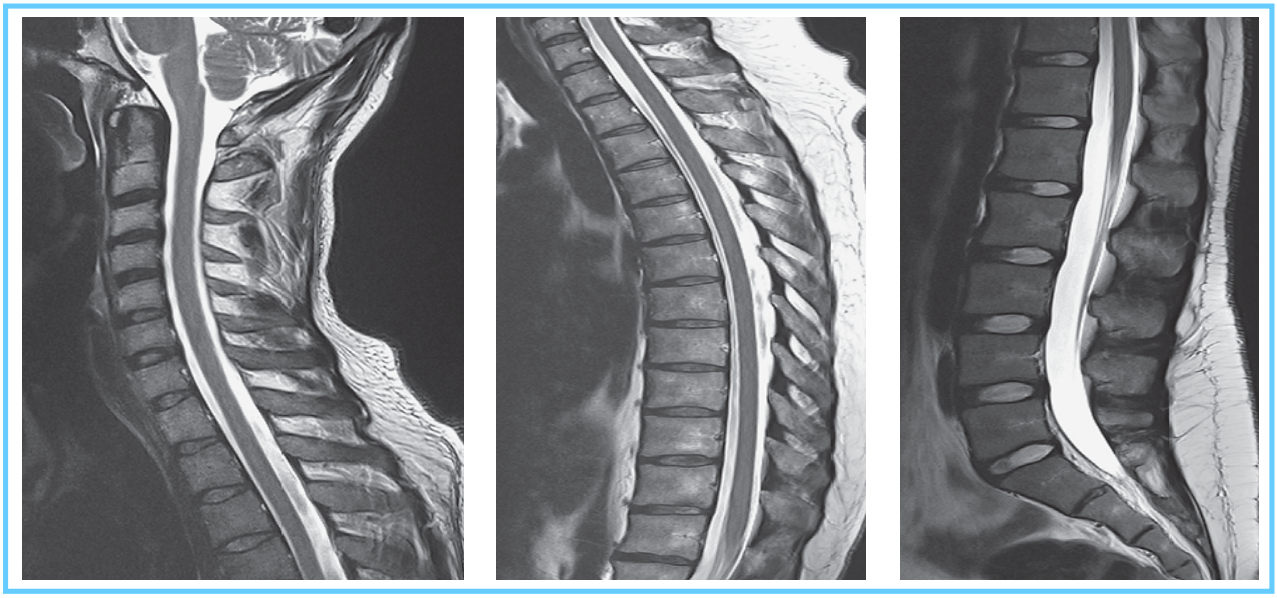
MR images are multi-planar (axial, coronal, sagittal, oblique planes) we can also do the whole spine it may take 5 minutes more (25 or 30 minutes) you can join the images together to look as a whole body MRI

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

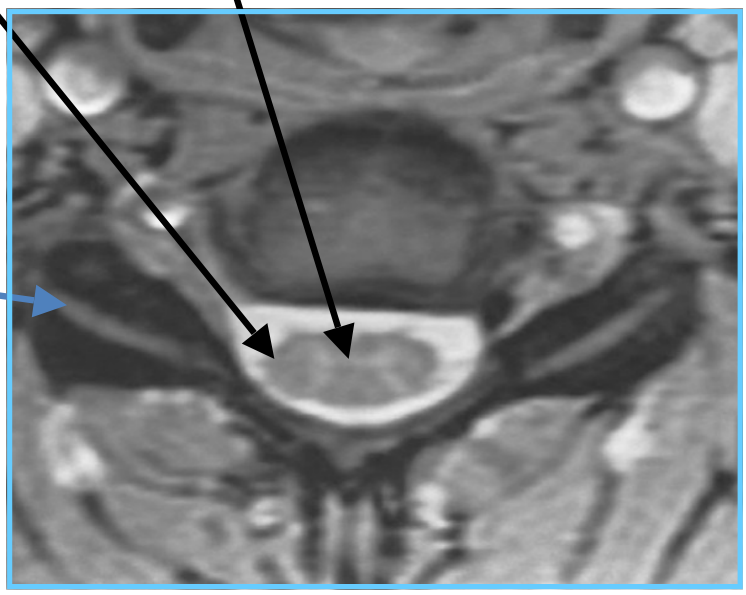




MR images have very high resolution



you can see inside spinal cord such as white matter (dark color)gray matter (gray/little whitish)



You can see the **facet joints** here

like a burger.

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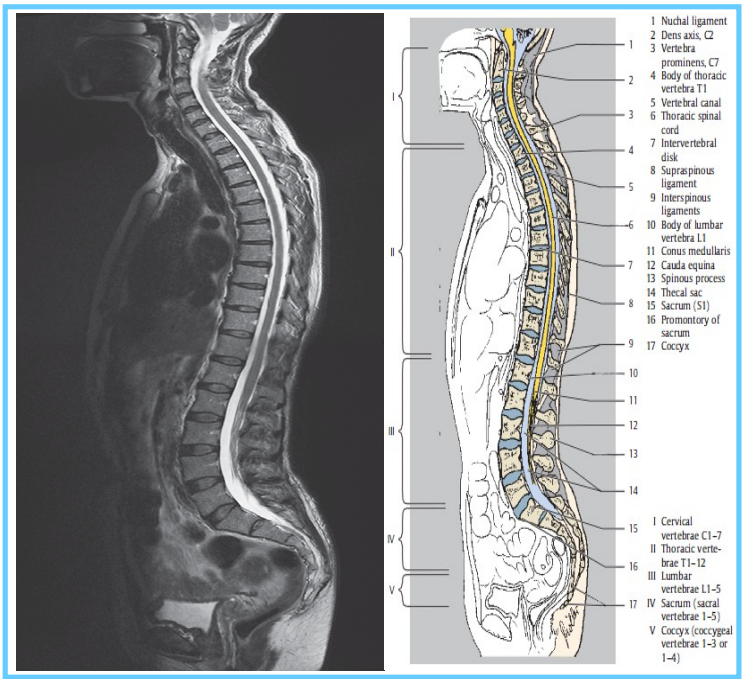


The outline and inner details of the cord and CSF.

