


1

**Recommendations:** 


- Download the course handouts
- Follow along and make notes on the handouts
- Take your time – you have 10 weeks
- View the units several times (you can go back multiple times)
- Let us know if we have made any mistakes (we are not quite perfect yet)
- Take Medical Imaging Foundations

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## Medical Imaging for the Spine

1. Cervical 1
2. Cervical 2
3. Thoracic
4. Cranium
5. Lumbar 1
6. Lumbar 2
7. Lumbar 3
8. Pelvis
9. Practice integration 1
10. Practice integration 2



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## Program goals

- What you will get:
  - Identify the commonly used imaging views of the musculoskeletal system
  - Understand the fundamental process of image interpretation and practice these skills
  - Know and apply published **utilization** guidelines for medical imaging
  - Appreciate the **utility** of various medical imaging studies
  - Integrate imaging results into your existing practice

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## Program goals



- **What you won't get:**
  - The skills needed to interpret medical diagnostic images independently
  - The right to order medical imaging (unless allowed by Provincial legislation & Regulatory College)

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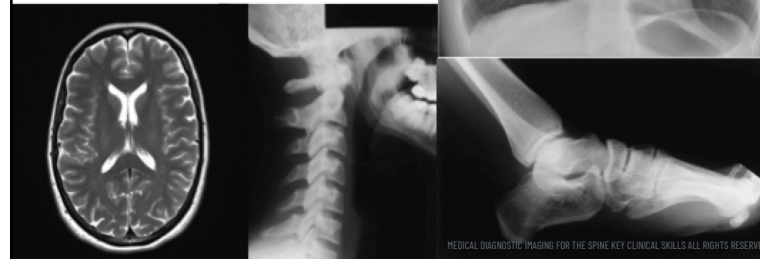
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## Medical Imaging for the spine



### Unit 1

#### Cervical spine 1



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## Radiographic Evaluation – Cervical Spine



### Standard views

- Antero-posterior
- Lateral
- Open mouth odontoid

### Extended views

- Oblique
- Flexion-extension views
- Swimmer's view

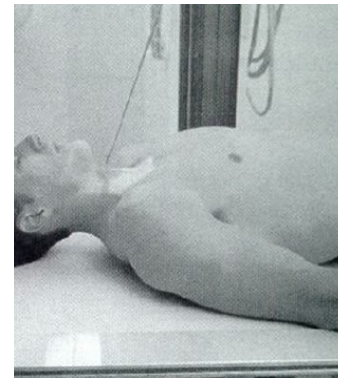
### Advanced Imaging

- CT Scan
- MRI
- Fluoroscopy
- Video fluoroscopy

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## Cervical Antero-Postero (A-P)

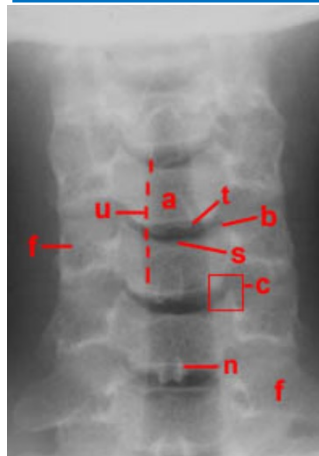


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## What does the A-P show us?



<b>a</b>	vertebral body
<b>b</b>	uncinate process
<b>c</b>	uncovertebral joint
<b>u</b>	tracheal wall
<b>s</b>	superior end-plate
<b>n</b>	spinous process
<b>t</b>	inferior end-plate
<b>f</b>	articular mass (lateral column)

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## What does the A-P show us?




- The height of the cervical vertebral bodies should be equal
- The height of each joint space should be equal
- Spinous processes should be in midline and aligned


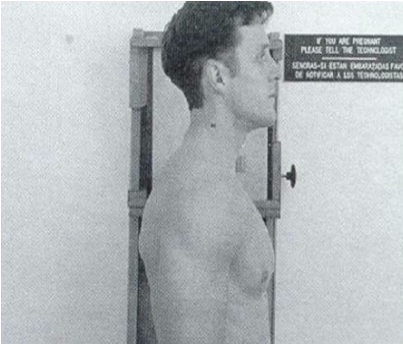


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## Cervical Lateral




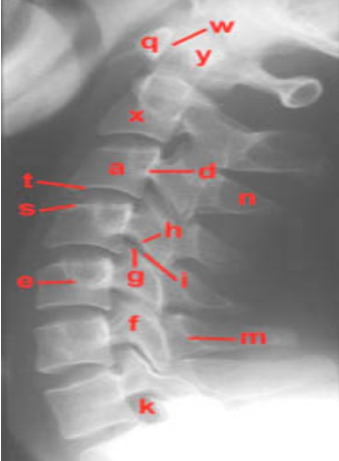



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## What does a lateral show us?



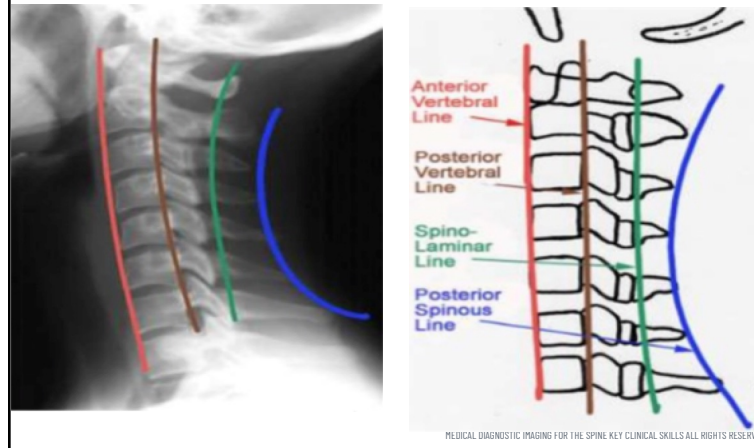


<b>a</b>	body
<b>t</b>	inferior end plate
<b>s</b>	superior end plate
<b>v</b>	disk space
<b>e</b>	transverse process
<b>q</b>	anterior arch, C1
<b>y</b>	dens
<b>w</b>	anterior atlanto-odontoid interval
<b>x</b>	axis vertebra, C2
<b>d</b>	pedicle
<b>n</b>	spinous process
<b>h</b>	inferior facet
<b>i</b>	interfacetal joint
<b>g</b>	superior facet
<b>f</b>	articular mass
<b>m</b>	spinolaminar line
<b>k</b>	intervertebral foramen

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## Spinal Lines

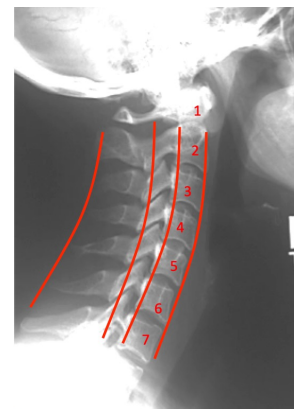


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## What should be visible?



- All 7 vertebral bodies and C7-T1 joint space should be seen
- Count the vertebrae
- Alignment on AP and lateral views
  - Ant. Spinal Line
  - Post. Spinal Line
  - Spino- laminal line
  - Spinous process line



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## Lateral View Measurements

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### Pre-vertebral soft tissue

- C1-naso-pharyngeal space < 10mm
- C2-C4 retro-pharyngeal space < 5-7mm
- C5-C7 retro-tracheal space < 14mm children < 22mm adults




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## Atlantodental Interval

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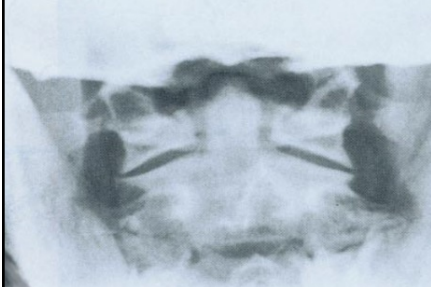

- On the lateral view, measure the distance between the:
  - posterior margin of the anterior tubercle and
  - the anterior surface of the odontoid.
- The space should be no more than 3mm.
- If the distance is more than 3mm, instability could be present and further workup is indicated prior to initiating PT.
- Most frequent causes of increased ADI include trauma, Down's syndrome, AS, RA, psoriatic arthritis, and Reiter syndrome.
- **Indicative of mechanical instability**



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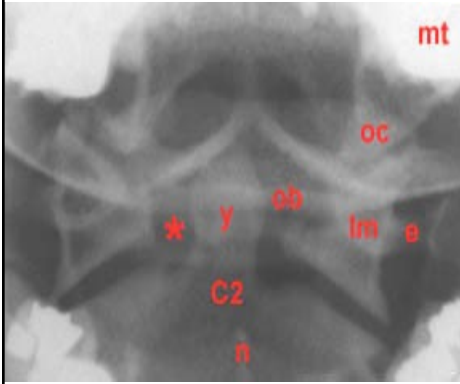
## Upper cervical Open mouth

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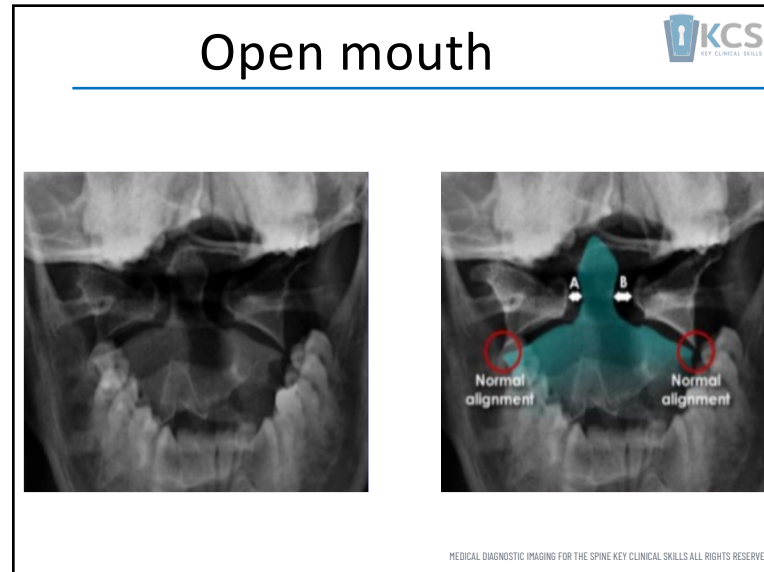
## What does an open mouth show us?



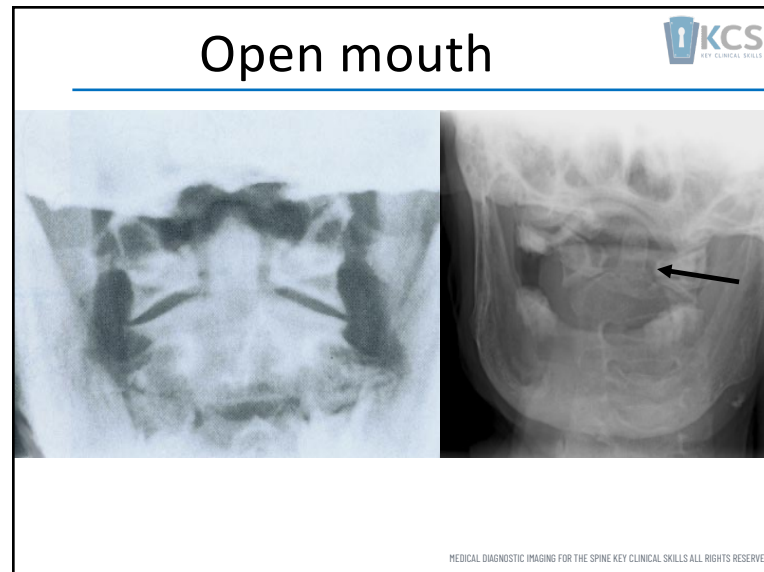
<b>mt</b>	maxillary teeth
<b>oc</b>	occipital condyle
<b>ob</b>	occipital bone
<b>y</b>	odontoid
<b>C2</b>	axis body
<b>n</b>	C2 spinous process
<b>*</b>	lateral atlanto-odontoid interval
<b>e</b>	C1 transverse process
<b>lm</b>	C1 lateral mass

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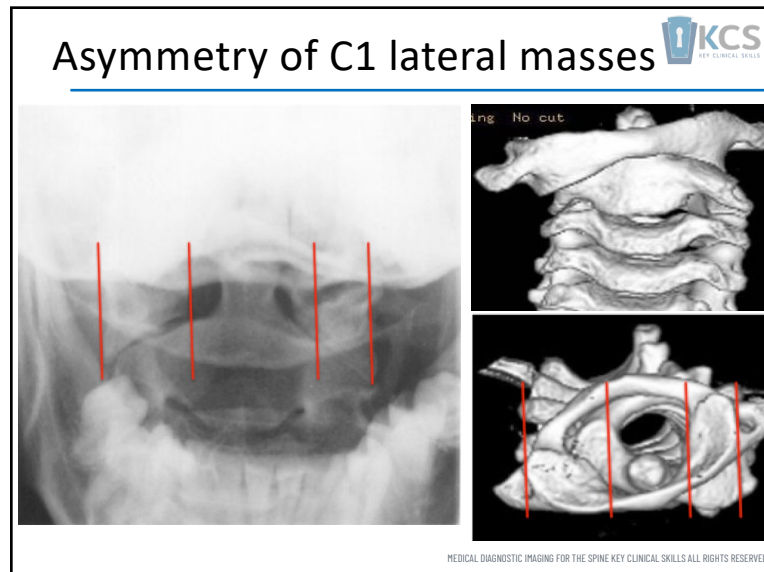
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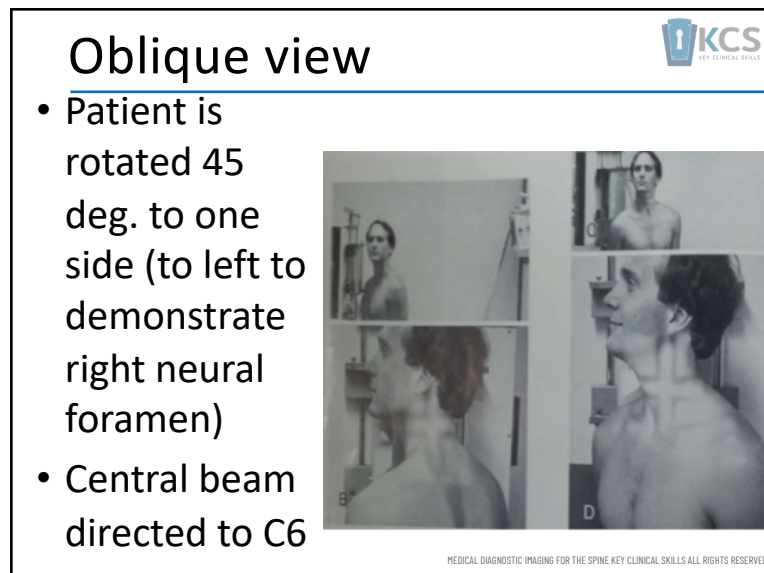
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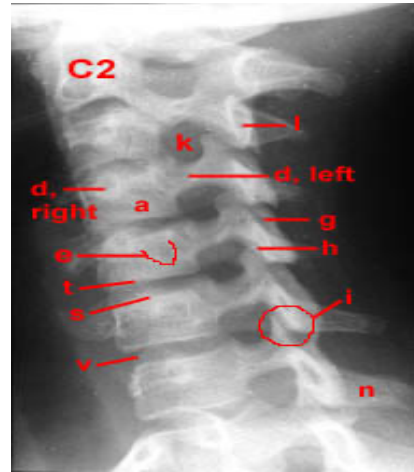


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## What does the oblique view show us?



<b>l</b>	lamina
<b>k</b>	intervertebral foramen
<b>d</b>	pedicle
<b>a</b>	vertebral body
<b>g</b>	superior facet
<b>h</b>	inferior facet
<b>e</b>	transverse process
<b>t</b>	inferior end-plate
<b>s</b>	superior end-plate
<b>i</b>	interfacetal joint
<b>r</b>	disk space
<b>n</b>	spinous process

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## Oblique Projection



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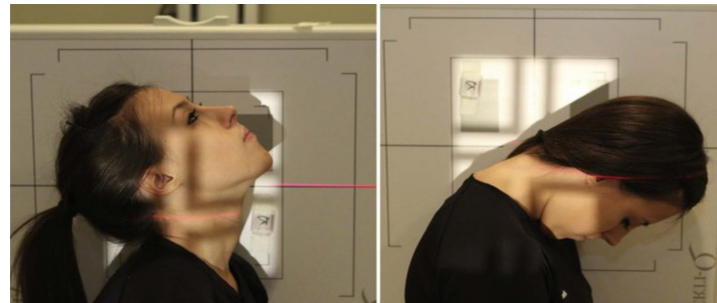
## Swimmer's view (CT Jnt)



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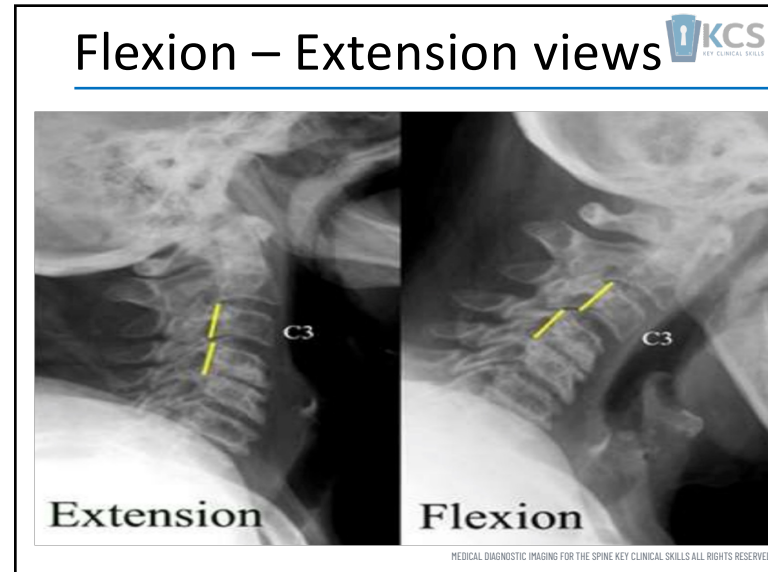
## Flexion – Extension views



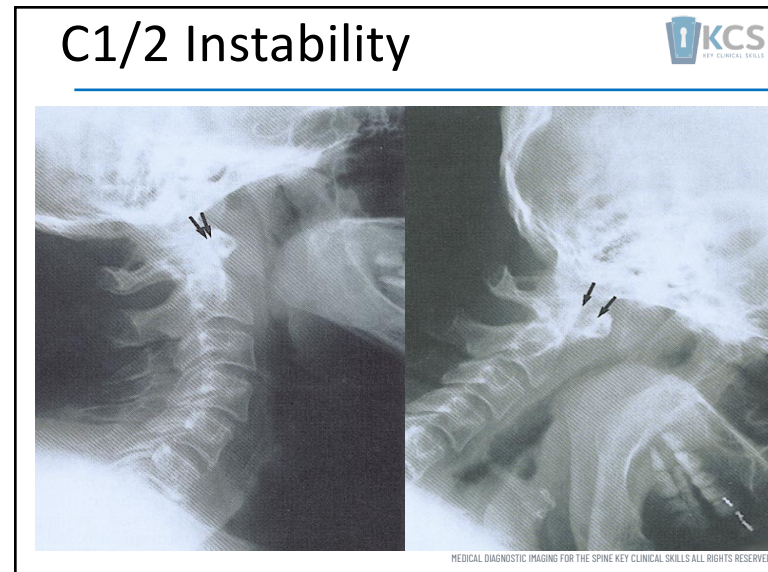
- Used to demonstrate normal AP movement or fracture/luxation
- Spinous processes should elevate on and separate on flexion, depress and approximate on extension

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## Video fluoroscopy



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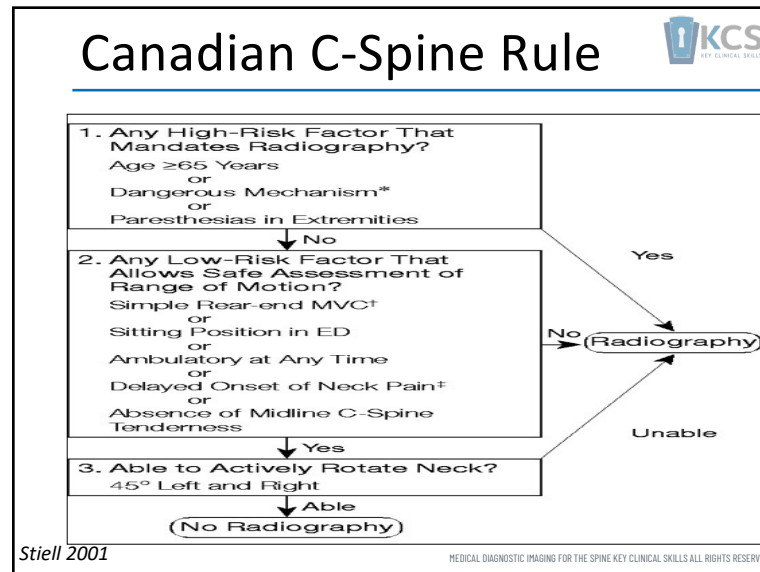
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## Video fluoroscopy



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## Test Properties: Sensitivity and Specificity

### Specificity:

The portion of the population without the target disorder who have a negative test

- Tests with high specificity ( $Sp$ ) that have a positive ( $P$ ) result help *rule in* ( $in$ ) the condition ( **$SpPin$** )

**43% specific**

*Stiell I, 2001* MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Test Properties: Sensitivity and Specificity



### Sensitivity:

The portion of the population with a positive test and the target disorder

- Tests with high sensitivity ( $S_n$ ) that have a negative ( $N$ ) result help *rule out* the condition ( **$S_nNout$** )
- **100% sensitive**