DISCOGRAM

The doctor said he will not discuss this because it's not done nowadays (many patients refuse this procedure because it produce pain and we cannot give anesthesia).

Discs are the cushions between the vertebral bodies

While MRI and CT scans can provide structural information, discogram better identifies the relationship of disc to pain

PROCEDURE:

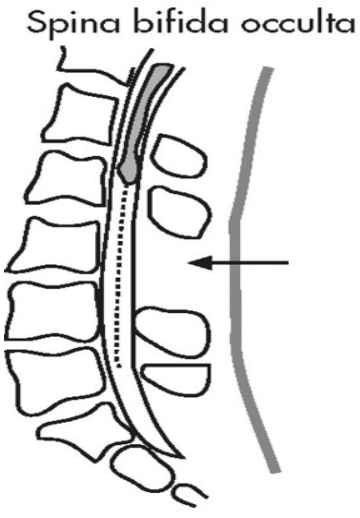
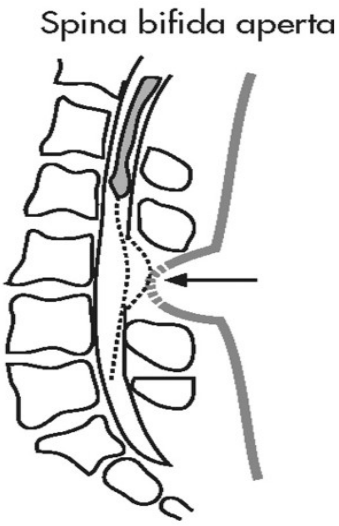
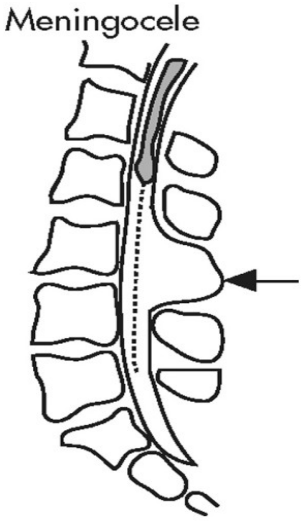
fluoroscopy (continuous x-ray imaging) A needle is A needle is placed into center of the disc under (placed into center of the disc under fluoroscopy (continuous x-ray imaging

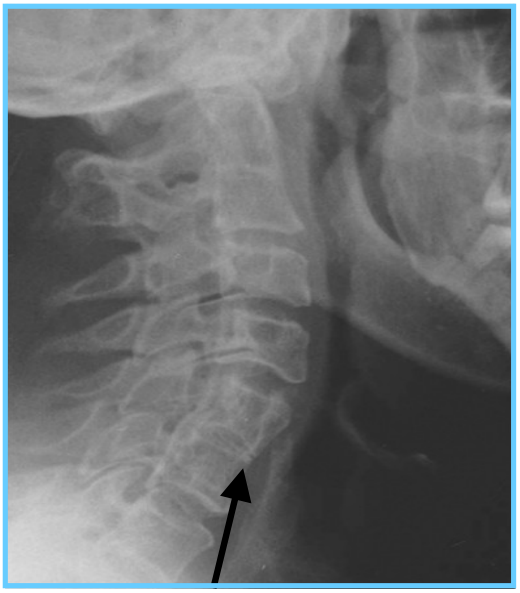
A contrast material (dye) is injected. Radiologist then observes if patient experiences pain that is similar to his/her usual pain, and is increased by injecting contrast. X-rays (+ CT scan) are then done to see if dye stays within the center of the disc or leaks to outer border of the disc indicating a tear in annulus .fibrous of disc which can be a source of pain.

B: Spine Abnormalities

1) Congenital Anomalies

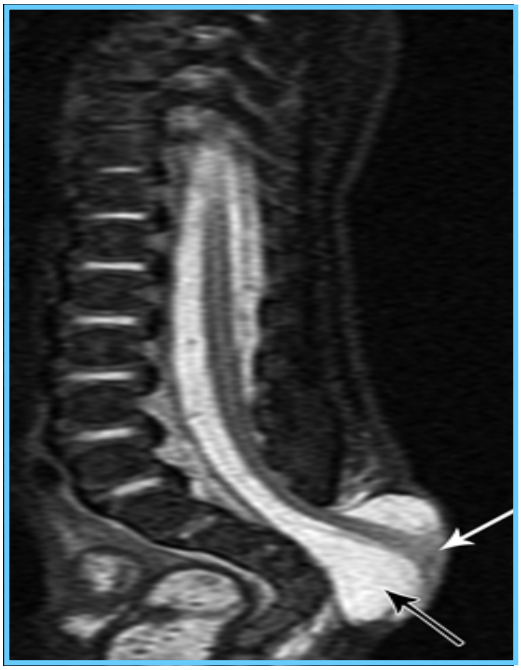
- Skin covered defects and Open skin defects
- MRI is the best to assess the contents of the cavity, extent of abnormalities, and spinal cord.
- MRI is the best modality to investigate these abnormalities.

		
Spina Bifida means overlying skin If the overlying skin is intact, very clear and you don't see abnormality in the skin surface → call it spina bifida occulta (occulta means something hidden).	Here there is also skin defect → call it spina bifida aperta (aperta means something obvious)	Fluid filled thecal sac with meninges and CSF it comes out like a balloon → call it meningocele. Sometimes even spinal cord comes out → call it 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.



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

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2) 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

This is a normal images :

It shows:

Anterior arch of c1

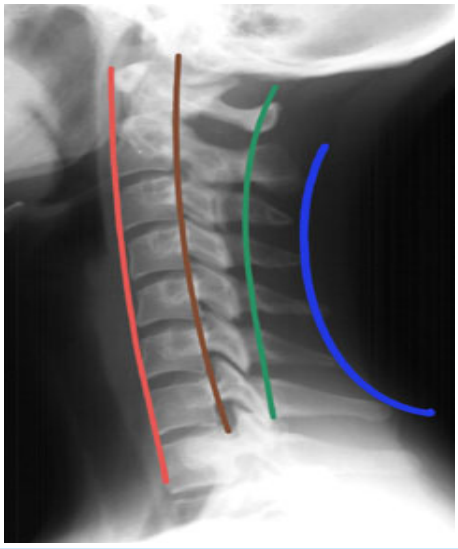
Odontoid process of c2

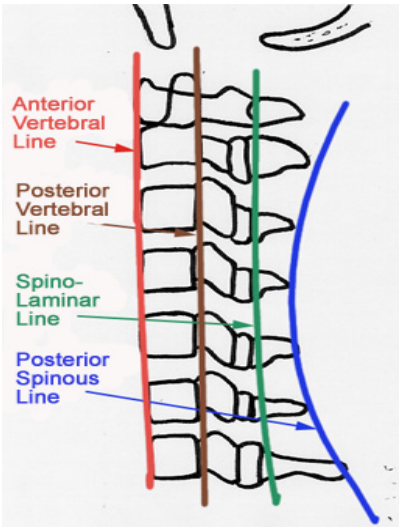
Vertebral body of c2 ,3,5,6,7

Posterior arch of c1

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)

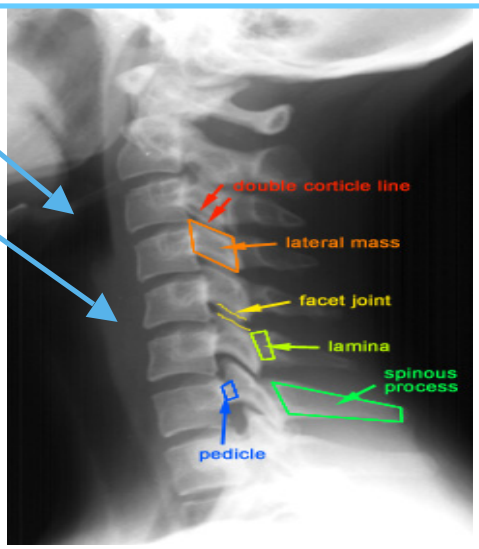
We call this free vertebral

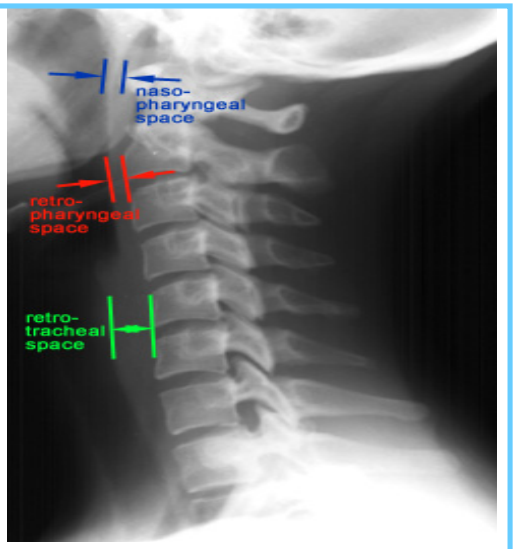
soft tissue space. So it **is soft tissue** anterior to the spine.

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.



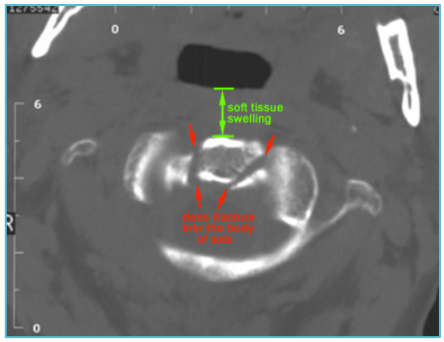


Soft tissue anterior to spine is very important

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 area.

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.