*Stiell I, 2001*

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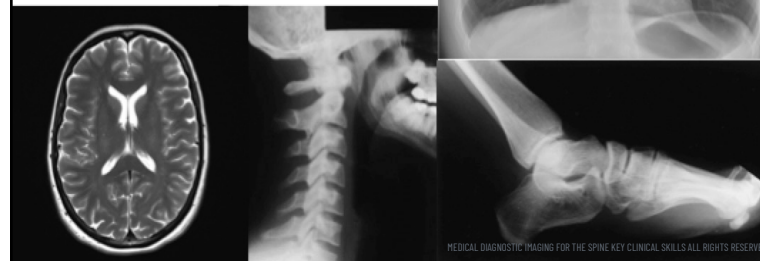
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## Medical Imaging for the spine



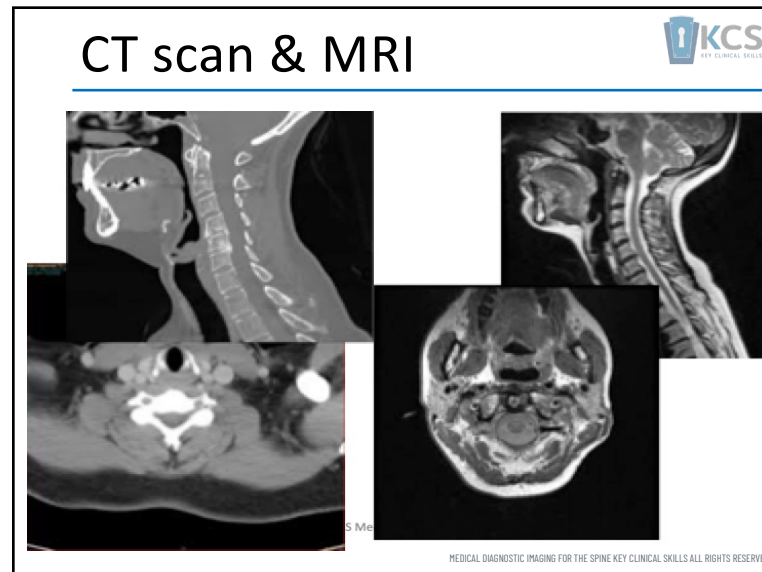
### Unit 2

#### Cervical spine 2



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## CT Scan

KCS  
KEY CLINICAL SKILLS

- Radiography remains appropriate for low-risk subjects (+ve Can C-spine rules)
- For fractures single detector CT scan has:
  - **Sensitivity of 98%**
  - **Specificity of 93%**

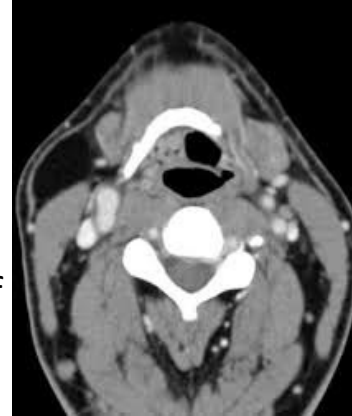
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## CT Scan



- Fractures of upper cervical (particularly C2) more common in elderly pop. (>75yrs=50)%
- Used for screening of high risk (Nexus positive) patients



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## Nexus criteria



- Midline cervical spine tenderness
- Focal neurological deficit
- Intoxication
- Painful distracting injury
- Altered mental status
  - GCS <15
  - Disorientation in time, place person or event
  - Inability to recall 3 objects at 5 minutes
  - Delayed in inappropriate response to stimulus

<b>Sensitivity</b>	<b>99.6%</b>
<b>Specificity</b>	<b>12.9%</b>
<b>NPV</b>	<b>99.9%</b>

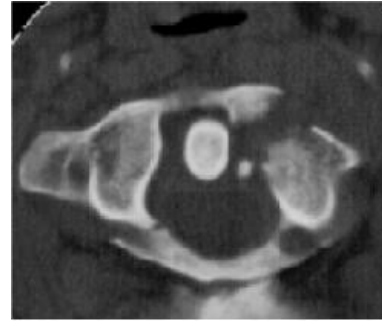
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## CT Scan



- Up to 20% fractures are missed on x-ray
- CT particularly useful in fractures of posterior elements of the cervical canal (i.e. Jefferson #'s)



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## CT Scan

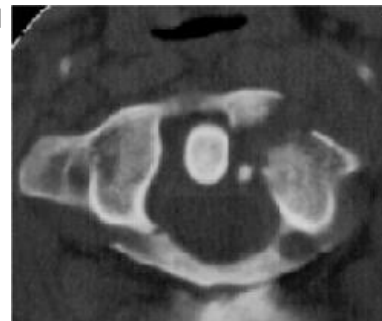


### Advantages

- Absence of superimposed structures
- High contrast improves visualization
- Reconstruction in any plane

### Limitations

- Ionizing radiation
- Unable to show ligamentous tissue
- Difficult to identify fractures in axial plane (i.e. dens #'s)



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## Indications for Cervical MRI

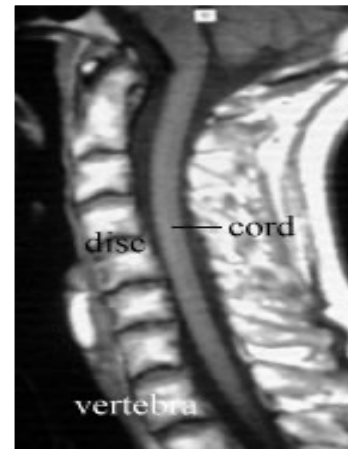
1. Known diagnosis of cancer with suspicion of metastases to the cervical spine, meninges, or spinal cord.
2. Further investigation of spinal abnormality of unknown or uncertain cause seen on plain film.
3. Clinical suspicion of cervical myelopathy or cervical nerve root compression with new onset of extremity weakness, bladder/bowel symptoms, ataxia, spasticity, spinal level sensory loss, etc.
4. Signs/symptoms suggestive of spinal stenosis (weakness, spasticity, clonus, muscle wasting, generalized sensory loss, nerve root compression, hyperactive reflexes, suggestive x-ray findings).
5. To delineate the presence or absence of demyelinating disease.

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## T1 or T2?


- High signal
  - Vertebral bodies
  - Cancellous bone
- Low signal
  - Cortical bone
  - Intervertebral discs
  - Spinal cord
  - CSF



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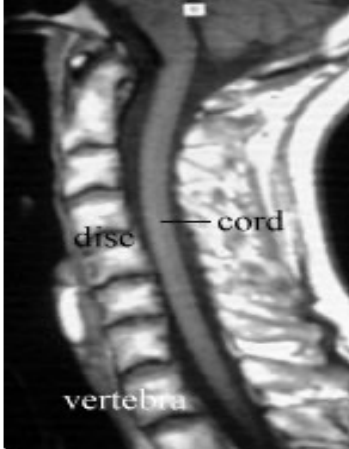
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## T1 or T2?



- High signal
  - Vertebral bodies
  - Cancellous bone
- Low signal
  - Cortical bone
  - Intervertebral disks
  - Spinal cord
  - CSF


**T1 weighted MRI**




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## T1 or T2?




- Low signal
  - Vertebral bodies  
cortical bone
  - Intervertebral discs
  - Spinal cord
- High signal
  - CSF



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## T1 or T2?



- Low signal
  - Vertebral bodies  
cortical bone
  - Intervertebral discs
  - Spinal cord
- High signal
  - CSF


**T2 weighted MRI**



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## Cervical pathology



- Congenital
- Degenerative changes
- Cervical disc herniation
- Dislocations
- Fractures
- 3 column concept of stability
- Key features of serious cervical pathology

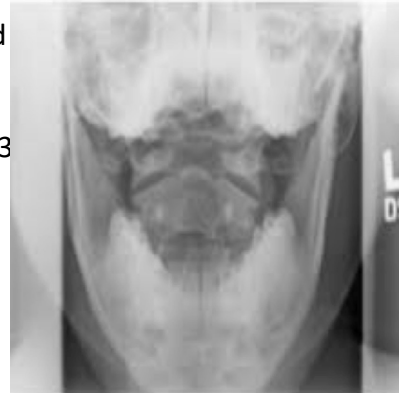
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## Os odontoidium



- AKA: un-united odontoid process
- Failure of dens to ossify to body of C2 (normally 3-6 yrs)
- Associated with Down's syndrome, atlas hypoplasia, Klippel-Feil syndrome, skeletal dysplasia
- Audible crepitus, suboccipital pain, headache



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## Klippel Feil deformity



- Congenital MSK syndrome characterized by fusion of at least 2 cervical vertebrae
- The neck is short and stocky and there is a low hair line
- Often associated "Sprengel's shoulder" (high and small scapula)
- Can cause neck pain, headache and restriction of mobility



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## C-Spine Degenerative Changes



- Lower cervical segments (C4-7)
- Commonly begin to appear by age 30-40.
- Decreased disc space, sclerosis and spurring of the margins of the vertebral bodies
- In patients with arm pain, an oblique plain film may show narrowing of the foramina

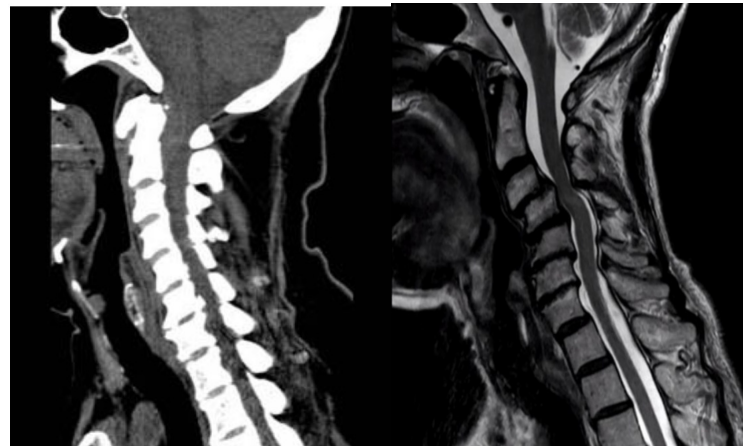
**BUT: These are normal findings in many asymptomatic individuals!**



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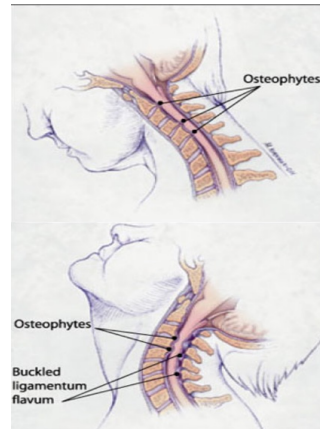
## C-Spine Degenerative Changes



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## Cervical myelopathy syndrome



### Pathology

Spinal cord compression due to degenerative changes in cervical spine or other “space occupying lesions”

### Typical features

- Weakness
- Loss of balance
- Decreased fine motor skills
- Spasticity
- Loss of sensation in extremities
- Concurrent radiculopathy
- Paresthesias (4 limb)
- Hyperreflexia of deep tendon
- Inverted supinator sign
- Clonus
- Babinski
- Hoffman's

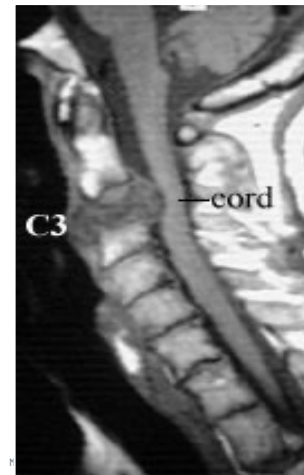
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## MRI T1



- Low signal intensity relative to marrow signal.
- C3 lesion causing compression of the cord.
- Presented with rapidly worsening weakness of arms and legs
- What clinical signs might you also see?



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## MRI finding of disc pathology



- Decrease hydration & proteoglycan + Increased collagen & fibrosis = decreased T2 signal and disk height.
- Annular tears = focal increase T2 and diffuse disc bulge.
- Nuclear herniation through annular tears = focal disc contour abnormalities.



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## Spinal Fractures




- Most common sites of spinal fractures are:
  - C1-C2
  - C5-C7
  - T9-L2
- Trauma due to:
  - MVA – 50%
  - Falls – 25%
  - Sports injuries – 10%

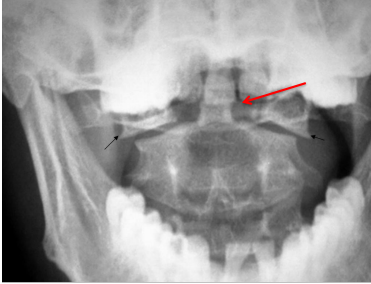
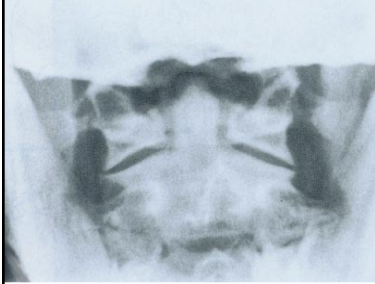


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## Cervical Fractures




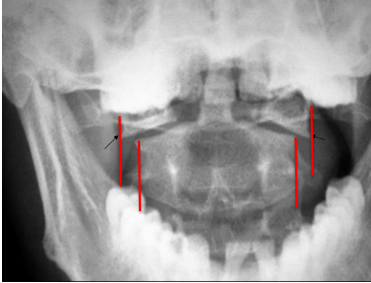
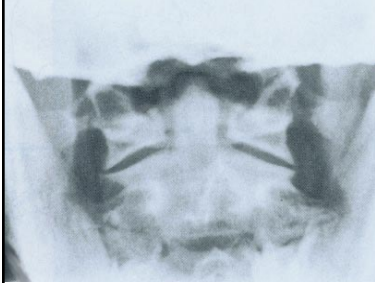


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## Cervical Fractures





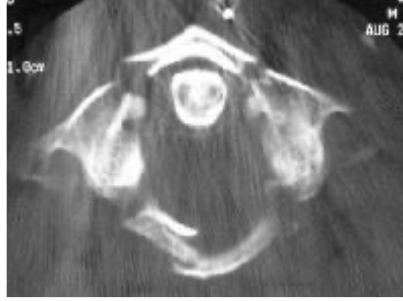

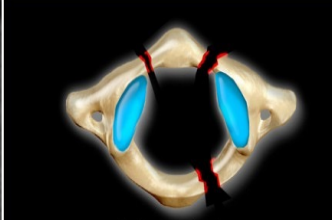
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## Cervical Fractures KCS KEY CLINICAL SKILLS

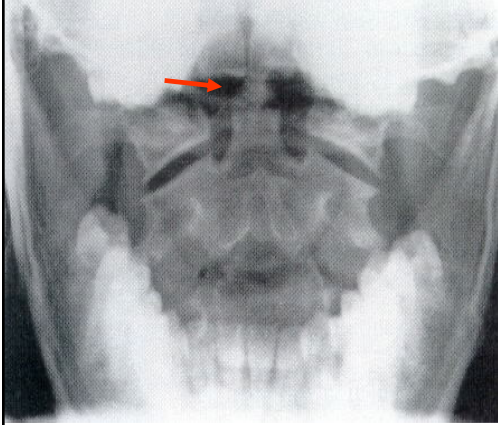
- Burst of the ring of C1.
- Due to axial loading of the head being forced down onto the spine.

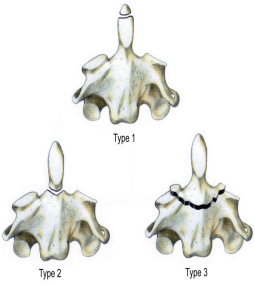




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## Cervical Fractures KCS KEY CLINICAL SKILLS





Type 1  
Type 2  
Type 3

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## Cervical Fractures



### Hangman's fracture

- Fracture of the posterior elements of C2.
- Hyperextension injury.
- Luxation of C2 over C3
- Often with spinal cord compromise & death (above C4)



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## Cervical Fractures



### Clay-shoveler's Fracture

- Fracture of posterior spinous process.
- Occurs at C6, C7, T1 or T2.
- Hyper-flexion injury
- Repeated high impact muscle function of upper limbs (like shoveling clay)



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## Cervical Fractures



### Tear drop fracture

- Posterior ligament disruption and anterior compression fracture of vertebral body
- Mechanics; hyper flexion and compression (diving into pool)
- Vertebral body may sublux posteriorly into the spinal canal



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## Cervical Fractures



### Burst fracture

- Fracture of C3-C7 from axial compression injury
- Compromise of spinal canal
- Injury to spinal cord common
- Best viewed by CT



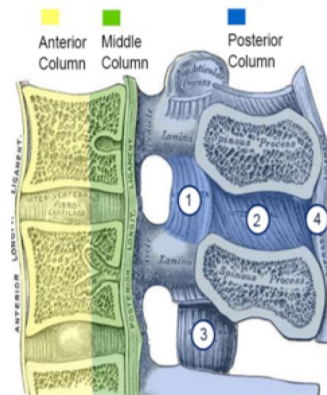
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## Three column system of spine stability

### Anterior column

- Anterior half of the vertebral body
- Nucleus of the intervertebral disc
- Anterior longitudinal ligament.



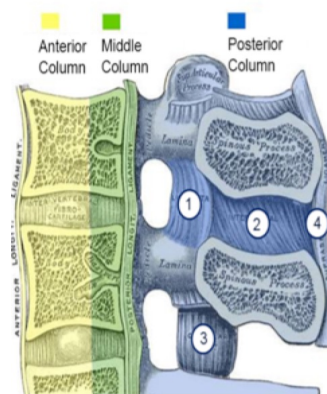
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## Three column system of spine stability

### Middle column

- Posterior of the vertebral body
- Posterior longitudinal ligament.



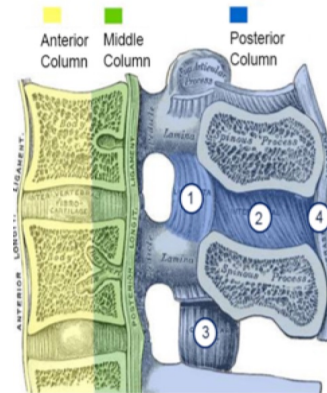
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## Three column system of spine stability

### Posterior column

- Pedicles
- Laminae
- Ligamentum flavum
- Interspinous ligament
- Supraspinous ligament



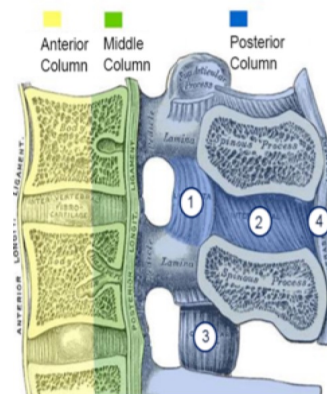
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## Three column system of spine stability

### Damage to more than one of the columns makes for an unstable injury.

Damage to the middle column is critical and is more serious  
 Very unlikely that a fracture would affect the middle column alone  
 Very likely that there is damage in front or behind and the whole spine is unstable



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## Instability



### Atlanto-occipital dislocation

- Disruption of the A/O junction/articulations
- Mechanism – Hyper flexion or extension injury
- Malposition of the occipital condyles in relation to the superior articulations of the atlas
- Cervico-cranial prevertebral soft tissue swelling



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## Instability



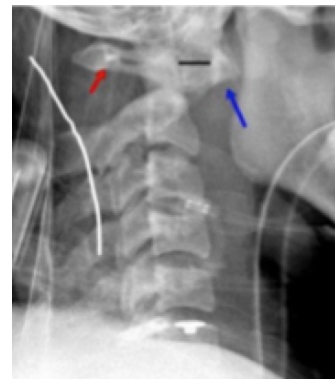
### Atlanto-Axial dislocation

AD interval > 3mm in children  
>5 mm in adults

Atlas subluxed anteriorly,  
narrows spinal canal and  
impinges on spinal cord

#### Etiology

- High impact injuries
- Down's syndrome
- Rheumatoid arthritis
- Osteogenesis imperfecta
- Morquio syndrome
- Grisel syndrome



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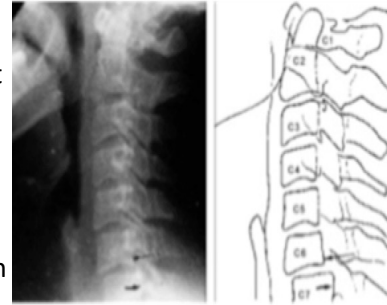
68

## Instability



### Anterior subluxation

- Disruption of the posterior ligamentous system
- May be stable initially but 20-50% become unstable
- Mechanism: Hyperflexion
- Best seen on flex/ext views
- Anterior sublux. of > 4mm
- Fanning of inter-spinous ligaments
- Loss of lordosis



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## Instability



### Unilateral facet dislocation

- “Jumped facet”
- Facet dislocation and rupture to joint ligaments
- Mechanism: simultaneous flexion and rotation
- Best seen on lateral or oblique views
- Anterior dislocation of affected vertebral body by less than  $\frac{1}{2}$  body's AP diameter
- Widening of disc space




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## Instability

### **Bilateral facet dislocation**

- Complete anterior dislocation of vertebral body
- Associated with high risk of cord damage
- Mechanism: extreme flexion without axial compression
- Best viewed on lateral projection
- Complete anterior dislocation of affected body by > ½ of vertebral body AP diameter
- “Bow tie” or “Bat wing” appearance of jumped facet



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## Key indicators of serious cervical pathology