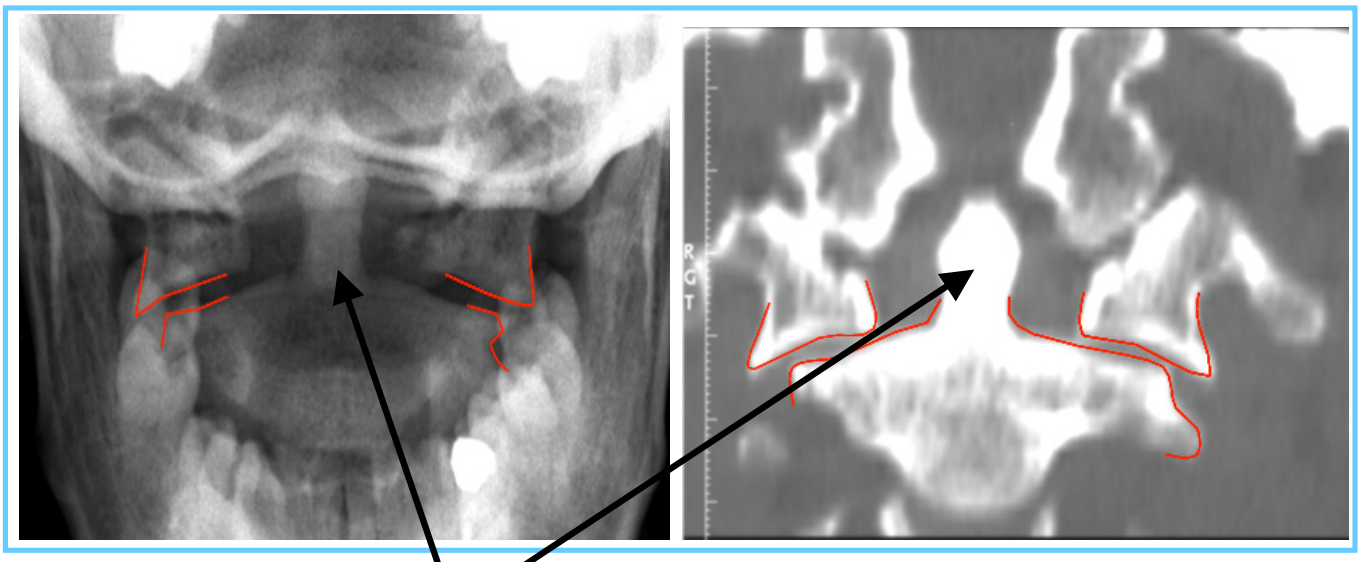
CT scan showing the fracture in C2 vertebra. We see the increased space.

Jefferson Fracture

Lateral displacement of C1 in plain film (A)

Coronal reconstruction from a CT confirms the findings from the odontoid view

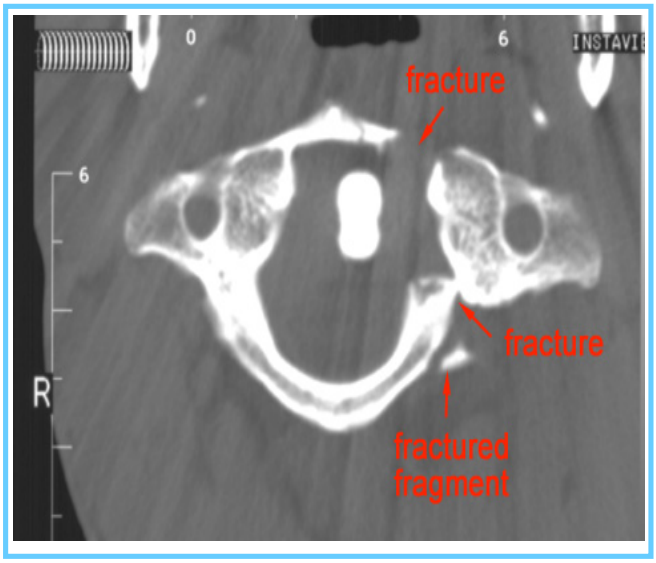
Axial CT clearly shows the location of the fractures of C1



C2 vertebra with the odontoid process.

The lateral aspect of C1(red lines)

C1 1 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:

1- Object hitting the head.

E.g. When a hard block falls on the head of a worker.

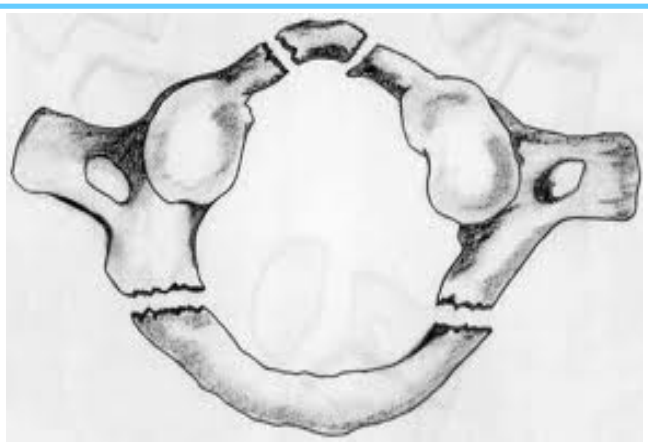
Nowadays workers wear helmets, but they are still not fully protected. The helmet will protect the direct head injury, but the ultimate weight will transmit to the whole cervical spine.

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.