Cervical Myelopathy	Neoplastic Conditions	Upper Cervical Ligamentous Instability	Vertebral Artery Insufficiency	Inflammatory or Systemic Disease
<ul style="list-style-type: none"> <li>•Sensory disturbance of the hands</li> <li>•Muscle wasting of hand intrinsic muscles</li> <li>•Unsteady gait</li> <li>•Hoffman's reflex</li> <li>•Hyperreflexia</li> <li>•Bowel and bladder disturbances</li> <li>•Multisegmental weakness and/or sensory changes</li> </ul>	<ul style="list-style-type: none"> <li>•Age over 50 years</li> <li>•Previous history of cancer</li> <li>•Unexplained weight loss</li> <li>•Constant pain, no relief with bed rest</li> <li>•Night pain</li> </ul> <p style="text-align: center; font-size: small;"><i>Childs 2004</i></p>	<ul style="list-style-type: none"> <li>•Occipital headache and numbness</li> <li>•Severe limitation during neck AROM in all directions</li> <li>•Signs of cervical myelopathy</li> </ul>	<ul style="list-style-type: none"> <li>•Drop-attacks</li> <li>•Dizziness (lightheadedness) related to neck movement)</li> <li>•Dysphasia</li> <li>•Dysarthria</li> <li>•Diplopia</li> <li>•Positive cranial nerve signs</li> </ul>	<ul style="list-style-type: none"> <li>•Temperature &gt; 100 F</li> <li>•BP &gt;160/95 mmHg</li> <li>•Resting Pulse &gt;100bpm</li> <li>•Resting Respiration &gt;25bpm</li> <li>•Fatigue</li> </ul>

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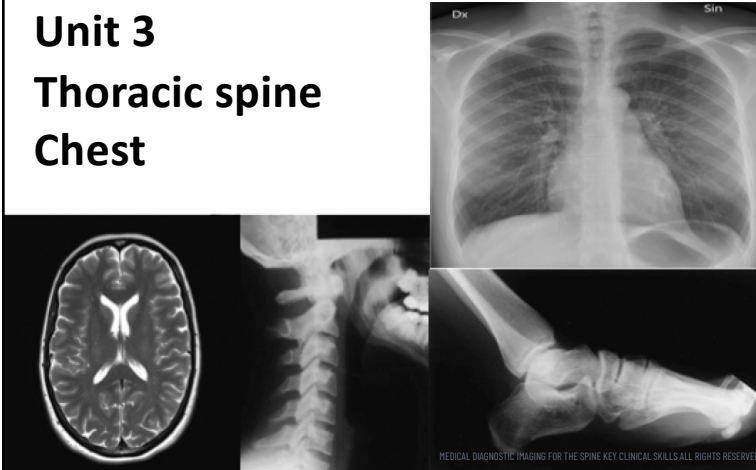


## Medical Imaging for the spine

### Unit 3

### Thoracic spine

### Chest



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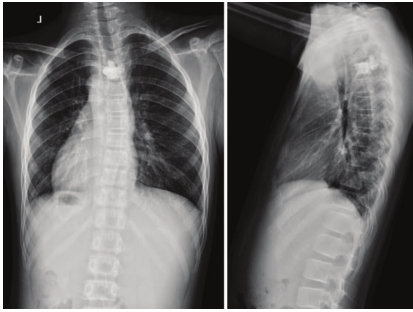
## Thoracic Views

### Standard

- Antero-postero
- Lateral

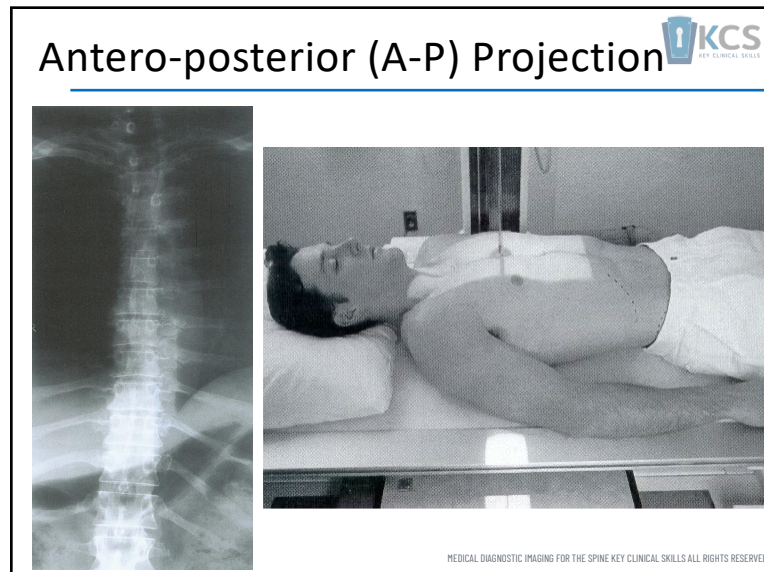
### Special

- Swimmer's



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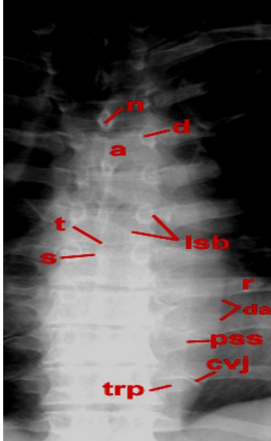
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## What does the A-P show us?


<b>n</b>	spinous process
<b>d</b>	pedicle
<b>a</b>	body
<b>t</b>	inf. end plate
<b>s</b>	sup. end plate
<b>cvj</b>	costovertebral joint
<b>trp</b>	transverse process
<b>tr</b>	trachea
<b>lsb</b>	left stem bronchus
<b>da</b>	descending aorta
<b>pss</b>	paraspinal line


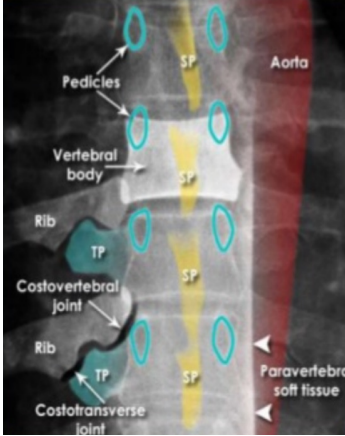


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## Thoracic AP View





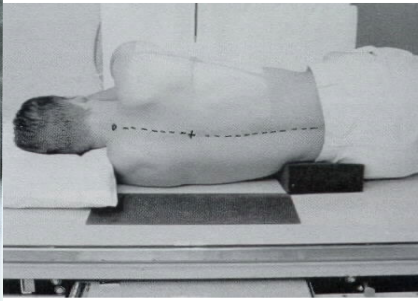



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## Lateral projection



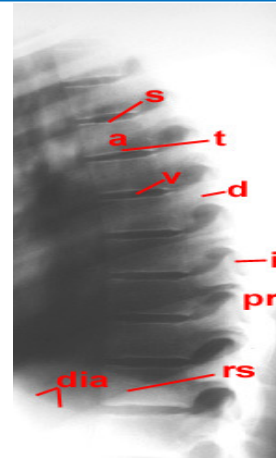



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## What do we see on a lateral projection?

s	sup. end plate
a	body
t	inf. end plate
v	disk space
d	pedicle
i	interfacetal joint
pr	post. ribs, superimposed
rs	rib shadow
dia	diaphragm



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## Lateral projection



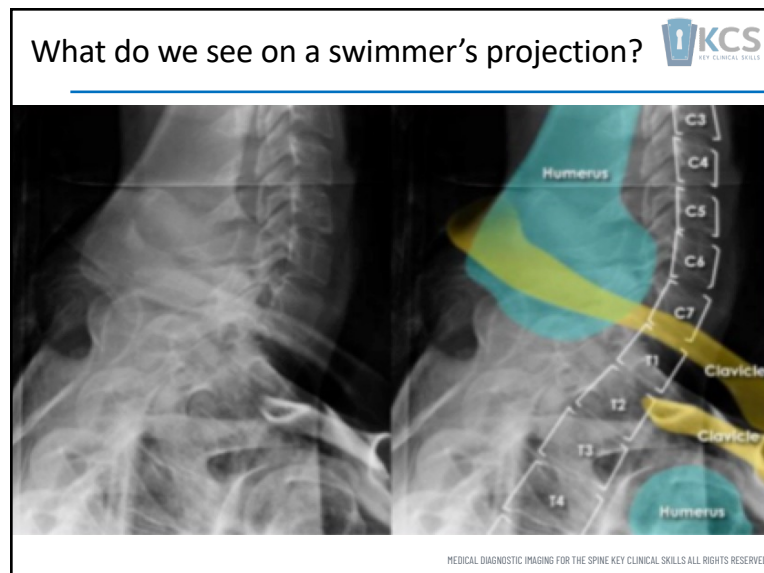
VB = Vertebral body    P = Pedicle  
 SP = Spinous process    F = Spinal exit foramen

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## Thoracic pathology



- Scoliosis
- Kyphosis
- Degenerative changes
- Disc herniations
- Spondyloarthropathies
- Spinal infections
- Spinal tumors
- Fractures

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## Scoliosis



### Non-structural scoliosis

- Compensatory scoliosis (short leg)

### Transient scoliosis

- Sciatic scoliosis (“lateral shift”)

### Structural scoliosis

- Idiopathic (70-80%)
- Congenital
- Neuromuscular
- Neurofibromatosis
  - Mesenchymal disorders (ie. Marfan’s)

### Trauma

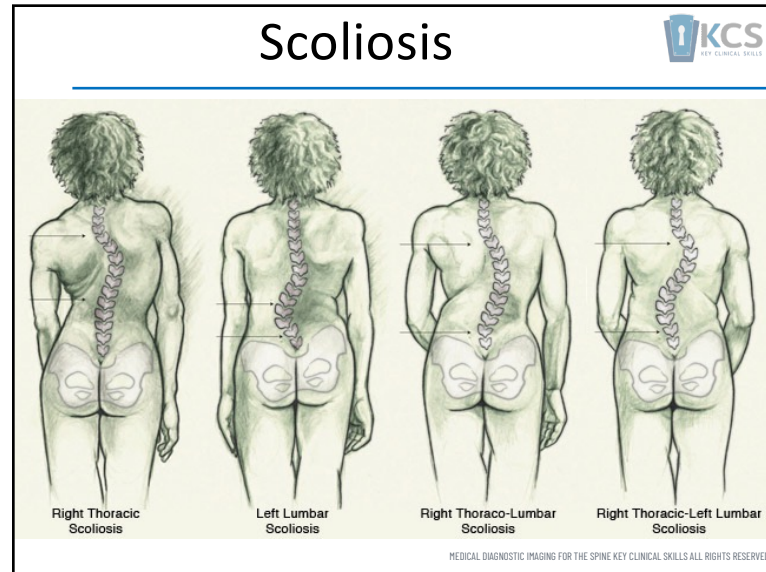
- Fractures

### Surgery

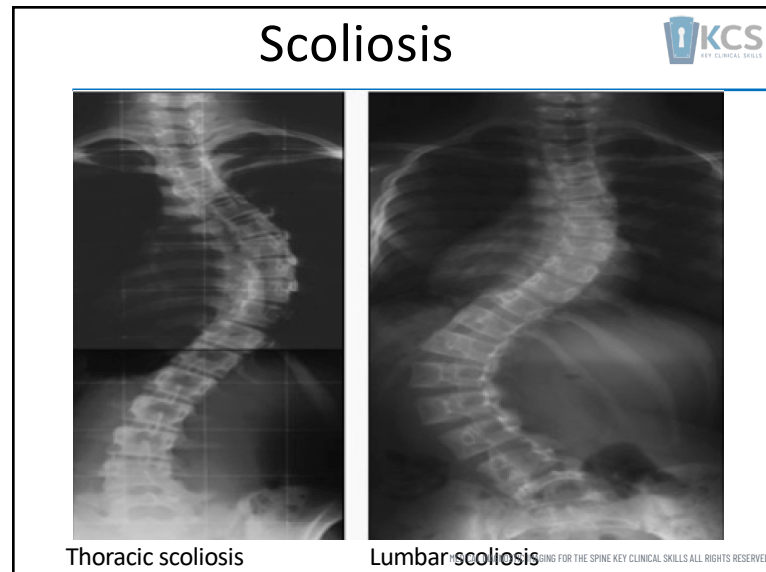


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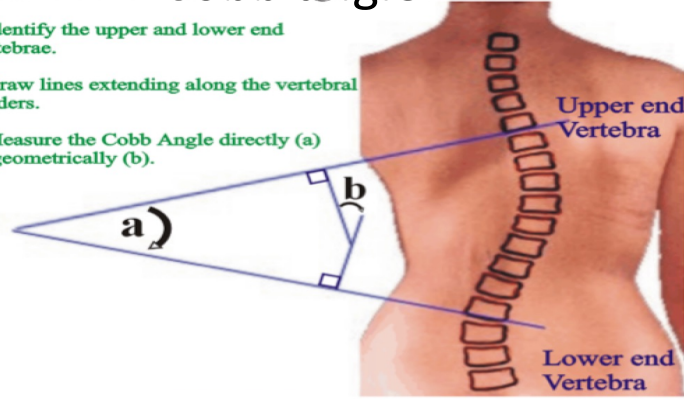
## Scoliosis



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### Cobb angle


1. Identify the upper and lower end vertebrae.
2. Draw lines extending along the vertebral borders.
3. Measure the Cobb Angle directly (a) or geometrically (b).



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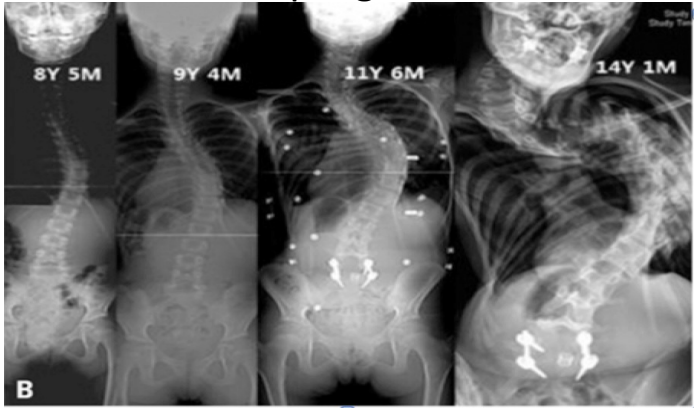
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## Scoliosis



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### Curve progression




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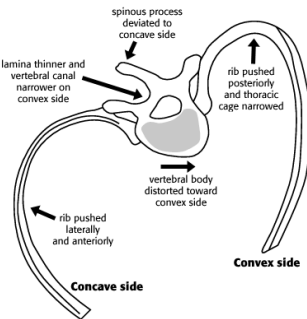
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## Scoliosis



### Rib hump related to rotation






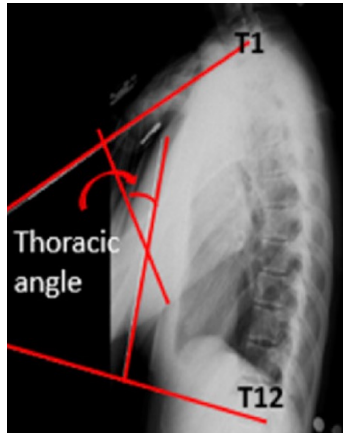
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## Kyphosis



- Identify T1 and T12 end plates
- Draw lines extending along vertebral borders
- Draw right angle bisector lines
- Measure Cobb angle off intersection of right angle bisectors



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## Degenerative Changes



Spurs (hypertrophic osteophytes)

- Usually of no clinical significance

Calcification of the anterior spinal ligament

- Diffuse idiopathic skeletal hyperostosis – DISH



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## Degenerative Changes



- Diffuse idiopathic skeletal hyperostosis (DISH) “Forstier’s”
- Due to excessive bone formation at skeletal sites subject to normal or abnormal stresses, generally where tendons and ligaments attach to bone



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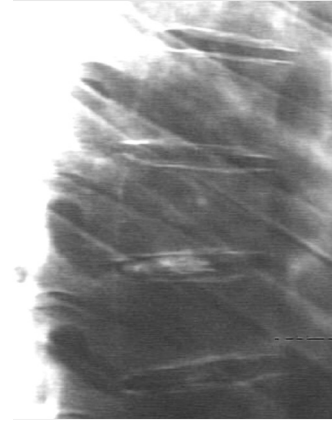
## Degenerative Changes



### Disc calcification

Calcification of an intervertebral disc

- Usually seen in mid-thoracic region
- Usually due to trauma
- If present in more than one disc may be due to hyper-calcemia or other pathology.



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## Axial arthritis




- Calcification of intervertebral discs give the appearance of a “Bamboo Spine”
- Kyphosis is usually prominent



MEDICAL DIB

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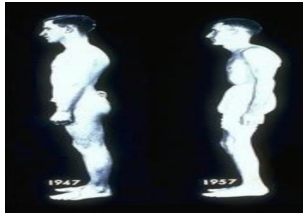
## Spondyloarthropathy




### Ankylosing spondylitis

**Early stages:**

- Intermittent back pain
- Non-traumatic
- Relieved by activity not rest
- Sacroillitis
- Inflammation, pain, tenderness in SI area
- Reactive guarding of para-vertebral muscles
- Loss of normal lordosis
- Loss of lumbar mobility
- Intermittent low-grade fever
- Fatigue
- Anorexia
- Anemia



1947      1957




1967      1972

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March 2020

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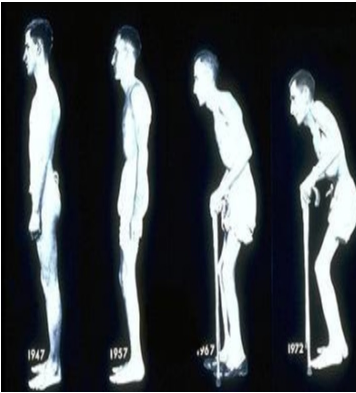
## Axial arthritis



### Ankylosing spondylitis

**Clinical Prediction Rule**

1. Morning stiffness > 30 min. duration
2. Improvement in back pain with exercise but not rest
3. Awakening because of back pain in second ½ of night only
4. Alternating buttock pain If 3 or more present  
+ve LR = 12.4



1947      1957      1967      1972

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Rudwaleit 2006

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## Thoracic disc herniations

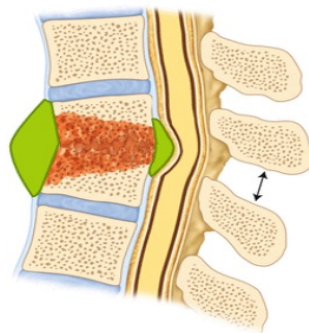
Large central disc herniation T9-10 with spinal cord impingement  
 Important as cord to canal ratio is lowest and is watershed region of cord blood supply  
 What clinical signs might you expect to see?



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## Spinal infections



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## Spinal infection



**NOTE:**  
Ability to cross the disc space

**Classic Radiological triad**

- > 50% of bone destruction before seen radiologically
- Primary Vertebral lesion
- Disc space narrowing
- Paravertebral abscess

Typical tubercular spondylitic features in long standing paraspinal abscesses

- Aneurysmal phenomenon
- Fusiform paraspinal soft tissue shadow
- Skip lesions 7-10%

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## Spinal infection

### Spinal infection

- Rare except in diabetics and post surgical patients
- Lesions appear as a bony destructive process
- TB of spine “Pott’s disease” is still prevalent in specific populations

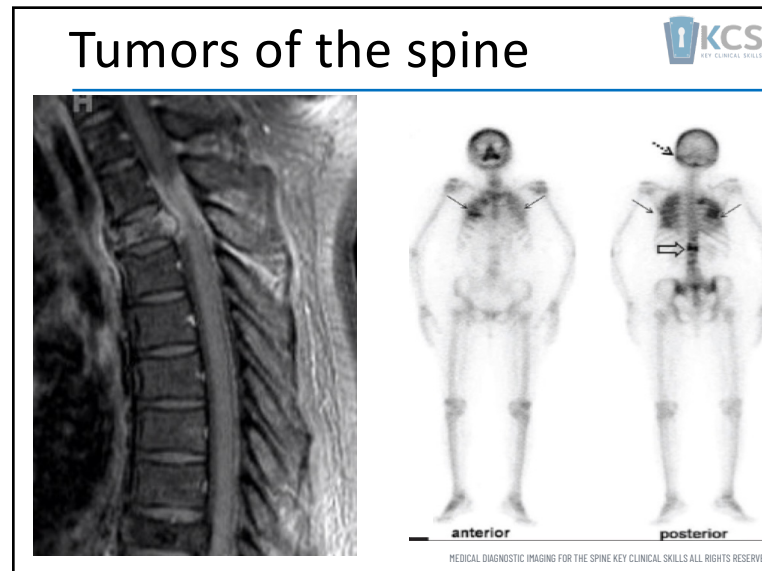
Yusuf 2019

**REGIONAL DISTRIBUTION**

Cervical	12%
Cervicodorsal	5%
Dorsal	42%
Dorsolumbar	12%
Lumbar	26%
Lumbosacral	3%

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## Tumors of the spine

**Location**

- Thoracic spine 60%
- Lumbo-sacral spine 30%
- Cervical spine 10 %

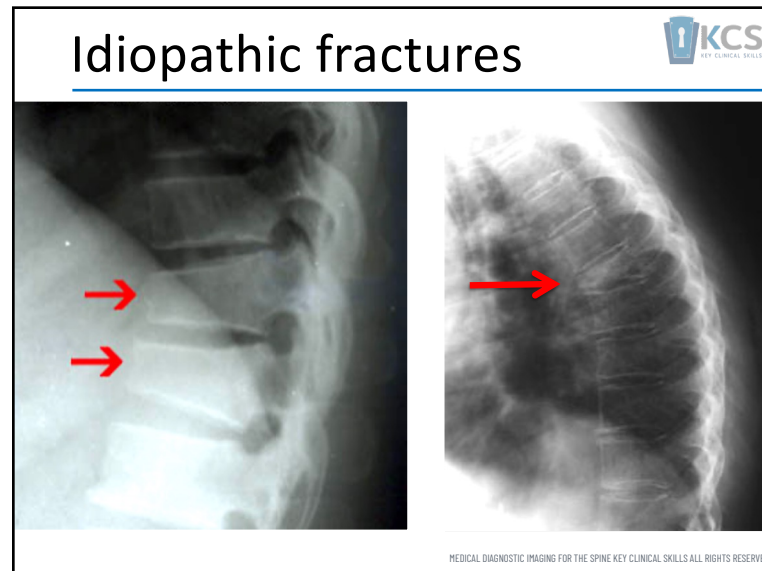
**Origin**

- Breast
- Lung
- Prostate
- Lymphoma
- Myeloma

*Foran 2014*

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## Idiopathic fractures

KCS  
KEY CLINICAL SKILLS

- Commonly seen in lower thoracic/ upper lumbar segments
- Often associated with fall onto buttocks  
“Grandad goes skating / Grandma goes tobogganing”
- May be idiopathic or pathological (osteoporosis)
- Usually very stable

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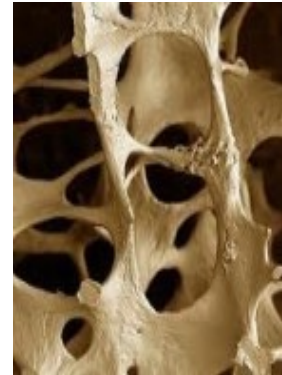
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## Idiopathic fractures



- Plain film X-ray do not show osteopenia until bone loss is > 30%
- **DEXA** (Dual Energy X-ray Absorbptiometry) is preferred method to quantify bone density
- Results are given as % of mean
- Normal bone density is within 1 SD of young adult males
- 1-2.5 SD < mean = osteopenia
- > 2.5 SD < mean = osteoporosis



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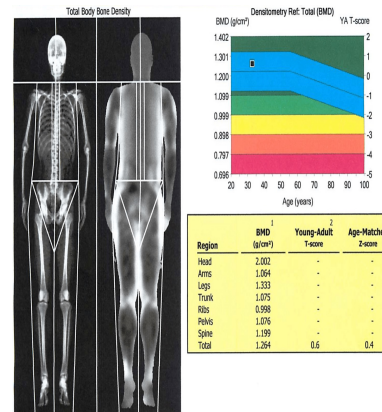
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## Idiopathic fractures




### DEXA Indications

- Osteopenia on plain film
- Non-traumatic vertebral fracture in menopausal female
- Metabolic disorders related risk
- Loss of 2.5 cm. in height
- Considering prescribing hormone



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What's wrong with this picture? 