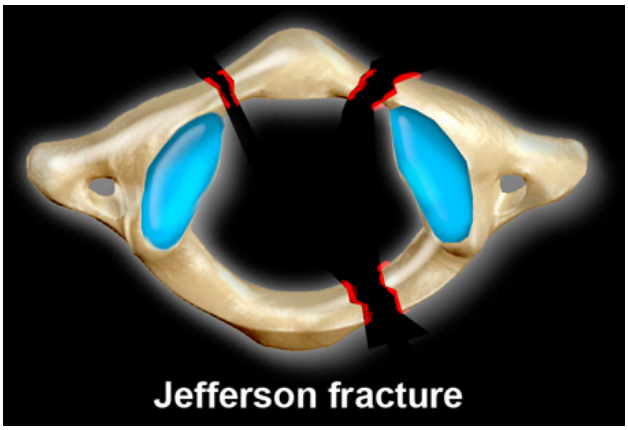
E.g. Jumping/diving into a swimming pool with shallow water will cause the head to hit the floor directly.

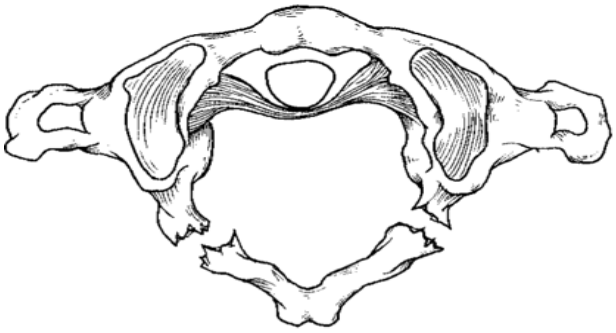
These images are C1 **(Jefferson Fracture)**



It can break at two site in anterior and posterior

or multiple site like this image

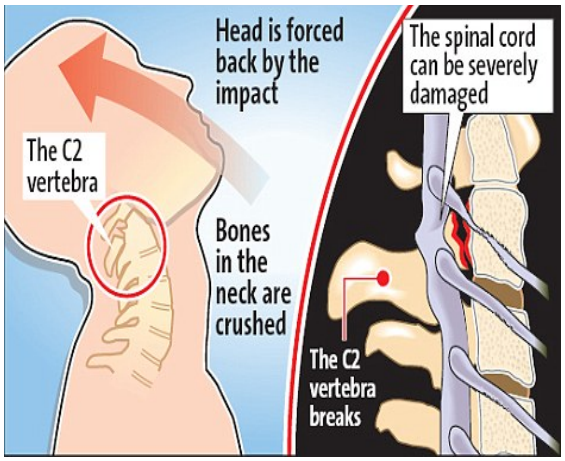


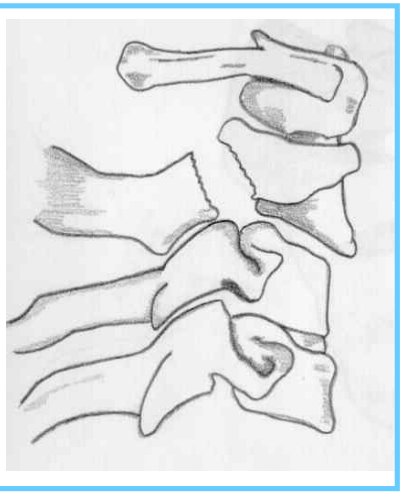


Here 2 anterior and one posterior

this is not **Jefferson. It's a** posterior arch fracture

Hangman's Fracture:





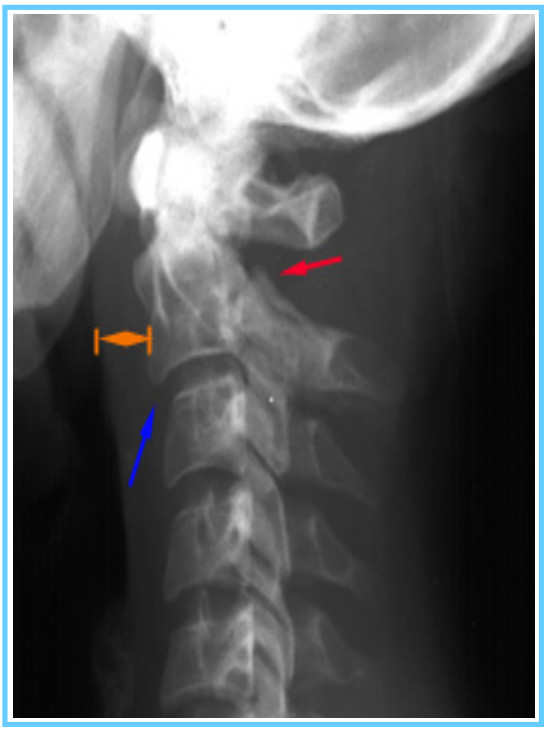
The mechanism is Hyperextension:

*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.

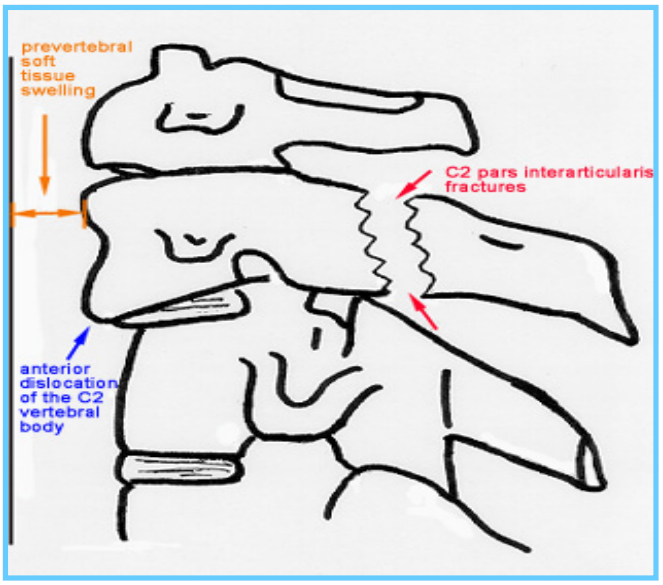
Fractures through the pars interaticularis of C2 resulting from hyperextension and distraction

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.