- An AP Thx-spine film following MVA Does this image look OK?
- Would you like
- any other views?



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What's wrong with this picture? 



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What's wrong with this picture? 



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What's wrong with this picture? 



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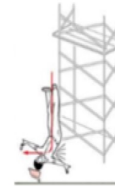
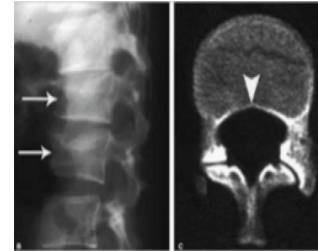
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## Traumatic fractures



### Flexion/compression Injury

- Typically anterior wedge compression fracture
- Found in the upper and mid-thoracic region
- Neurological instability is rare
- Usually only involves one end plate
- Distinguished from Sheuermann's disease (both end plates affected)



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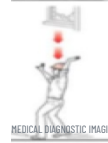
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## Traumatic fractures



### Vertical compression injury

- Burst fractures of the thoracolumbar junction
- Classically from fall /land onto feet (associated with calcaneal fractures) or buttocks
- Nucleus pulposus explodes into superior vertebral body
- Retropulsion of the posterior fragment into the canal
- Two-column injury (unstable)



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## Traumatic fractures



### Flexion/distraction injury

#### AKA: "Chance fractures"

- Most common at T/L junction
- Separation in a cranial/caudal direction
- Result of hyper-flexion injury (lap only seatbelt restrains pelvis in head on MVC)



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## Traumatic fractures



### Shear Injury

- Typically results in a severe unstable 3-column injury
- Mechanism high-force lateral impact
- Neurological impairment is common
- High association with abdominal injuries



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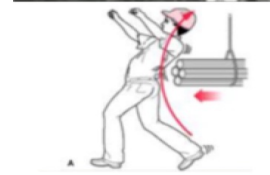
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## Traumatic fractures



### Extension Injury

- Posterior element impaction
- Fractures (often comminuted) of the spinous process, lamina or facets
- Association with anterior disc wedging or avulsion fracture of endplate
- If severe enough may result in “lumberjack fracture-dislocation” (complete loss of continuity of the upper and lower spinal segment)



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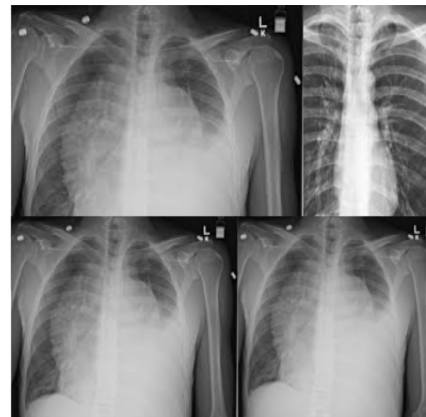
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## Chest X rays



### Views

- PA
- AP
- Lateral



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## Chest X rays



### Chest AP View



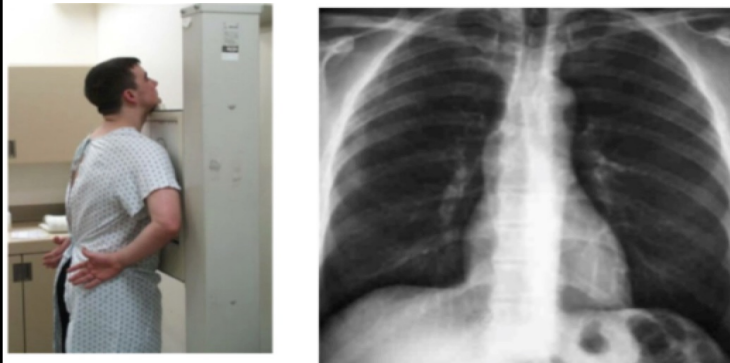
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## Chest X rays



### Chest PA View



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## Chest X rays



### PA vs AP

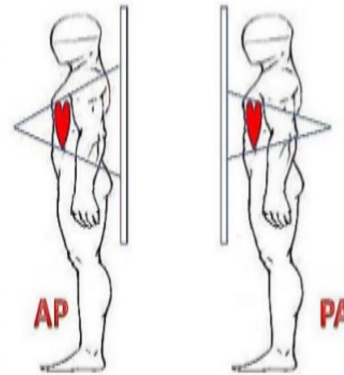
#### AP View

- Cardiac shadow is functionally enlarged due to parallax

#### PA View

- If heart seems enlarged most likely real not artifact

**PA & AP views both read as standing face to face**



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## Chest X rays



- AP View



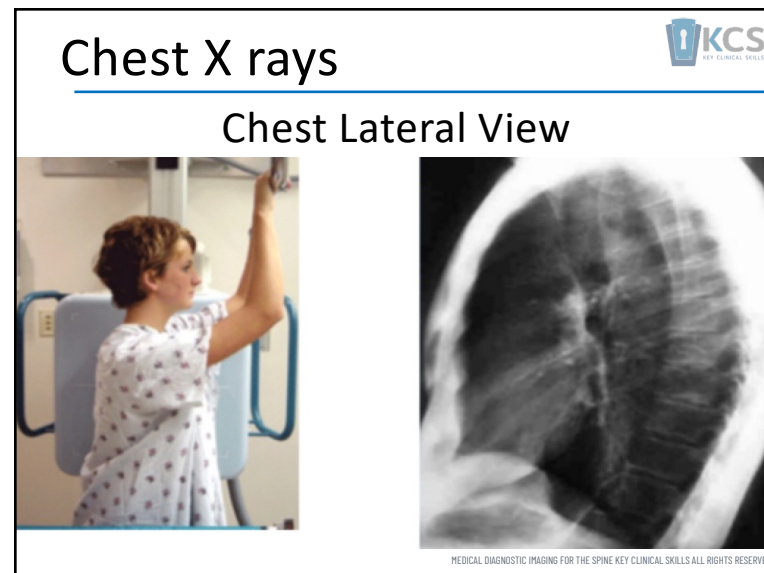
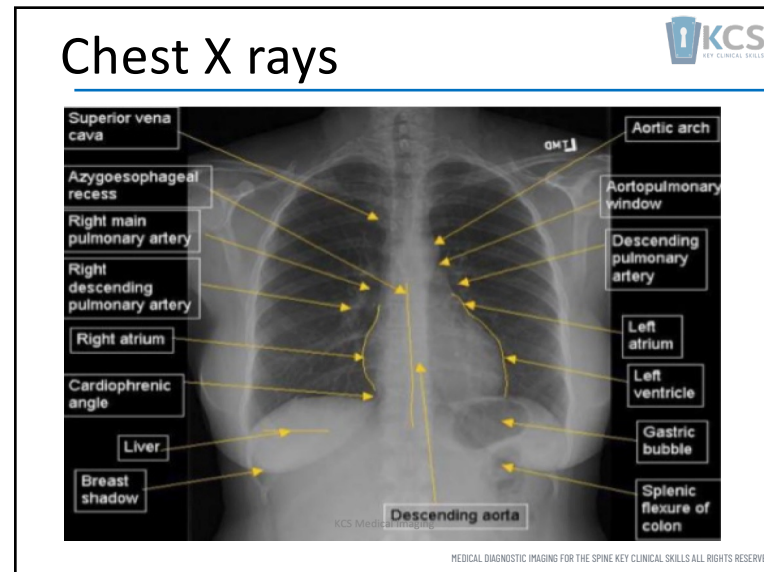
- PA View



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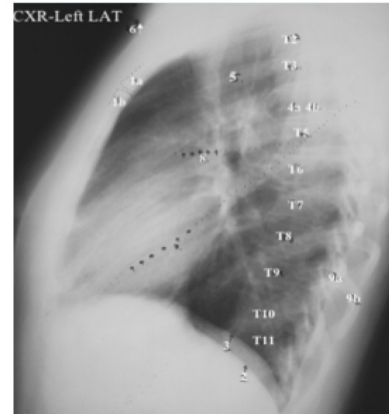




## Chest X rays



- 1a. Manubrium sternum
- 1b. Body of Sternum
- 2a. Right hemi diaphragm
- 3 Left hemi-diaphragm
- 4a Right scapula
- 4b Left scapula
- 5 Major fissure
- 8 Trachea
- 9 Soft tissue of the arms
- 9a 9<sup>th</sup> left rib
- 9b 9<sup>th</sup> right rib
- T2 –T11 Thoracic vertebrae



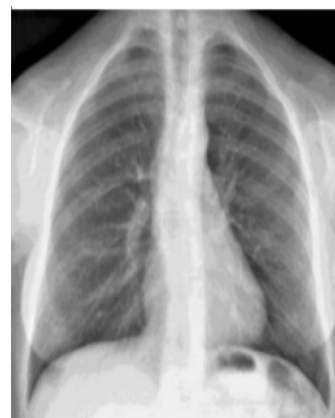
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## Osseous pathology

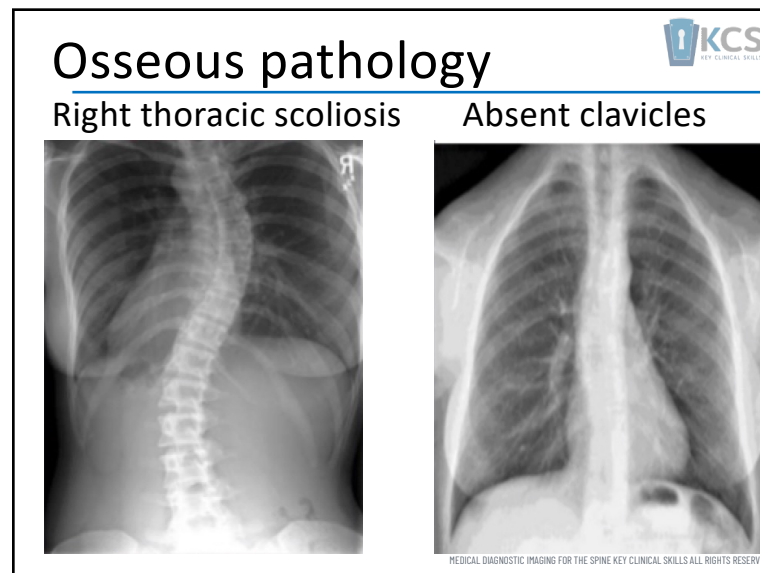


What pathologies do you see?

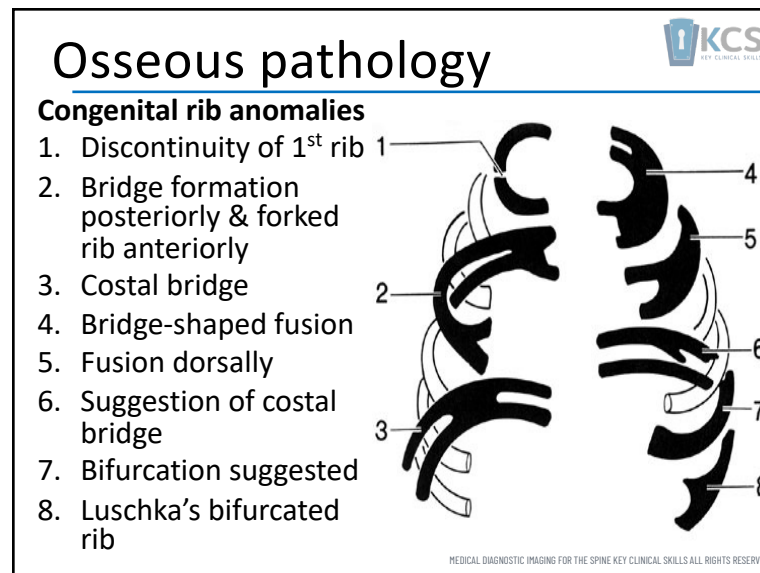


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# Osseous pathology



## Congenital sternum anomalies


I. Main types

Superior sternal cleft




a

Subtotal sternal cleft




b

Total sternal cleft



c

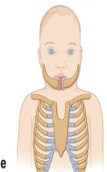
Inferior sternal cleft



d

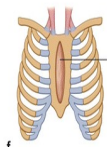
II. Rare types

Superior sternal cleft with cleft mandible



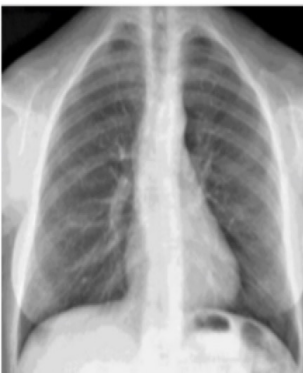
e

Median sternal cleft



f


### Absent clavicles



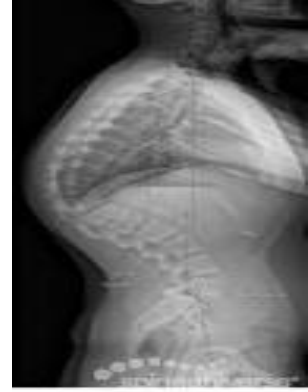
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# Osseous pathology



- Kyphosis



- Scoliosis

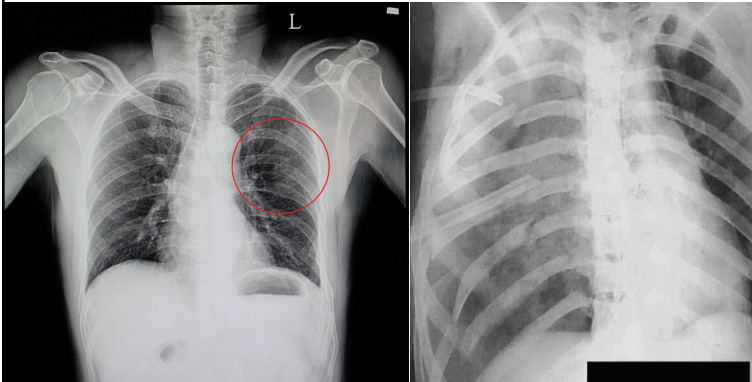


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## Osseous pathology

- Rib fractures
- Flail chest

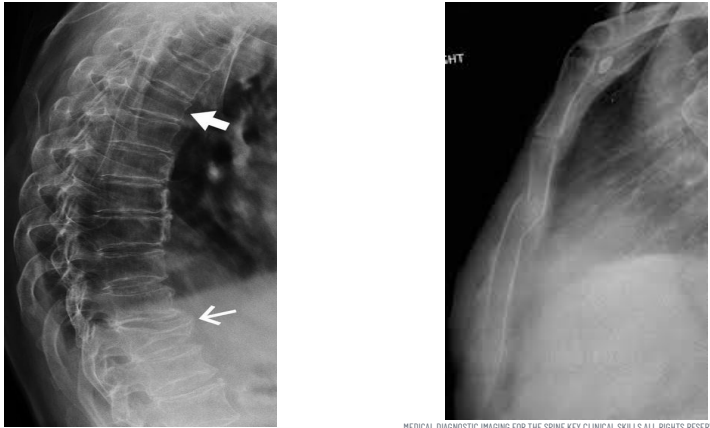


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## Osseous pathology

- Thoracic fractures
- Sternal fractures



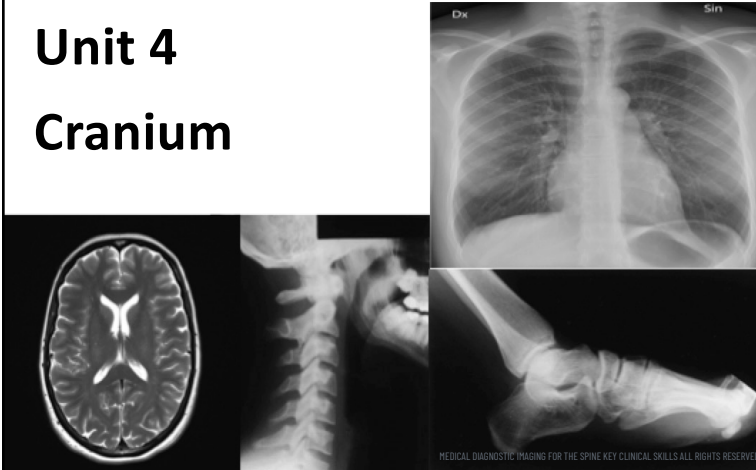
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## Medical Imaging for the spine

### Unit 4

### Cranium



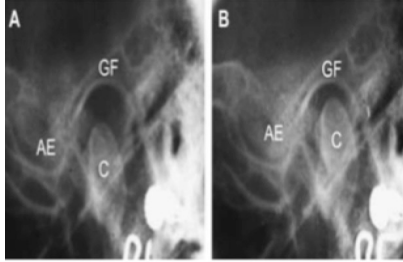
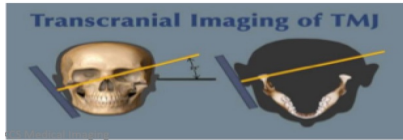
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## Temporomandibular joint

### Trans-cranial View

- External auditory meatus
- Petrous line
- Lateral and medial poles fo condyle
- Neck of condyle
- Articular eminence
- Mandibular fossa

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## Temporomandibular joint

### Panoramic radiography

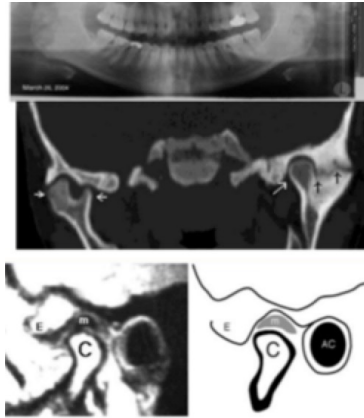
- Both TMJ
- Teeth
- Mandible

### CT Scan

- Used to diagnose internal derangement

### MRI

- Used to diagnose internal derangement



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## Neuro-imaging Modalities

### Radiology

X-Ray

### Fluoroscopy

Angiography

Diagnostic

Interventional

### Ultrasound

Gray scale duplex

Colour Doppler

### Computed Tomography

CT Angiography (CTA)

Perfusion CT

CT Myelography

### Magnetic Resonance

MR angiography/venography (MRA/MRV)

Diffusion and diffusion tensor MR

Perfusion MR

MR Spectroscopy (MRS)

Functional MR (fMR)

### Nuclear Medicine

Single Photon Emission

Computed Tomography (SPECT)

Positron Emission Tomography (PET)

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## Radiography



### Primarily used for:

- Trauma
- Post operative
- Spine



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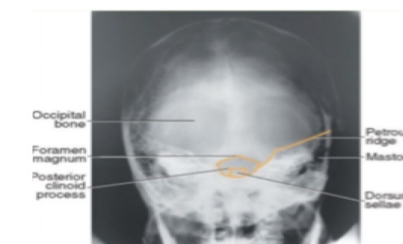
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## Radiography



### Skull AP Axial

- Occipital bone
- Petrous pyramids
- Foramen magnum
- Dorsum sellae
- Used to visualize fractures of base of skull



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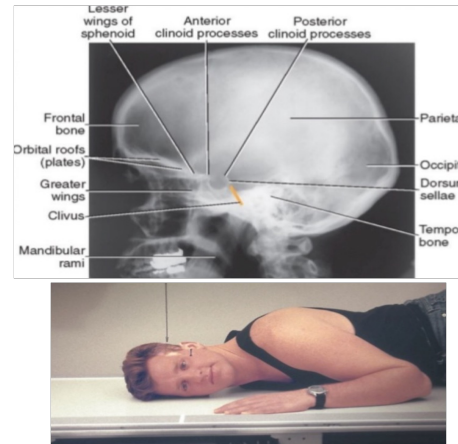


## Radiography



### Skull Lateral

- Superimposed cranial halves
- Sella turcica
- Posterior clinoids
- Dorsum sellae
- Clivus
- Demonstrates skull fractures



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## Radiography



### Skull PA


- Superior orbital fissures
- Foramen rotundum
- Inferior orbital rim
- Greater and lesser sphenoid wings
- Frontal bone
- Ethmoid sinuses



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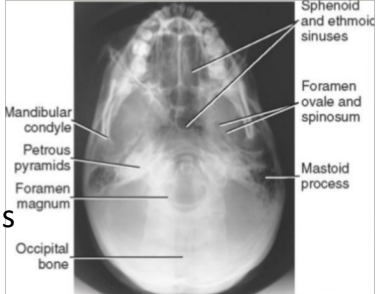
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## Radiography



### Skull Submentovertex

- Foramen ovale
- Mandible
- Sphenoid sinus
- Posterior ethmoid sinus
- Mastoid processes
- Petrous ridges
- Hard palate
- Foramen magnum
- Occipital bone






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## CT Scan



### CT Indications

<ol style="list-style-type: none"> <li><b>1. Skull &amp; skull base</b> <ul style="list-style-type: none"> <li>• Trauma</li> <li>• Bone lesions</li> </ul> </li> <li><b>2. Ventricles</b> <ul style="list-style-type: none"> <li>• Hydrocephalus</li> </ul>           Shunt placement         </li> <li><b>3. Intra-cranial masses &amp; mass effect</b> <ul style="list-style-type: none"> <li>• Headache</li> <li>• Visual symptoms</li> </ul> </li> </ol>	<ol style="list-style-type: none"> <li><b>4. Hemorrhage /Ischemia</b> <ul style="list-style-type: none"> <li>• Stroke</li> <li>• Mental status change</li> </ul> </li> <li><b>5. Calcification</b> <ul style="list-style-type: none"> <li>• Lesion characterization</li> </ul> </li> </ol>
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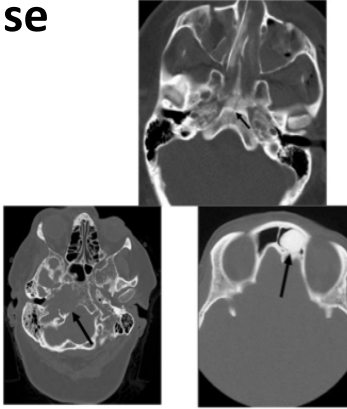
140

## CT Scan

**Skull and skull base**

Fractures

Tumors



Multiple myeloma      Osteoma

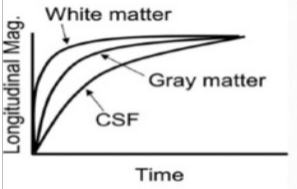
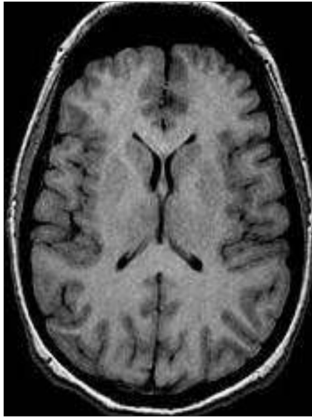
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## Magnetic Resonance

**T1 weighted images**

- Fat containing tissues are bright
- Water & fluid containing tissues are dark

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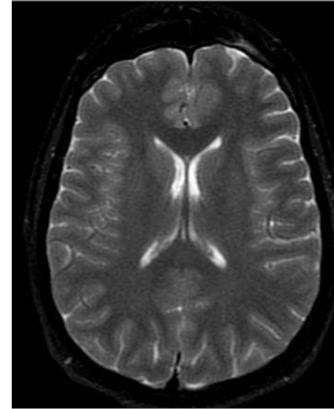
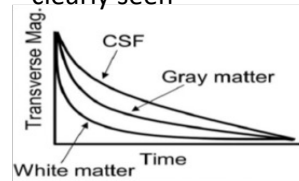
142

## Magnetic Resonance



### T2 weighted images

- Water & fluid containing tissues are bright
- Fat containing tissues are dark
- Sensitive for pathology as secondary edema clearly seen



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## MR vs CT



### MR

#### Advantages

- Broader range of tissue contrast
- No ionizing radiation
- Direct multi-planar imaging
- IV contrast better tolerated

#### Disadvantages

- Higher costs
- Difficult for unstable patients
- Multiple contraindications
- Claustrophobics may need sedation
- Lacks bone detail

### CT

#### Advantages

- Simpler, cheaper, more accessible
- Tolerated by claustrophobics
- No absolute contraindications
- Fewer pitfall in interpretation
- Better than MR for bone detail

#### Disadvantages

- Ionizing radiation
- IV contrast complications
- Need reconstruction for multi-planar
- Limited range of tissue contrasts

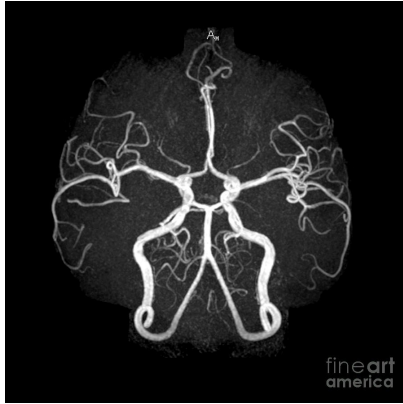
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## CT angiography

**Indications**

- Atherosclerosis
- Thromboembolism
- Vascular dissection
- Aneurysms
- Vascular malformations
- Penetrating trauma



**KCS**  
KEY CLINICAL SKILLS

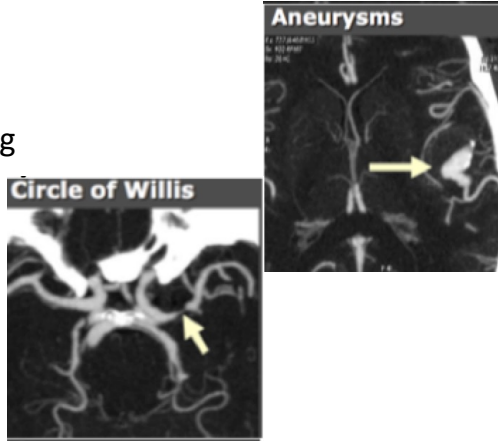
fineart  
america

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## CT angiography

- Rapid arterial contrast bolus
- Dynamic scanning during arterial phase
- 2 D & 3D reconstruction



**Circle of Willis**

**Aneurysms**

**KCS**  
KEY CLINICAL SKILLS

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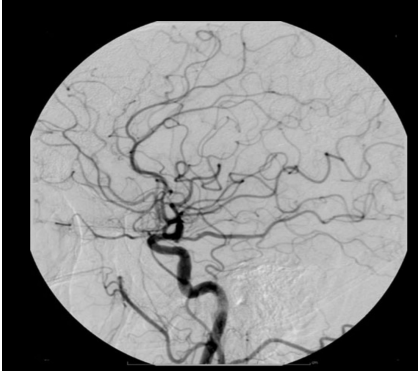
146

# Fluoroscopy

**Digital Subtraction Angiography**

**Indications**

- Aneurysms
- Vascular malformations
- Fistulae
- Vessel stenosis
- Thrombosis
- Dissection
- Pseudo-aneurysm
- Stenting
- Embolization
- Thrombolysis



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# Fluoroscopy

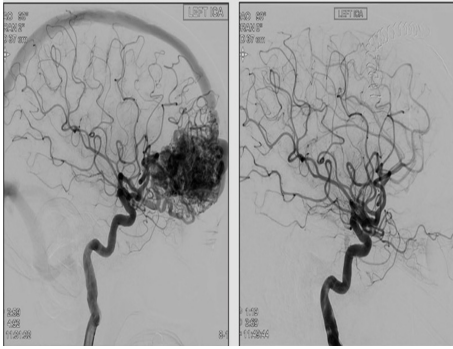
**Digital Subtraction Angiography**

**Advantages:**

- Ability to intervene
- Time-resolved blood flow dynamics
  - Artery
  - Capillary
  - Venous

**Disadvantages:**


- Invasive
- Risk of vascular injury
- Risk of stroke
- Iodinated contrast
- Ionizing radiation



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# Ultrasound



**Indications:**

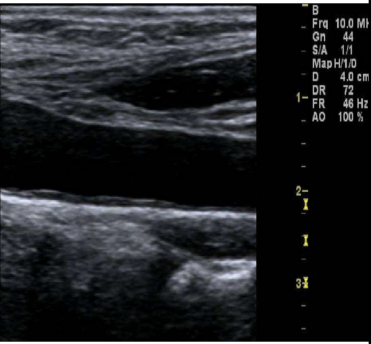
- Carotid stenosis
- Vasospasm
- Infant brain imaging

**Advantages:**

- Non-invasive
- Well tolerated
- Readily available
- Low cost
- Quantitates blood flow velocity
- Reveals morphology

**Disadvantages:**


- Severe stenosis may appear occluded
- Limited coverage difficult through air/bone
- Operator dependent



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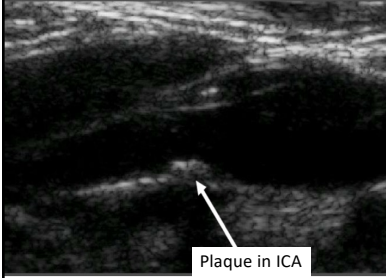
149

# Ultrasound

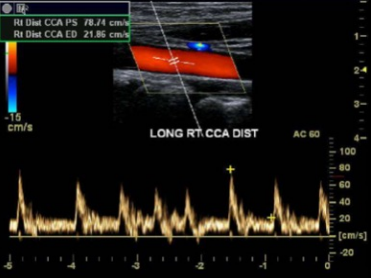


- Grey scale

- Colour Doppler



Plaque in ICA



Peak Systolic Velocity (cm/sec)	ICA Stenosis (% diameter)
125-225	50-70
225	70-90
>350	>90

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## Common neurological conditions

- Trauma
- Tumors
- Cerebrovascular disease
- Hydrocephalus
- CNS infections



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## Skull fractures

### Types of fracture

#### Linear

- Hair line (vault of the skull)
- Basilar (base of the skull)
- Diastatic (along a skull suture)

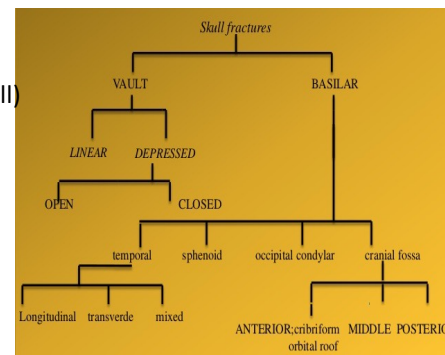
#### Depressed

- Hinged door
- Comminuted

#### Pond

- Dent (in babies)

### Classification of skull fractures



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## Skull fractures



### Radiographs

- Demonstrate most linear fractures
- Show air-fluid levels in sinuses
- Delineate the cranio-cervical junction well
- Do not help in assessing intra-cranial complications
- Temporal bone fractures may easily be missed
- Detection of skull fractures on x-ray is regarded as an indication for CT scan

### CT Scan

- Excellent modality for demonstrating intermediate and late sequelae of head trauma
- A linear or slightly depressed fracture may be missed
- Basilar fractures are difficult to demonstrate

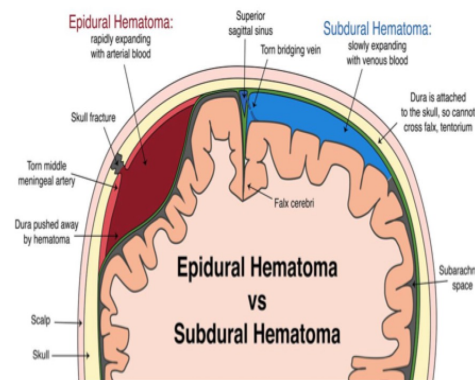
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## Trauma



- Epidural hematoma
- Subdural hematoma
- Acute contusion / lacerations



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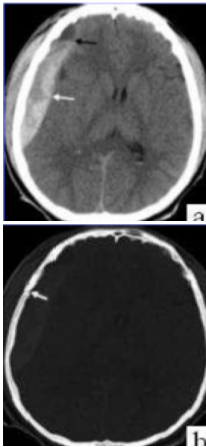
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## Trauma

**Epidural hematoma**

**CT appearance**

- Confined convex shaped
- High density
- Adjacent to skull fracture
- Midline deviation
- Cerebral edema



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## Trauma

**Sub-Dural hematoma**

**CT appearance**

**Acute stage**

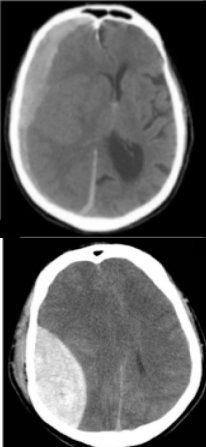
- Crescent-shaped high density beneath skull
- Significant mass effect

**Sub-acute stage**

- Crescent-shaped high density or iso-density
- Inward shift of gray & white matter junctions on affected side sulci disappear ventricle deformation


**Chronic stage**

- Crescent-shaped low density



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## Trauma

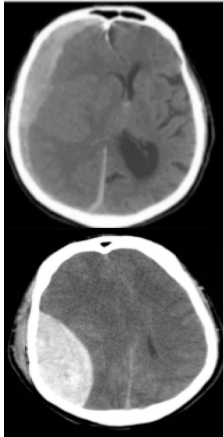
### Subdural vs Epidural

**Subdural**

- Crescent shaped
- Do not cross the midline (meningeal reflections block bleeding)


**Epidural**

- Biconvex
- Restricted by tethering at cranial sutures



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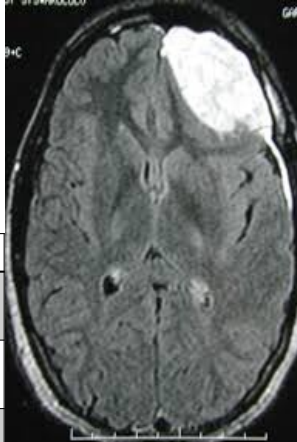
## Trauma

### Epidural hematoma

**MR appearance**

- Morphological similar to CT

Phase	T1	T2
Acute (0-4D)	Iso intense	Hypo intense
Sub-acute (4D-3W)	Hyper intense	Hyper intense
Chronic (> 3W)	Hyper intense	Hyper intense



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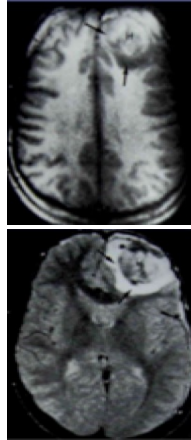
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## Trauma

### MR appearance

### Sub-Dural hematoma

Phase	MR
Acute	Multiple areas of mixed signals
Chronic	Edema & mass effect reduced Malacia Brain atrophy



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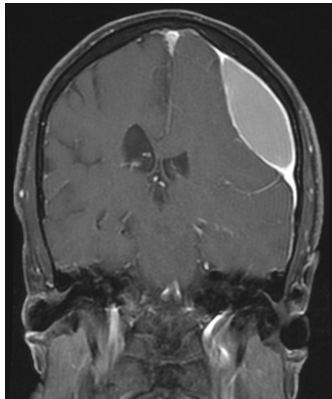
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## Trauma

### MR appearance

### Sub-Dural hematoma

Phase	T1	T2
Acute (0-4D)	Iso or Hyper intense	Hypo intense
Sub-acute (4D-3W)	Hyper intense	Hyper intense
Chronic (> 3W)	Hyper intense	Hyper Intense surrounded by hypo intense ring



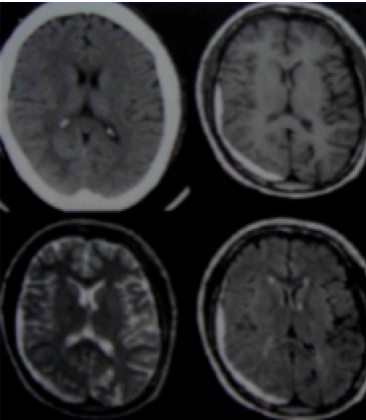
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## Trauma

**Sub-Dural hematoma**

Phase	MR	CT	Advantage
Acute (0-4D)	High Intensity	Iso intense	CT
Sub-acute (4D-3W)	Iso intense	Hyper intense	MR
Chronic (>3W)	Low density (like CSF)	Hyper Intense	MR



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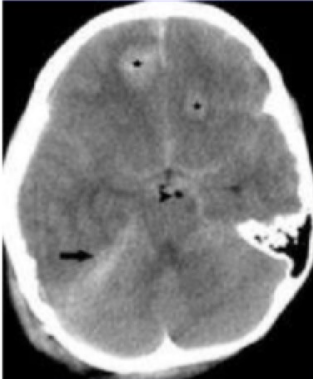
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## Trauma

**Contusion/Laceration**

**CT appearance**

- Low density
- Edema with multiple scattered micro hemorrhages
- Mass effect subarachnoid hemorrhage subdural hematoma



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## Brain Tumor



### Primary

- Glioma 40-50%
  - Astrocytoma 70%
- Angioma
- Medulloblastoma
- Lymphoma

### Secondary

- Metastatic

### Astrocytomas

- Most common type of Glioma
- At any age but commonly between 20-40
- Presents with:
  - Seizures
  - Focal neurological deficits
  - Headache

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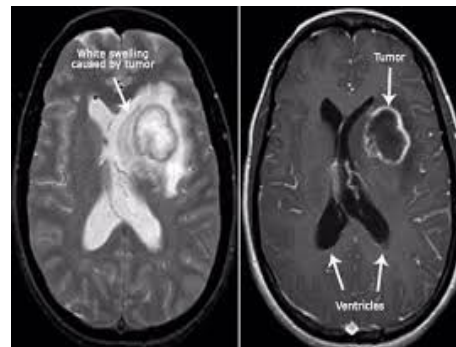
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## Brain Tumor



### Astrocytomas (Non-Malignant)

- Lower density on CT
- Long T1 & T2 intensity
- Slight mass effect
- Mild surrounding edema
- Well-demarcated boundary
- No post-contrast enhancement



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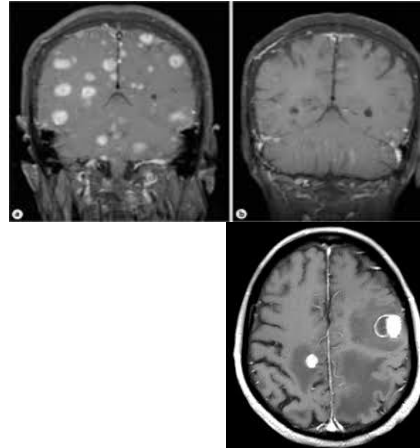
164

## Brain Tumor



### Brain metastases

- Via blood stream route
- Most commonly from lung
- Imaging features
  - Multiple nodules common
  - Necrosis-frequent
  - Massive peri-nodular edema
  - Substantial post-contrast enhancement
  - MR
    - T1 - Hypointense
    - T2 - Hyperintense



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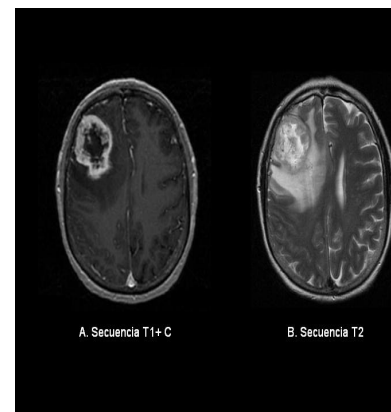
165

## Brain Tumor



### Malignant

- Heterogeneous density
- Mixed signal intensity
- Marked mass effect
- Severe surrounding edema
- Ill-demarcated boundary
- Post-contrast enhancement



A. Secuencia T1+ C

B. Secuencia T2

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## Brain Tumor

**Meningioma**

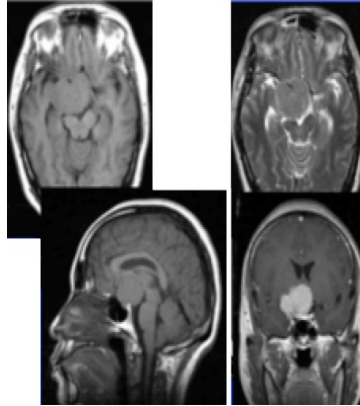
- Most common tumor outside brain
- Solid tumors commonly
- Adjacent skull reactive hyperplasia or bone destructions

**CT**

- Iso intense or low density
- Sometimes calcification

**MR**

- T1 Iso intense
- T2 Slight hyperintense
- High vascularization around tumor
- Enhancement significant



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## Brain Tumor

**Acoustic neuroma**

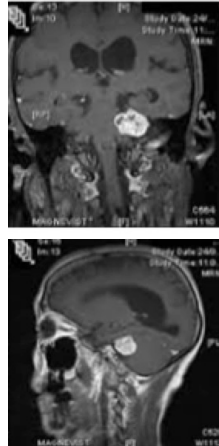
- High incidence
- Located in internal auditory canal

**CT**

- No calcification
- Slight hyperdense
- Post contrast enhancement

**MR**

- T1 Isointense
- T2 Hyperintense
- Enlarged internal auditory canal
- Post contrast enhancement




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## Cerebro-vascular disease KCS KEY CLINICAL SKILLS

- Angiography
- Hypertensive intra-cerebral hemorrhage
- Intra-cranial aneurysm
- Brain infarctions
- Multiple sclerosis

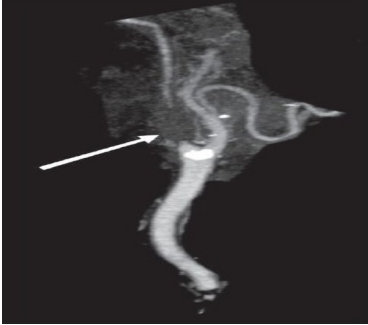


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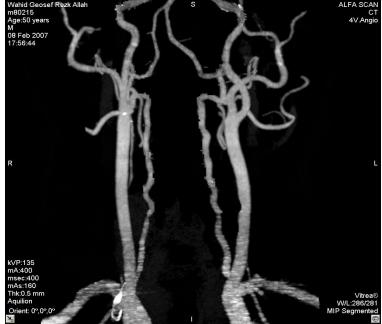
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## Cerebro-vascular disease KCS KEY CLINICAL SKILLS