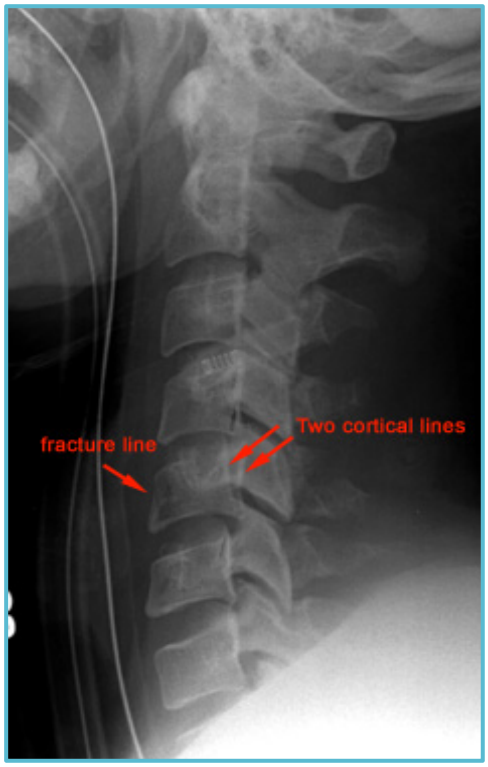
There will be very little movement, but still it one vertebral body will be over the other

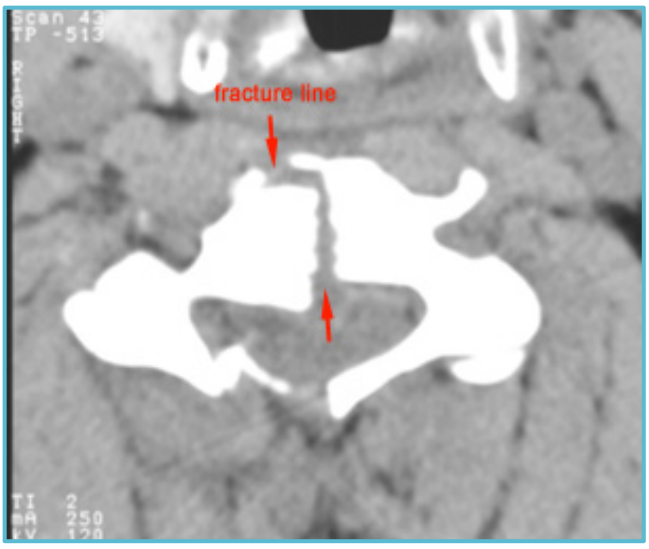
Burst Fracture

- Results from axial compression.

- Injury to spinal cord is common due to displacement of posterior fragments.

- CT is required for all patients to evaluate extent of injury.





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3) INFECTIONS

Discitis and Osteomyelitis

*Usually the result of **blood–borne** agents especially from lung 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 the 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 endplate.

*Other causes: surgical, radiological when inserting a needle (lumbar puncture), penetrating objects like knived and bullets.

Site of involvement:

L3/4*

L4/5*

Unusual above T9*

Usually involvement of one disk space (occasionally 2) *

Note :
Tumors don't cross the disc.

Things that doctor mentioned in infection:
- Osteomyelitis >> vertebral bone.
- Discitis >> the disc.
  Both are usually combined
- The causes: blood borne, post surgery, lumber puncture, penetrating objects

IMAGING FINDINGS (wasn't mentioned by the doctor)

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)

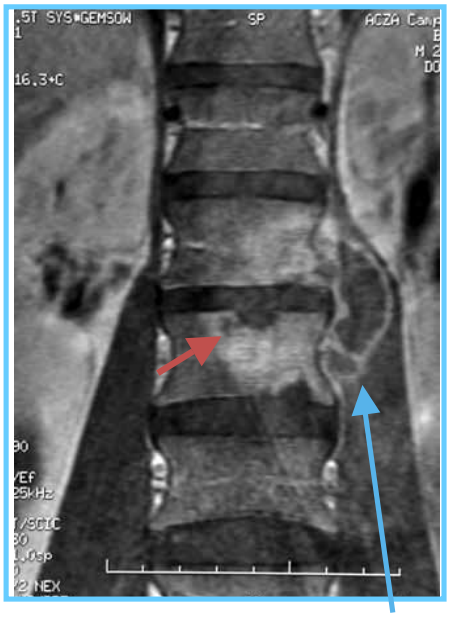
Bone fusion after 6 months to 2 years

MRI

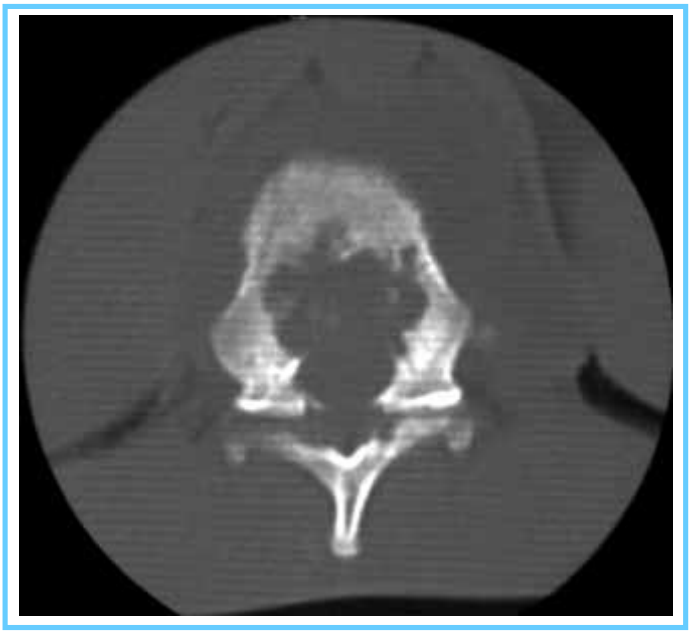
Bone marrow edema in infected vertebrae, discs and paraspinal soft tissues.

Dark on T1 and bright on T2 images

Enhancement of inflammed tissues after contrast Fluid collections (abscesses) are common.



Pus bucket



normal image.

abnormality and irregularity on the vertebral body (red arrow)

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 subligamentous ,

Abscess(it can go back and cause cord compression), epidural involvement and extension of inflammation in T6 with preserved endplate.

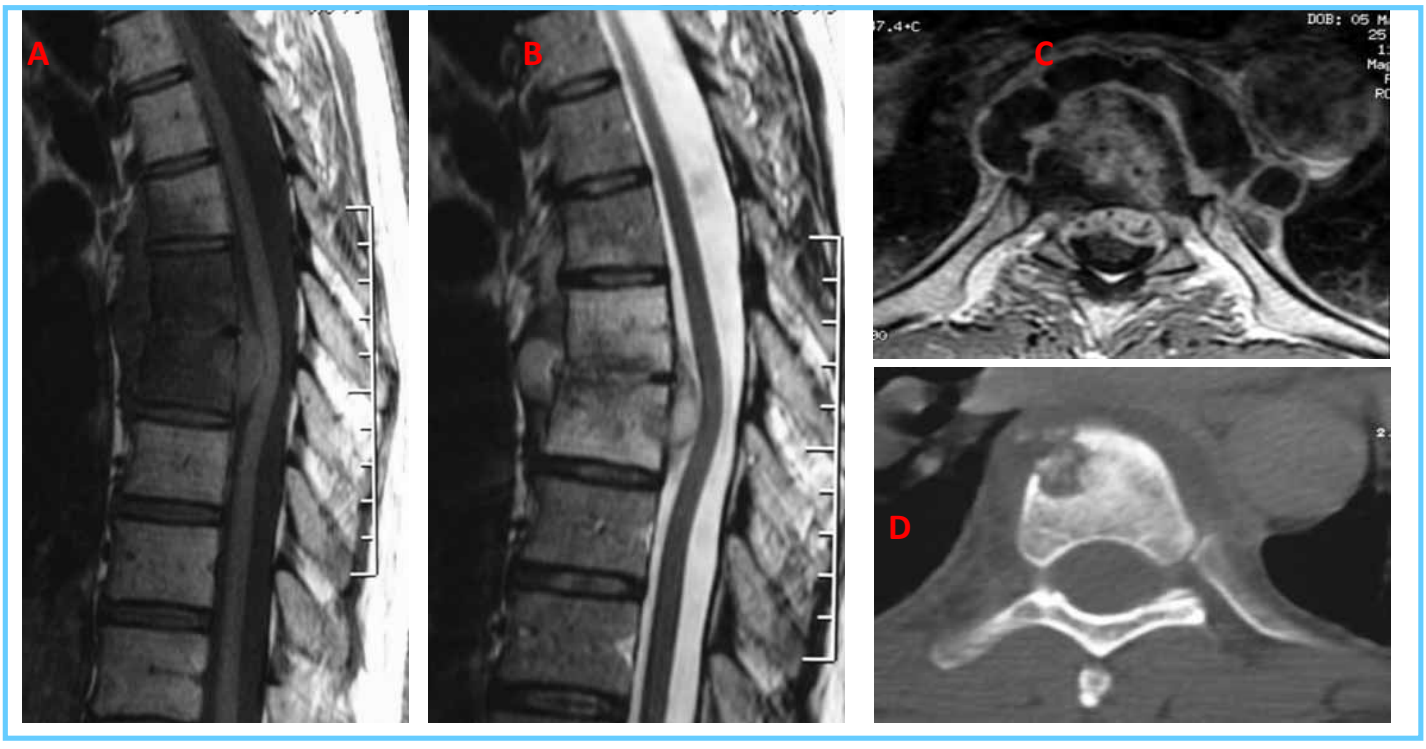
C. Axial contrast-enhanced T1 MRI shows peripheral enhancement of paravertebral abscess and

marked enhancement of epidural tissues causing displacement of spinal cord.