### CT angiography neck



Carotid bifurcations



Carotid arteries

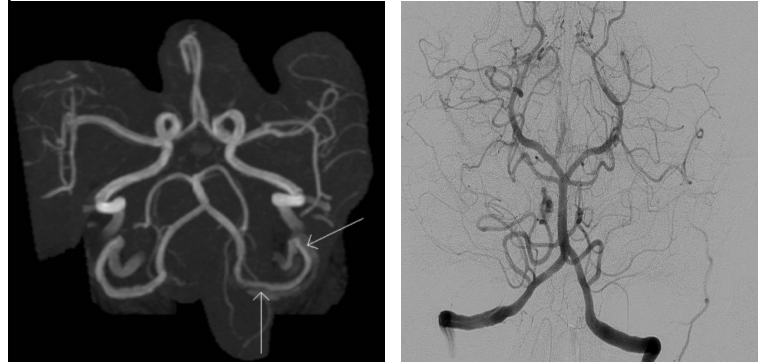
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## Cerebro-vascular disease



### CT angiography neck



Vertebral arteries

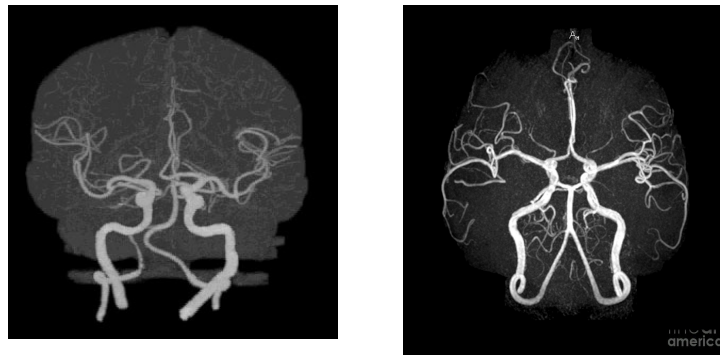
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## Cerebro-vascular disease



### CT angiography intra-cranial



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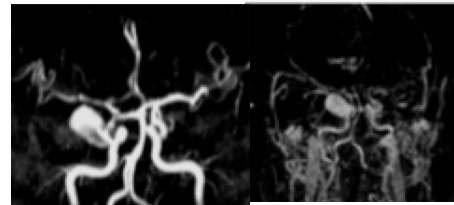
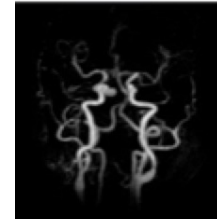
## Cerebro-vascular disease



### Intra-cranial aneurysm

#### Angiography

- May demonstrate aneurysm prior to impending rupture



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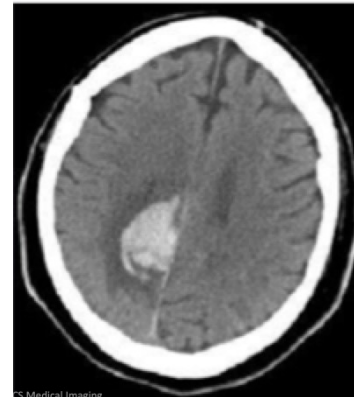
## Cerebro-vascular disease



### Hypertensive intra-cranial hemorrhage

#### CT appearance

- Ellipse-shaped high-density mass
- Surrounding edema
- Hemorrhage breaking into ventricle
- Mass effect
- Cerebral hernia



© Medical Imaging

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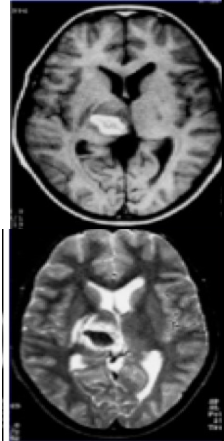
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## Cerebro-vascular disease

### Intra-cranial hemorrhage

#### MR appearance – acute phase

Stage	T1	T2
Super acute (< 6 H)	Iso intense	Hyper intense
Acute (7H-3D)	Iso intense	Hypo intense
Sub-acute (4D-4W)	Hyper intense	Central iso intensity surrounded by hyper intensity



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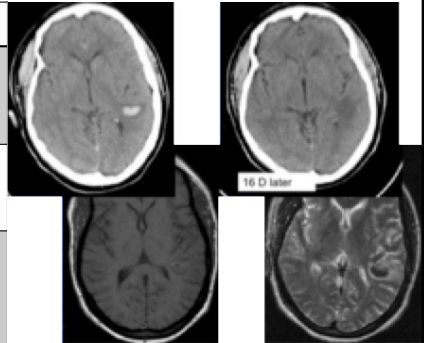
175

## Cerebro-vascular disease

### Intra-cranial hemorrhage

#### MR appearance –sub- acute phase

Stage	T1	T2
Super acute (< 6 H)	Iso-intense	Hyper intense
Acute (7H-3D)	Iso-intense	Hypo intense
Sub-acute (4D-4W)	Hyper intense	Central iso-intensity surrounded by hyper intensity



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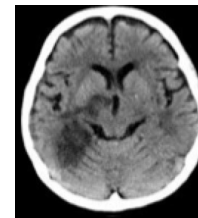
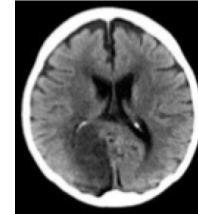
## Cerebro-vascular disease



### Brain infarction

#### CT

- Gray & white matter junctions vanish < 3Hr
- Direct signs
  - low density
- Indirect signs
  - Gyri swelling
  - Sulci disappearing
  - Ventricular compression



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## Cerebro-vascular disease



### Brain infarction

#### MR

After 36 hours

- Uniform hypodensity of gray & white matter of the right middle cerebral artery distribution



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## Cerebro-vascular disease

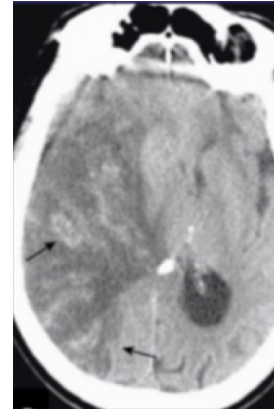


### Brain infarction

#### MR

After 4 days

- Increase in mass effect with transfalcial herniation
- Streak hyperdensity – reperfusion hemorrhage



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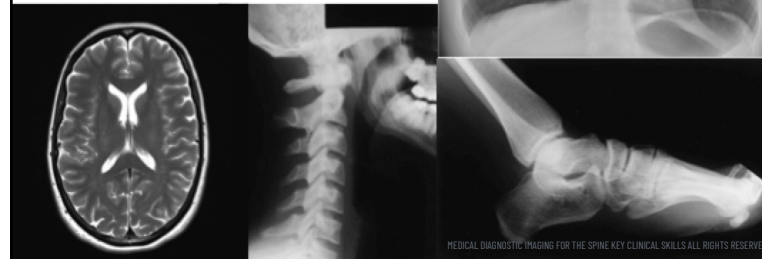
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## Medical Imaging for the spine



### Unit 5

### Lumbar spine 1



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## Radiographic Evaluation – Lumbar Spine



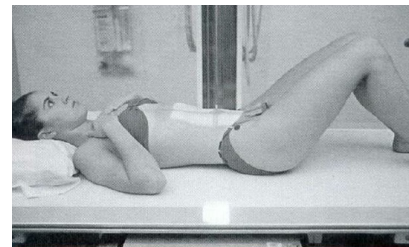
- **Standard 3-views**
  - Antero-posterior
  - Lateral
  - L5-S1 lateral “coned view”
- **Oblique views**
  - (high radiation exposure)
  - specialty view – only order if absolutely necessary



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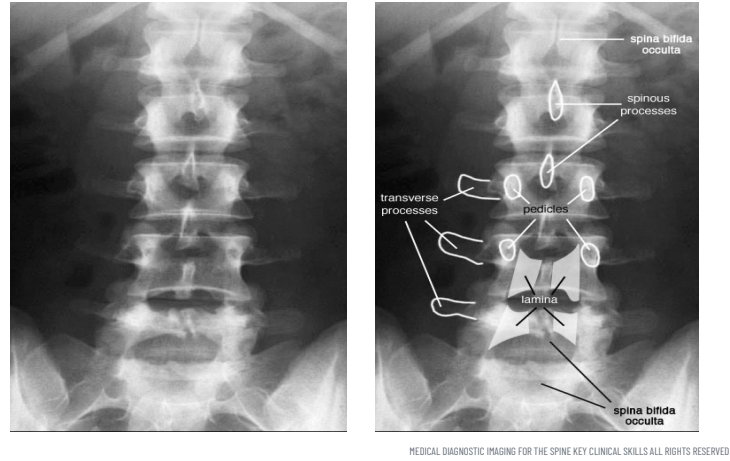
## Lumbar Antero-Postero (A-P)



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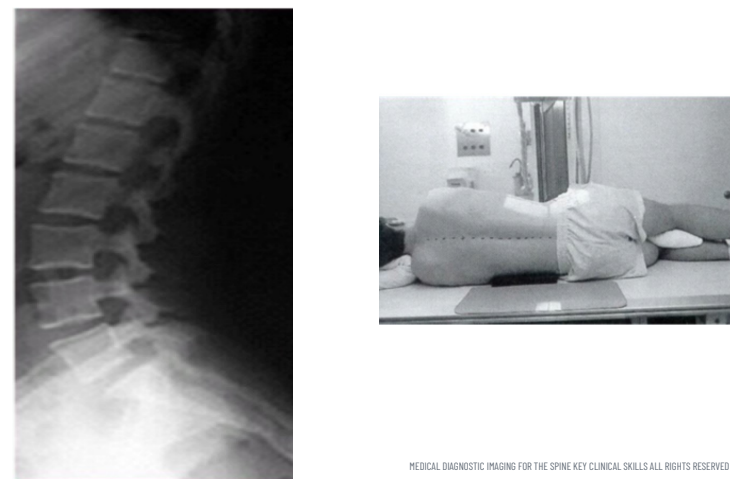
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## What does the A-P show us?



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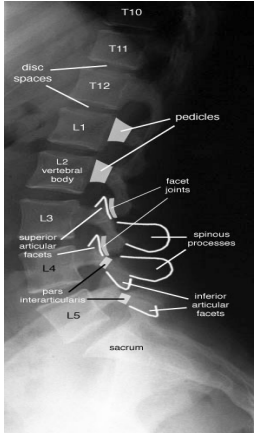
## Lumbar Lateral View



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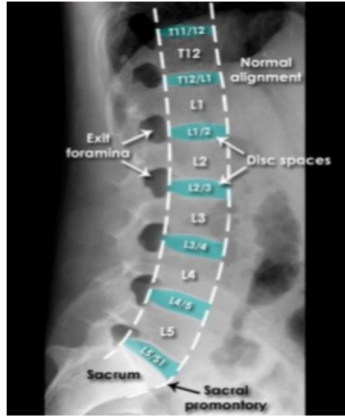
### What does the lateral projection show us?

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### Lateral view

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## Lateral view

The image shows a lateral view of the spine. On the left is a full-length lateral radiograph. On the right is a magnified view of the L2-L4 levels. Labels include: Facet joint (pointing to the joint between the superior articular process of one vertebra and the inferior articular process of the one above), SP (Spinous Process), P (Pedicle), Superior articular process, Pars interarticularis (a small gap between the superior and inferior articular processes), and Inferior articular process. The vertebrae are labeled L2, L3, and L4.

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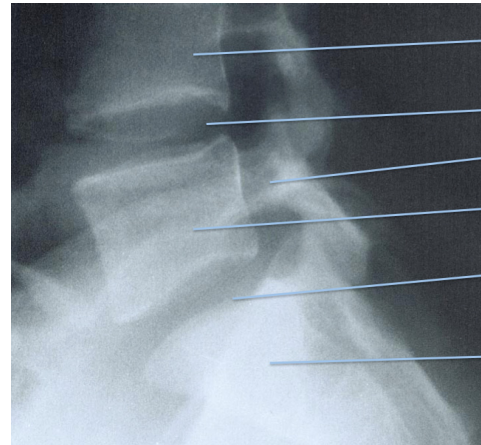
## L5-S1 Spot – “Coned view”

The image shows a spot view of the L5-S1 level. On the left is a radiograph of the L5-S1 spot. On the right is a photograph of a patient lying on their side on a table, with a black rectangular marker placed over the L5-S1 level to indicate the area to be imaged.

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## What does the Coned view show us?



- L4 vertebrae
- L4/5 disc space (slight parallax distortion)
- Pars inter-articularis L5
- L5 vertebrae
- L5/S1 disc space (minimal parallax distortion)
- Body of sacrum

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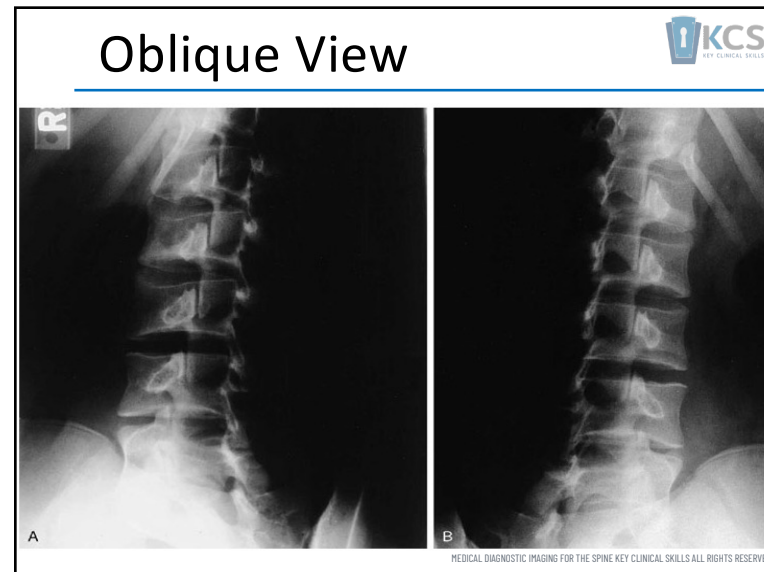
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## Lumbar oblique

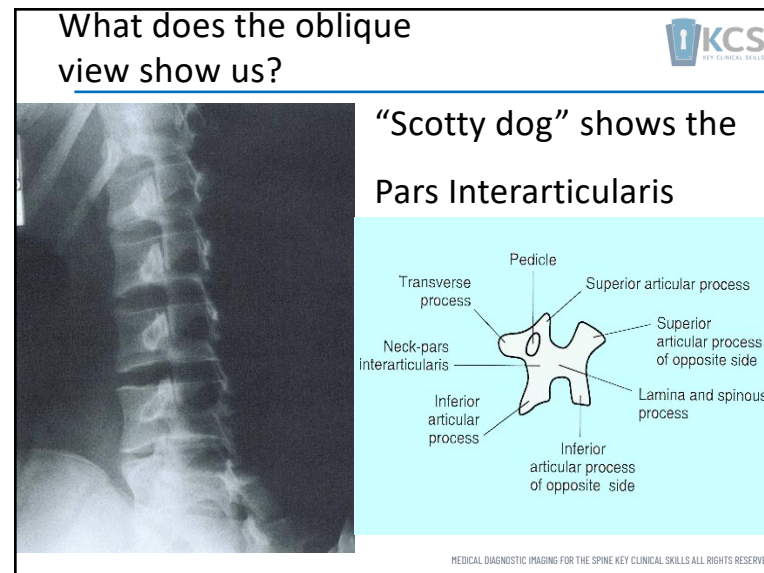


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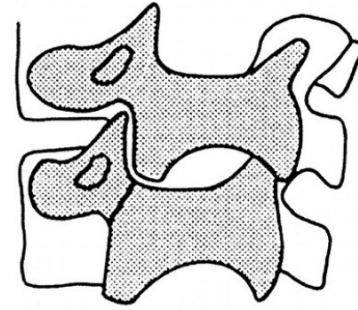


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## What if the “dog” has a collar



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## Indications for advanced spine imaging

- Cauda equina syndrome
- Suspicion of underlying systemic disease
- Progressive neurological deficits
- Potential surgical candidates



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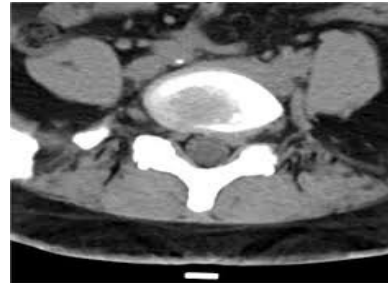
## CT Scan in disc herniation

### Advantages

- Highly accurate and non-invasive tool in the evaluation of spinal disease
- Provides superior imaging of cortical and trabecular bone compared to MRI
- Provides contrast resolution and identifies root compressive lesions
- Helps differentiate between bony osteophyte and soft disc
- Helps diagnose foraminal encroachment of disc material

### Disadvantages

- Cannot differentiate scar from disc tissue
- Cannot differentiate annulus from nucleus



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## CT Scan in spinal stenosis

- It allows direct visualization of the offending agents such as osteophytes
- It can be combined with myelogram to obtain more details
- A mid-sagittal diameter or 1-mm or less and AP diameter or of the lateral recess of 3 mm or less is considered abnormal

- Sagittal reconstructions useful in assessing foraminal stenosis
- Loss of epidural fat can be fairly well delineated
- In patients with pacemakers or other metal implants contraindicating MRI, a CT myelogram is the only reliable imaging study before surgery

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## MRI advantages



- Most accurate and sensitive modality for subtle spinal pathologies
- Gives useful information about size and contour of the foramen and conus
- Helps to assess the extradural CSF interface and central canal dimensions
- There is no radiation exposure
- Entire lumbar spine is imaged



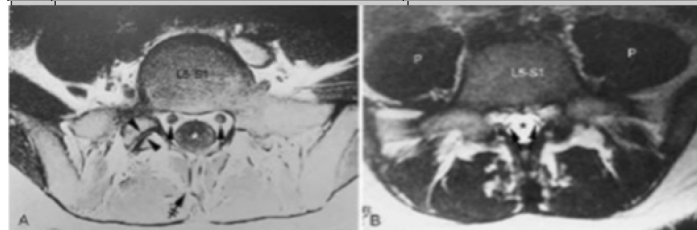
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## T1 vs T2



	T1	T2
Fat	Bright	Less bright
Fluid	Dark	Bright
Uses	Study the anatomy the anatomy of cord & nerve Roots & cord	Study the pathological changes in spine Differentiate the nucleus from annulus



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## Contrast enhanced MR



- Gadolinium labeled diethylenetriaminepentaacetate (Gd-DTPA)
- Administered intravenously and then MR scan done

### Advantages

- Displays the inflammatory reaction critical to the pathophysiology of radicular pain or radiculopathy
- Allows discrimination of scar from recurrent disc material



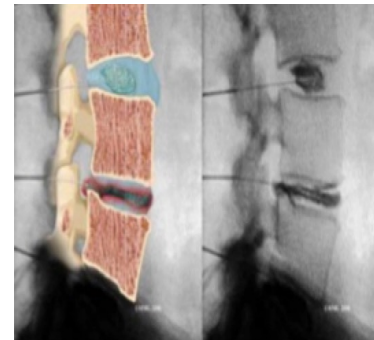
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## Discography - Uses



- Evaluate equivocal abnormality seen on CT or MR
- Isolate a symptomatic disc among multiple level abnormality
- Diagnose a lateral disc herniation
- Establish discogenic cause of symptoms
- Select fusion levels
- Evaluate previously operated spine
- Distinguish between mass effect of scar tissue and disc material




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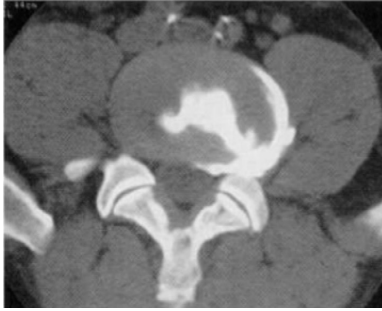
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## L4/5 Discogram




- Demonstrates large left posterolateral radial annular tear
- Associated with a left foraminal and extra-foraminal herniation



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## Myelography



Unnecessary if clinical and imaging findings are in complete agreement

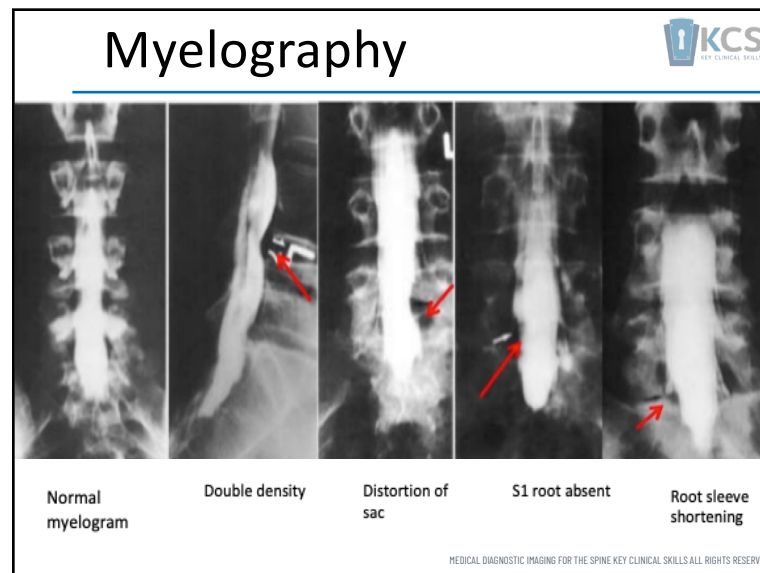
**Indications:**

- Suspicion of an intra-spinal lesion
- Patients with spinal instrumentation
- Questionable Dx resulting from conflicting clinical findings & other studies
- Marked bony degenerative change that may be understated in MR



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## Imaging osteoporosis

- Plain film X-rays do not show osteopenia until bone loss is > 30%
- DEXA (Dual Energy X-ray Absorbptiometry is preferred method to quantify bone density
- Results are given as % of mean
- Normal bone density is within 1 SD of young adult males
- 1-2.5 SD < mean = osteopenia
- > 2.5 SD < mean = osteoporosis

The image shows a close-up of a vertebral body, likely from a lumbar vertebra. The bone structure is highly porous and irregular, with many small holes and thinning of the bone walls, which is characteristic of osteoporosis.

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## Trauma



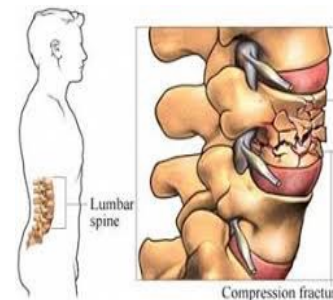
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## Lumbar spine Trauma



### The most typical lumbar spine fractures:

- Wedge compression fractures
- Compression burst fractures with fragments that are retro-pulsed
- Fracture of the pars interarticularis “spondylolysis” (if bilateral may allow anterior translation “lytic spondylolysis”)



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### 3 Column system of the Thoraco-lumbar spine



#### Anterior

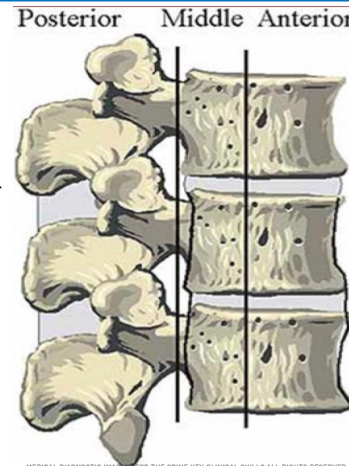
- Anterior longitudinal ligament
- Anterior ½ intervertebral disc
- Anterior ½ vertebral body

#### Middle

- Posterior ½ intervertebral disc
- Posterior ½ vertebral body posterior longitudinal ligament

#### Posterior

- Pedicles
- Facet joints
- Laminae
- Ligamentum flavum
- Interspinous ligament
- Intertransverseligament
- Interspinous ligament



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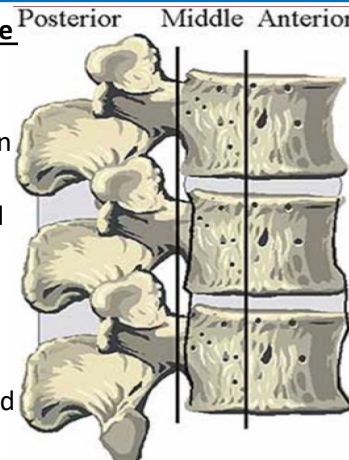
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### Three column concept of spinal stability



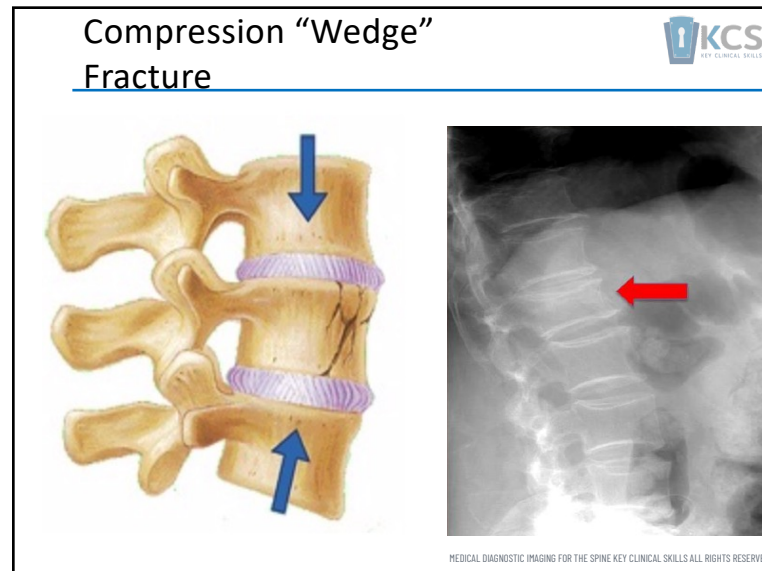
#### Damage to more than one of the columns makes for an unstable injury

- Damage to the middle column is critical and is more serious.
- Unlikely that a fracture would affect the middle column alone.
- If this region is broken, it is very likely that there is damage in front or behind and the whole spine is unstable.

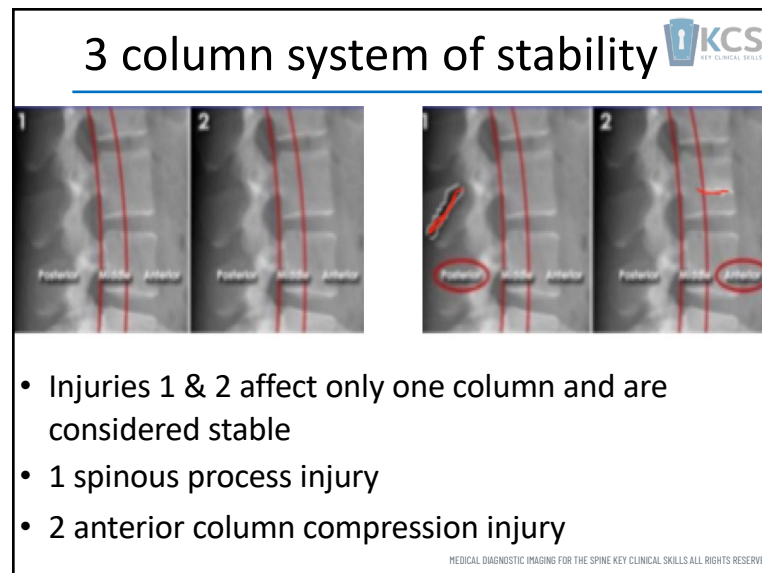


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- Injuries 1 & 2 affect only one column and are considered stable
- 1 spinous process injury
- 2 anterior column compression injury

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## Stable or unstable? KCS KEY CLINICAL SKILLS



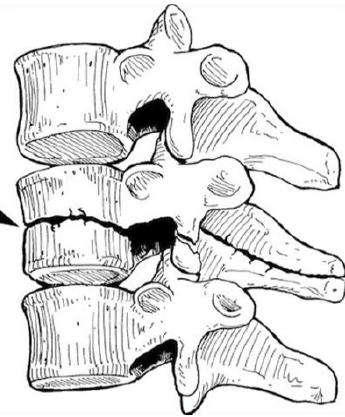
- Injuries 3 & 4 affect 2 or more columns and are considered unstable
- 3 burst fracture
- 4 flexion-distraction “chance” injury

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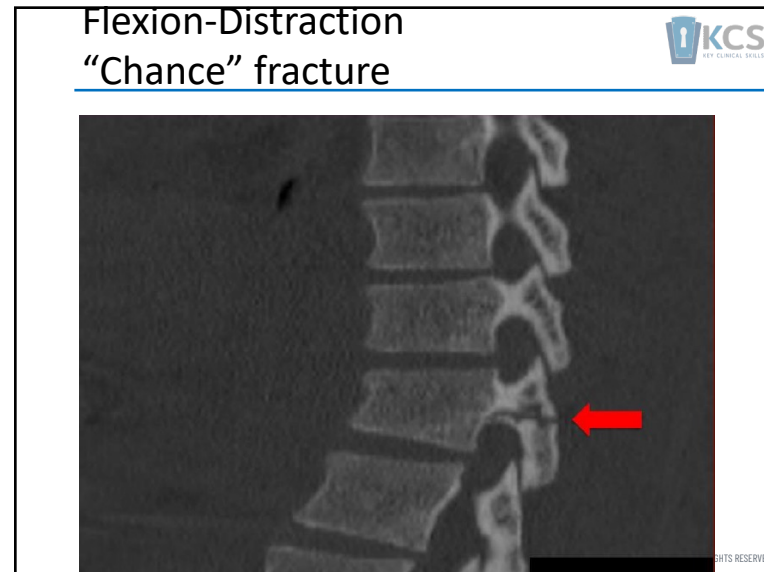
## Flexion-Distraction “Chance” fracture KCS KEY CLINICAL SKILLS

- Flexion-distraction injury (usually L1/2)
- Head-on with lap belt only
- Seat belt becomes the axis of rotation
- CT more sensitive than x-ray
- Up to 50% have associated blunt abdominal trauma (Spleen, Pancreas, Liver)

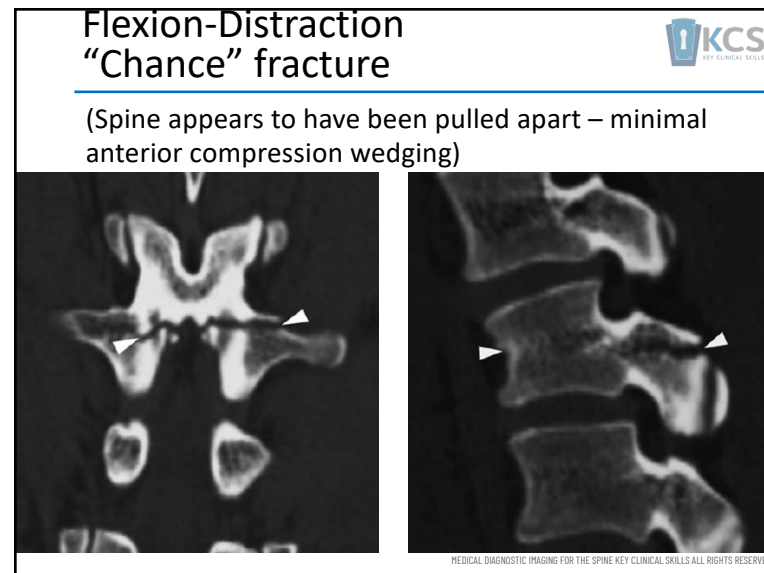


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## Compression Fracture



- Commonly seen in lower thoracic/ upper lumbar segments
- Often associated with fall onto buttocks “Grandad goes skating / Grandma goes tobogganing”
- May be idiopathic or pathological (osteoporosis)
- Usually very stable



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## Insufficiency fracture



- Commonly seen in lower thoracic/ upper lumbar segments
- Often associated with fall onto buttocks “Grandad goes skating / Grandma goes tobogganing”
- May be idiopathic or pathological (osteoporosis)
- Usually very stable



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### So is this fracture “stable”?



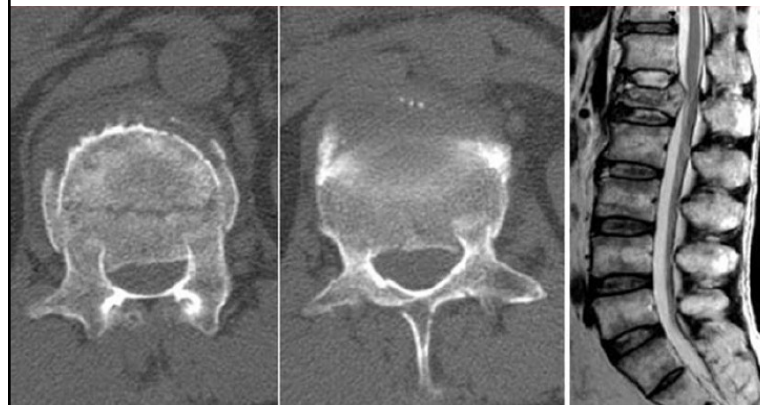
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### So is this fracture “stable”?




**Unstable** – because it is a “burst” not a compression fracture




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Risk factor for spinal fracture 		
Risk factor	Context	Raised suspicion
Osteoporosis	History of osteoporosis Family history of osteoporosis Previous osteoporotic fracture have 4-5 X increased risk of vertebral and 2-8 X increased risk of hip fracture	Previous osteoporotic fracture Concurrent osteoporotic risk factors
Corticosteroid use	Oral corticosteroids: <ul style="list-style-type: none"> <li>• 7.5mg for &gt; 3 months</li> </ul> Inhaled corticosteroids <ul style="list-style-type: none"> <li>• Inconclusive evidence</li> </ul>	Steroid use of > 7.5 mg over 3 months
Previous history of cancer	Decreased bone density especially in the thoracic spine (70% of cases)	History metastatic bone cancer of cancer
Severe trauma	Fall of 5 stairs or 1 meter Flexed posture at time of trauma increases risk in minor trauma	Immediate spinal pain post-injury Focal tenderness in midline of spine


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Risk factor for spinal fracture 		
Risk factor	Context	Raised suspicion
Female gender	Women with: <ul style="list-style-type: none"> <li>• Late menarche (&gt; 16 yrs.)</li> <li>• Early menopause (&lt; 45 yrs.)</li> </ul>	Women with history of late menarche and/or early menopause
Older age	Spinal fractures found in: <ul style="list-style-type: none"> <li>• 12% women &gt; 50-70 yrs.</li> <li>• 20% &gt; 70 yrs.</li> </ul> 70% unaware of fracture	<ul style="list-style-type: none"> <li>• Women &gt; 70 yrs.</li> <li>• Men &gt; 75 yrs.</li> </ul>
Previous history of spinal fracture	Past spine fracture: <ul style="list-style-type: none"> <li>• 4-5 X increased likelihood of spine fracture in 1 yr.</li> <li>• 2-8 X increased likelihood of hip fracture in 1 yr.</li> </ul>	Previous history of low-impact spinal fracture
History of falls	Parkinsonism, MS, Dementia, alcoholism, malnutrition increase risk of falls	Comorbidities that increase risk of falls


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Symptoms of spinal fracture 		
Symptoms	Context	Raised suspicion
Thoracic pain	70% non-traumatic spinal fractures occur in thoracic spine	Past history of: <ul style="list-style-type: none"> <li>• Cancer</li> <li>• Myeloma</li> <li>• Osteoporosis</li> </ul>
Severe pain	In patients with a past history of LBP, a new, different and severe pain unlike past episodes	Description of an unfamiliar and worsening pain
Neurological symptoms	Neurological deficits rare in non-trauma-related spine fracture	Bilateral or quadrilateral possibly neurological symptoms including: <ul style="list-style-type: none"> <li>• Gait disturbance</li> <li>• Coordination</li> <li>• Bowel/bladder disturbance</li> </ul>

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Signs of spinal fracture 		
Sings	Physical assessment	Raised suspicion
Spine tenderness	Percussion over spine may reveal tenderness Vibration over mid-line spine with 128 Hz tuning fork	Tenderness or reproduction of symptoms on palpation, percussion, vibration
Neurological signs	Examination of the: <ul style="list-style-type: none"> <li>• Upper motor neuron system</li> <li>• Lower motor neuron system</li> </ul>	Symptoms in the limbs Coordination disturbances Bowel/bladder disturbances
Spinal deformity	Observable and/or palpable gibbus deformity	New change in spine shape/angulation related to trauma in a know osteoporotic patient
Contusion / abrasion	May indicate site of trauma and should be considered if associated with a painful site	Abrasion following trauma associated with midline bony tenderness

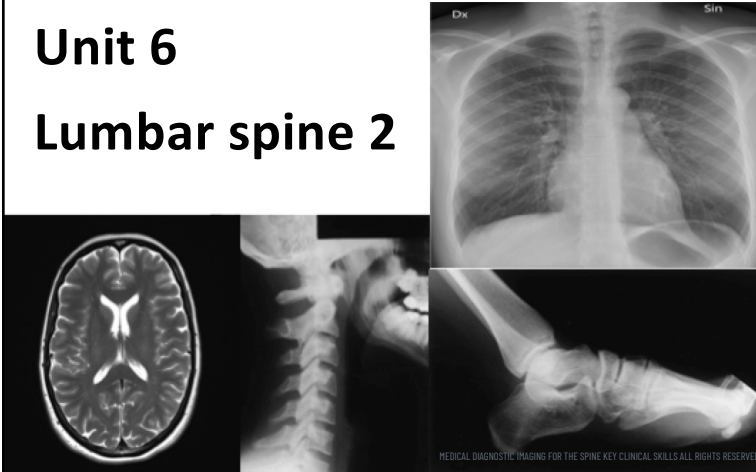
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# Medical Imaging for the spine

## Unit 6

### Lumbar spine 2



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# Young skin



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# Aging skin

The diagram, titled "structural atrophy", illustrates the degradation of skin's structural proteins. On the left, a network of blue collagen fibers and green elastin fibers is shown. On the right, the skin is depicted as yellow, irregularly shaped, and sagging. Labels "collagen", "elastin", and "sagging skin" are positioned below the diagram. To the right of the diagram is a close-up photograph of an older man's face, showing wrinkles and sagging skin.

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# How a person's looks change but ...

Two side-by-side photographs of Mick Jagger. The left image shows him as a young man with dark, wavy hair, singing into a microphone. The right image shows him as an older man with long, grey hair, also singing into a microphone. The contrast highlights the changes in his appearance over time.

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Does it relate to how they function? 



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How a spine's looks change but ... 



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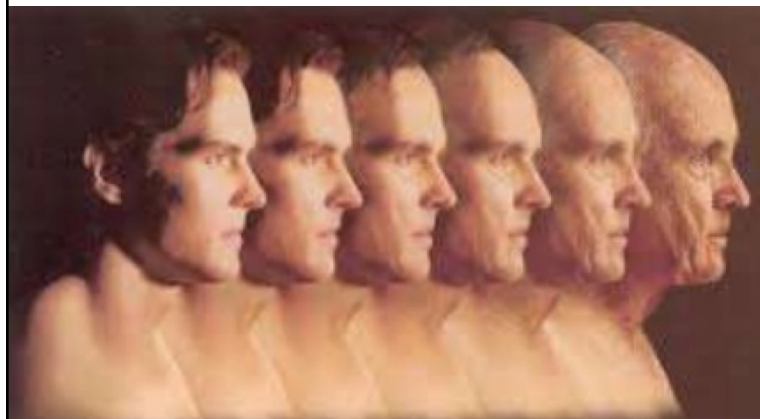
Does that relate to how it functions?



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We would not call these changes  
“Degenerative skin disease”



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So why call these changes  
 “Degenerative Disc Disease” (DDD)

healthy      mild deg.      moderate deg.      severe deg.

(height loss)      (annular tears)      (disc disruption)

(water content loss)

(osteophytes)      (endplate sclerosis)

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Position Statement from AAOMPT

“To discontinue the use of the term degenerative disc diseases and the inaccurate implication of a clinical relationship between age-related changes in the disc and patient symptoms”

AAOMPT 2019

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## Position Statement from AAOMPT

“To discontinue the use of the term degenerative disc diseases and the inaccurate implication of a clinical relationship between age-related changes in the disc and patient symptoms”

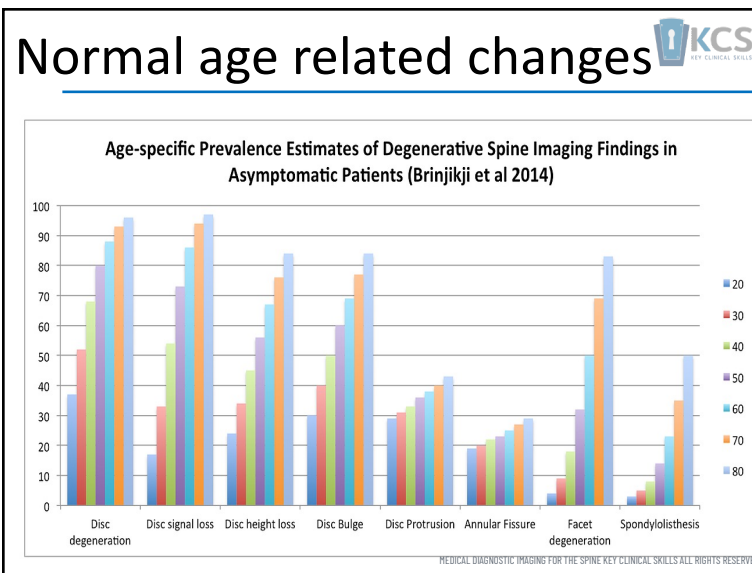
So let’s start by call these “Normal Age Related Changes” (NARC)



*AAOMPT 2019*

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## Normal age related changes

Did you know  
your MRI can  
be misleading?



If you take people without back pain and put them through a CT scan or MRI, you get some surprising results.

37% of 20 year olds  
80% of 50 year olds  
96% of 80 year olds  
Have "disc degeneration"

30% of 20 year olds  
60% of 50 year olds  
84% of 80 year olds  
Have "disc bulging"

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## Percent of lumbar MRI findings in asymptomatic lumbar spines

Investigation	Disc bulge	Disc protrusion	Disc extrusion	Disc pathology	Root compression
Boden et al.		20%			
Jensen et al.	52%	27%	1%	64%	
Boos et al.		63%	13%		4%
Greenburg et al.	39%	18%	18%	57%	
Weishaupt et al.	24%	40%	18%		4%
Wood et al.	53%	37%		63%	
Mean	38%	29%	9.5%	60.5%	4%

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## Imaging intervertebral disc pathology



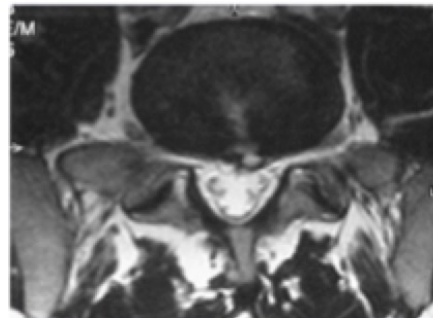
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## Annular tears



- Tears of the posterior annulus allows nucleus to come into contact with outer 1/3rd (nociceptor innervated)
- Attempts at repair of tear through neovascularization cause in-growth of nociceptors



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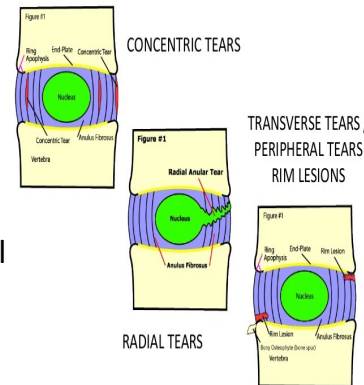
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## Annular tears



### Nomenclature

- Concentric
- Radial
- Transverse “Rim”
- Considered pathological and precursor to herniation
- High signal zone in posterior annulus on T2



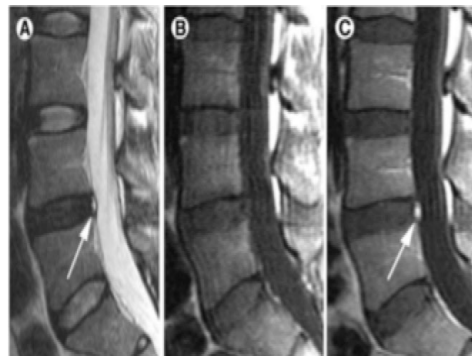
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## Annular tears




- T1 Contrast enhancing nidus in disc margin
- T2 High signal zone at edge of disc (which has low intrinsic signal)



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## CT discography








Figure # 4 Axial L4



Normal Axial CT Discogram  
Injected Dye  
Fig. #1



Grade 4 Tear  
Fig. #2

Black arrows point to concentric annular tear in disc periphery. White arrows point to central radial tear.