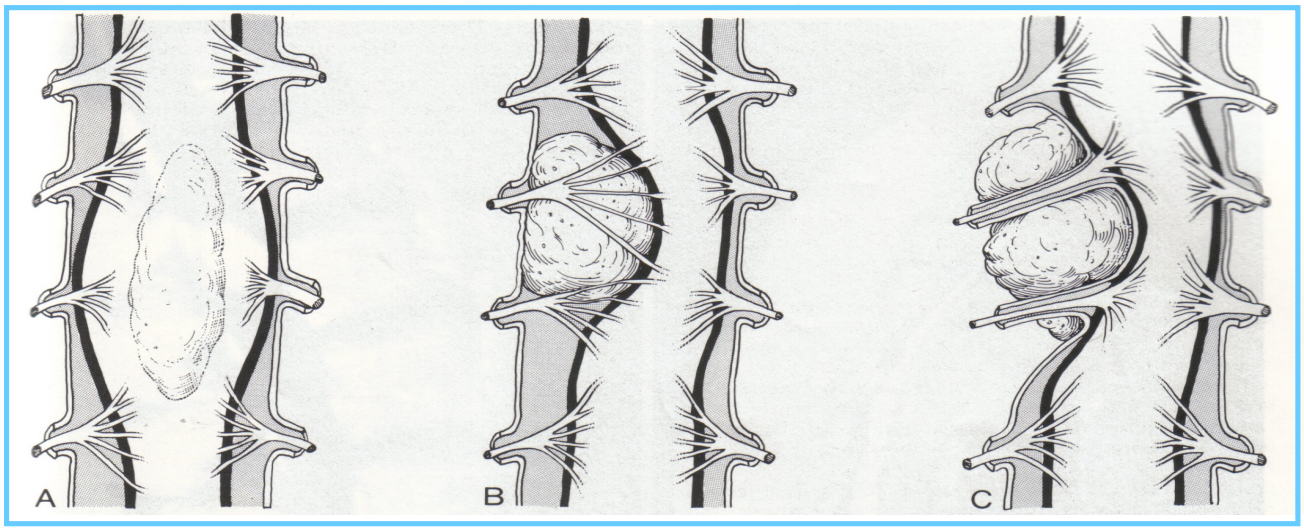
Whenever you see 2 vertebral abnormality with intervining disc abnormality this is very classified for infecton

And usually there are pus bucket .

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



4) TUMORS



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

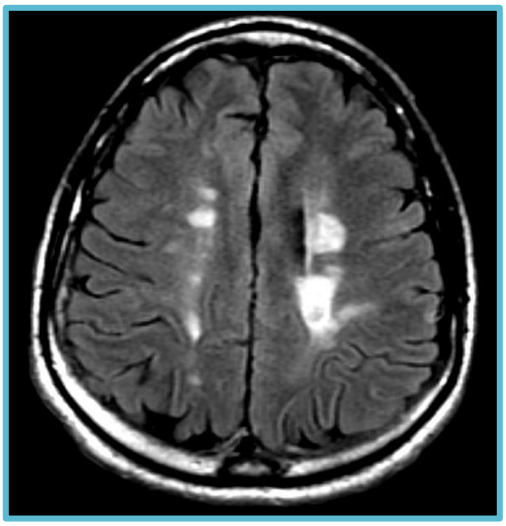
Tumor inside the cord >> the cord will be big and expanded.

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)

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



Multiple lesions in the brain
This is MS

Summary

X-RAYS the first diagnostic imaging test.
(CT SCAN) gives detailed information regarding bony and soft tissues but Poor in visualizing inner details of spinal cord.
MYELOGRAM: material is injected into CSF to better identify areas where spinal cord or spinal nerves may be compressed, most often between L3 and L4 vertebral bodies.
(MRI) The gold standard of imaging for spinal disorders Can identify abnormalities (much better and clear details) of bone, discs, muscles, ligaments and spinal cord, But there are certain contraindication for MRI.

- **Congenital Anomalies**: MRI is the best modality to investigate these abnormality
- **TRAUMA** (VERY IMPORTANT) Plain film assessment of trauma – the first imaging method

Alignment should be normal – check by drawing - Soft tissue anterior to spine is very important.

a. **Jefferson Fracture ; Lateral displacement of C1:**

1- Something hitting on the head ,like workers in the buildings who work downstairs and something falls in their head
2- head hitting something like falling upside down or in swimming pool.

b. **Hangman's Fracture** :Fractures through the pars interaticularis of C2 resulting from hyperextension and distraction.
c. **Bilateral Facet Dislocation**:(too much vertebral bodies movement over each other) Unilateral Facet Dislocation (there will be very little movement ,still it will be one vertebral body over the others)
d. **Burst fracture:** Results from axial compression.

- **INFECTIONS**: Discitis and Osteomyelitis Usually the result of blood–borne agents, (usually the lumbar spine and sometime lower thoracic.
- **TUMORS** ((intramedullary), (extramedullary intradural), (extradural).

MCQ

1-What is the etiology of Hangman's fracture:

a- Collapsed vertebral body.

b- Fracture of pars pars interarticularis.

c- Disc prolapsed of C3.

d- TB of spine.

e- None of the above.

2-All of the following modalities can be employed to detect lesions in the spine, **except:**

a- CT scan.

b- MRI.

c- Ultrasound.

d- Plain film.

e- Radio nuclide scan.

3-All are true regarding collapse of vertebral bodies, **except:**

a- It's best appreciated on a lateral plain film of the spine.

b- It may be cause by trauma.

c- It's important to check if the pedicles are damaged.

d- It may be associated with disc space narrowing.

e- The most common cause is infection.

4-Plain X-Ray of skull is useful in all the following except:

a-Trauma.

b-metastasis .

c-congenital abnormality (microcephaly).

d-white matter disease.

e-metabolic disorder.

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

Answers: 1b - 2c - 3e - 4d

Thank you and good luck