#1 the injected dye (black) does not leak out of the normal nucleus.


#2 A grade 4 radial tear. Note how the contrast has leaked out from the centre of the disc through a complete radial tear






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## CT discography

### Adams classification




Discogram type	State of disc degeneration
1. Cottonball	 <p>No signs of degeneration. Soft white amorphous nucleus</p>
2. Lobular	 <p>Mature disc with nucleus starting to coalesce into fibrous lumps</p>
3. Irregular	 <p>Degenerated disc with fissures and clefts in the nucleus and inner annulus</p>
4. Fissured	 <p>Degenerated disc with radial fissure leading to the outer edge of the annulus</p>
5. Ruptured	 <p>Disc has a complete radial fissure that allows injected fluid to escape. Can be in any state of degeneration</p>

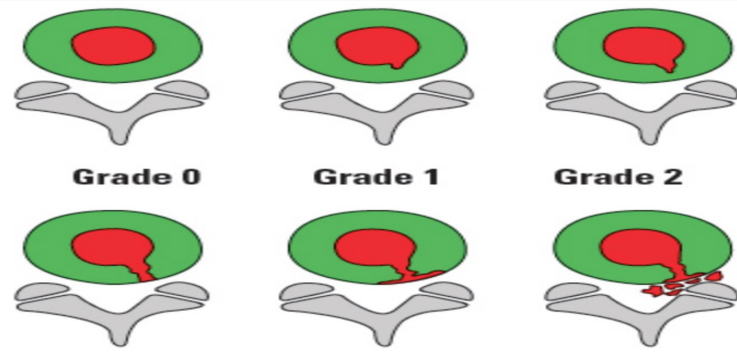
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## CT discography




### Modified Dallas Discogram Classification

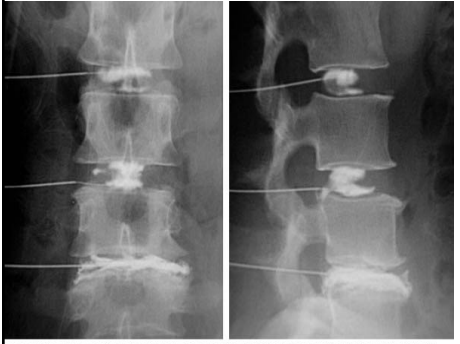


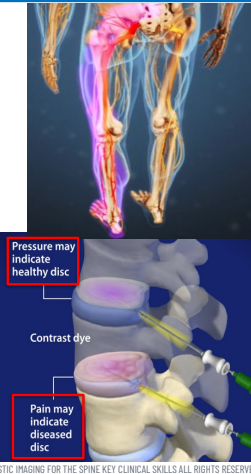
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## CT discography







Pressure may indicate healthy disc

Contrast dye

Pain may indicate diseased disc


Figure 4 Discographic patterns in a 43-year-old woman who had low back pain with radiation to the left calf. (A) Anteroposterior and (B) lateral radiographic projections show a normal bilobular L2/3 disc. There is small posteroinferior tear of the L3/4 disc that was asymptomatic. The L4/5 disc is decreased in height, and had extensive annular disruption and posterior protrusion. The L4/5 disc was also symptomatic.

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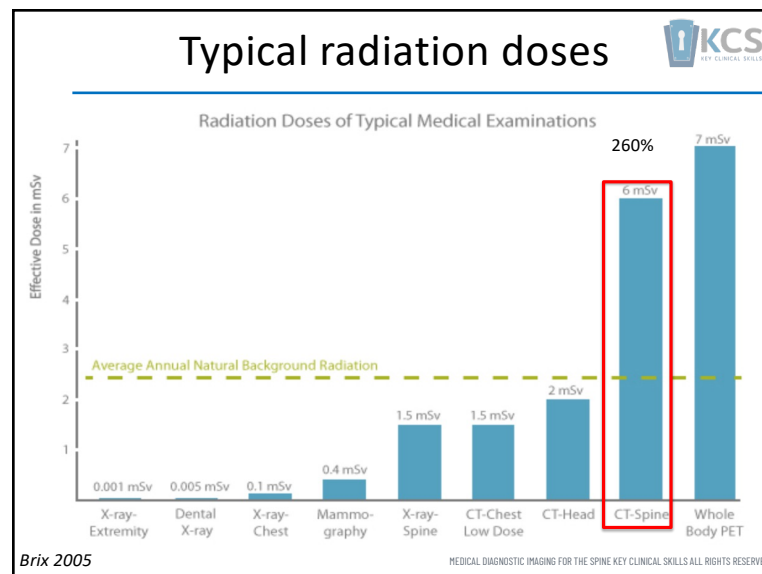
## Advantages of CT KCS KEY CLINICAL SKILLS

- Less expensive
- Greater availability
- Faster image times
- Less operator time
- Thinner slices
- Less loss of image quality (motion)
- Greater resolution power for cortical bone
- Easier imaging for patients with ferrous metal implants




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## Advantages of MR



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- Most accurate and sensitive modality for subtle spinal pathologies
- Gives useful information about size and contour of the foramen and conus
- Helps to assess the extradural CSF interface and central canal dimensions
- There is no radiation exposure
- Entire lumbar spine is imaged



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## Advantages of MR



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- Greater contrast resolution for soft tissue imaging
- No artifacts from interfering bone
- Less risk of missing disease as pathology missed on T1 is found on T2 and vice versa
- Greater image quality in non-axial planes

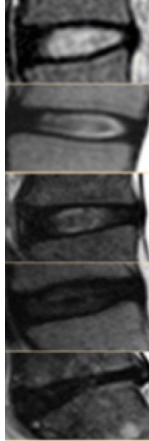


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## Normal disc age related changes

Grade 1	Disc has uniform high signal in the nucleus on T2	
Grade 2	Central horizontal line of low signal intensity	
Grade 3	High intensity in the central part of the nucleus with lower intensity in the peripheral regions of the nucleus	
Grade 4	Low signal intensity centrally and blurring of the distinction between nucleus and annulus	
Grade 5	Homogeneous low signal with no distinction between nucleus and annulus	

*Patharia 1987* MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Disc pathology terminology



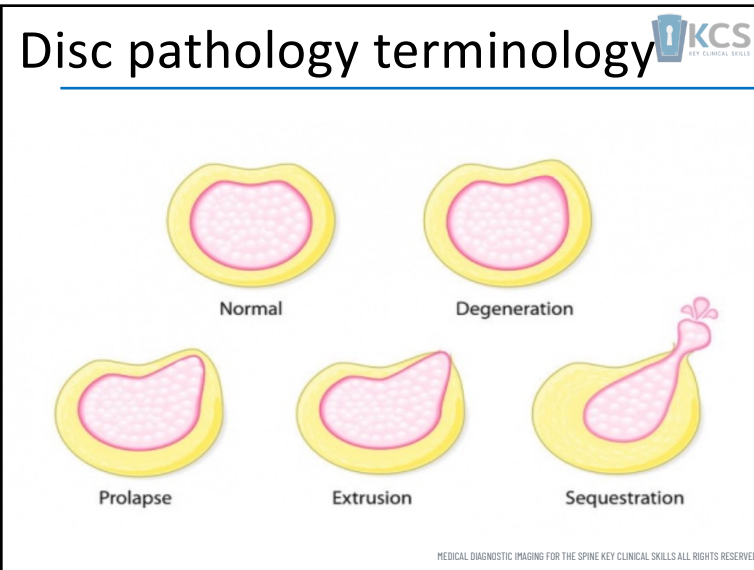
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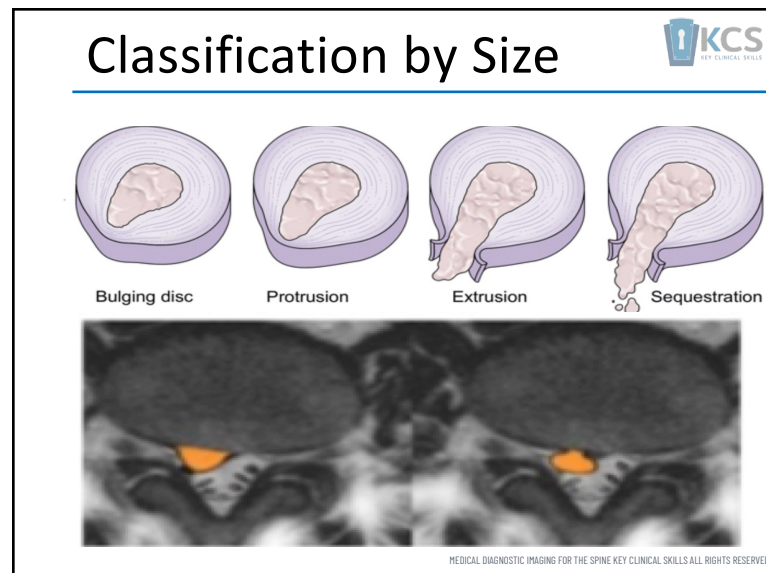
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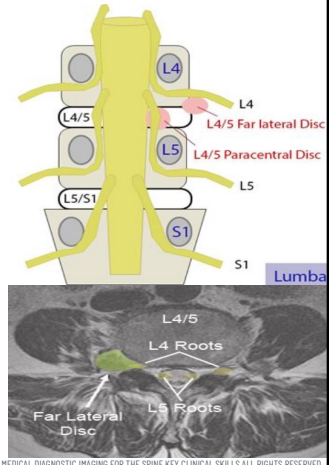


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Classification based on the location 


**Foraminal**  
**Extra foraminal**  
**Far lateral**

- Less common
- Herniated disc impinges on exiting root at same level (i.e. L4/5 disc affects L4 nerve root)



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Grading disc herniation 

Grade	Thecal sac deformation in vertebral canal
0 Absent	No visible disc material contacting or deforming thecal sac
1 Minimal	Disc material in contact with thecal sac
2 Moderate	Disc material deforming thecal sac A-P distance > 7mm
3 Severe	Disc material deforming thecal sac A-P distance < 7mm

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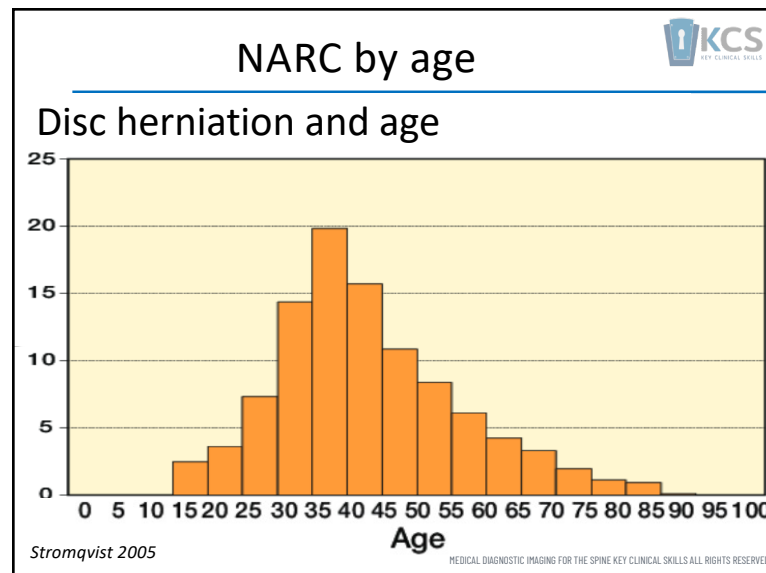
254

## Grading disc herniation

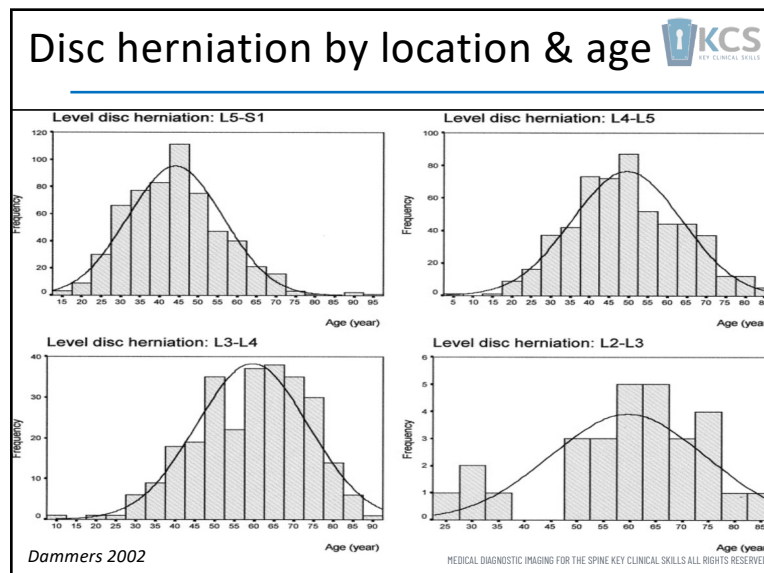
Grade	Spinal nerve deformation in lat. recess or IVF
0 Absent	No visible disc material contacting or deforming nerve
1 Minimal	Contact with disc material deforming nerve but displacement < 2 mm
2 Moderate	Contact with disc material displacing > 2mm nerve is still visible and not obscured by disc material
3 Severe	Contact with disc material completely obscuring nerve

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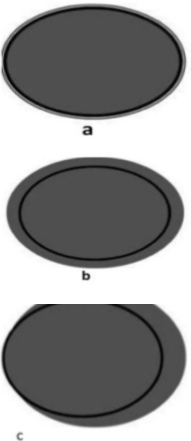


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## Nomenclature of disc pathology

### Disc bulge

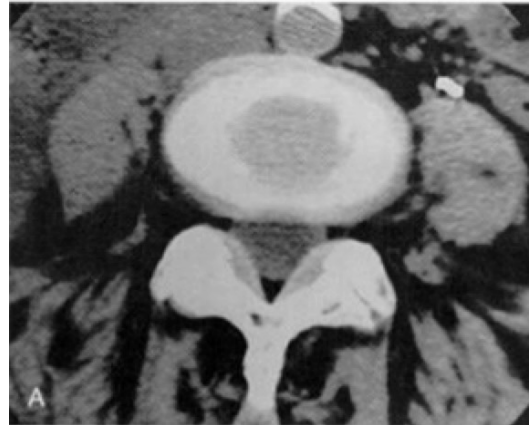
- Generalized or circumferential disc displacement (involving 50-100% of disc circumference)
- Can be:
  - Symmetrical
  - Asymmetrical
- Does not correlate with symptomatology
- Nucleus is fully contained by annulus
- Not a herniation
- May also be a “pseudo image” on CT secondary to volume averaging



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## Disc bulge



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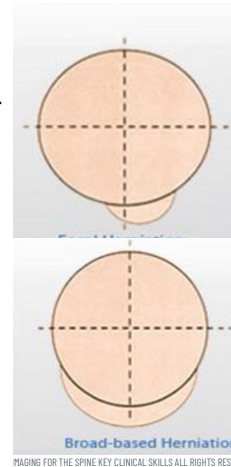
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## Nomenclature of disc pathology



### Herniated disc

- Term is used when the base of the disc is broader than any other diameter of the displaced material.
- Based on a two-dimensional assessment of the disc contour in the transverse plane, a protruded disc can be:
  - Focal (< 25% of the disc circumference)
  - Broad-based (25-50% of the disc circumference)



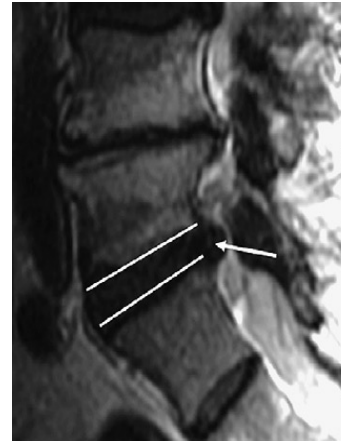
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## Herniated disc



- Less than 50% of circumference of disc
- May include;
  - Nuclear material
  - End plate cartilage
  - Fragmented apophyseal bone
  - Annular material
- Includes;
  - Protrusions
  - Extrusions
- **(Horse is pushing on inside of barn door)**



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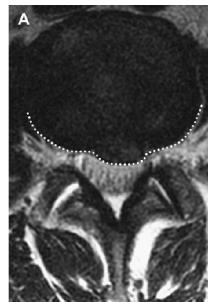
## Nomenclature of disc pathology



### Disc protrusions

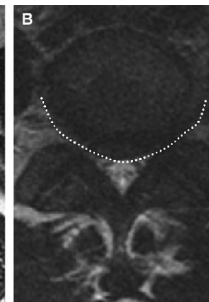
#### A. Focal

- Involves less than 90 degrees (50%) of disc circumference



#### B. Broad-based


- Involves greater than 90 degrees (50% of disc circumference)



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## Disc Protrusions



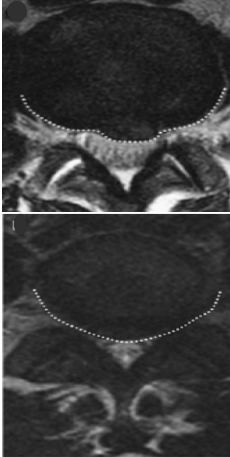
**A. Focal herniation**

- Involves less than 90 degrees
- <50% of disc circumference
- Younger population

**B. Broad-based bulge**

- Involves greater than 90 degrees
- >50% of disc circumference
- Older population


*Dammers 2002*



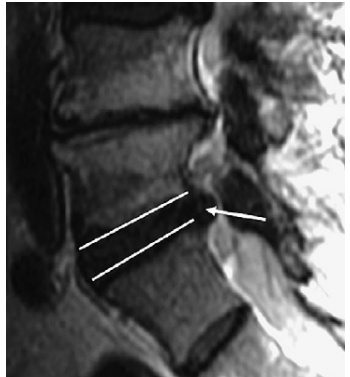
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## Protrusion



- Sub-classification of herniation
- Greatest distance of protruded material is less than the edges of the disc space
- (red line distance = white line distance)



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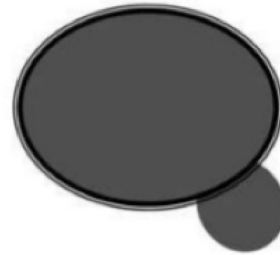
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## Nomenclature of disc pathology

### Disc extrusion

- Focal disc herniation
- The base against the parent disc is narrower than the diameter of the extruded disc



“The toothpaste sign”

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## Disc Extrusion

- Greatest distance of protruded material is more than the edges of the disc space
- **(horse's head is out of stable door)**



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## Disc Extrusion

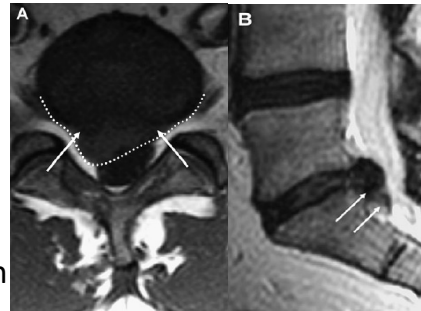


### Disc Extrusions

- Sub-classified into:

#### 1. Migration

- Disc fragment displaced away from site of extrusion but still in continuity
- **(horse is out of the stable)**



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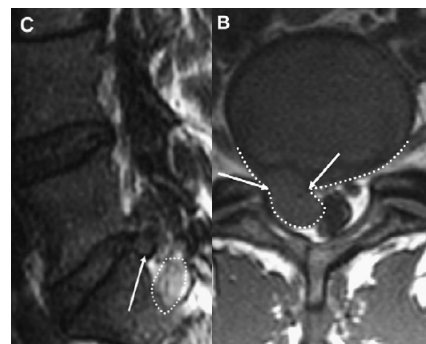
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## Disc Extrusion



### 2. Sequestration

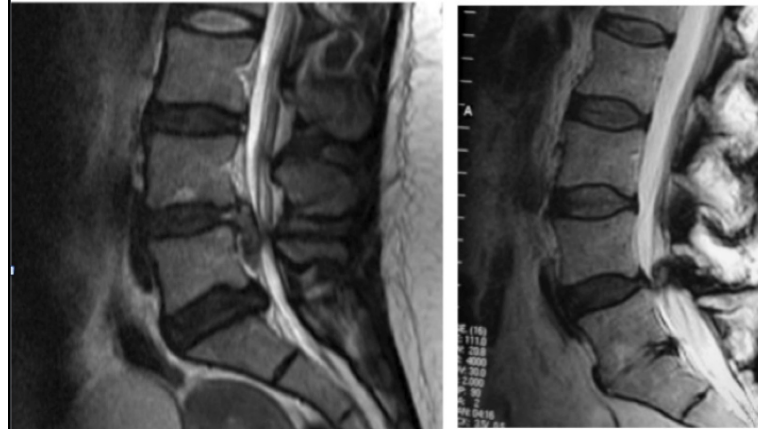
- Disc fragment displaced away from site of extrusion and no longer in continuity
- **(horse is in the field)**



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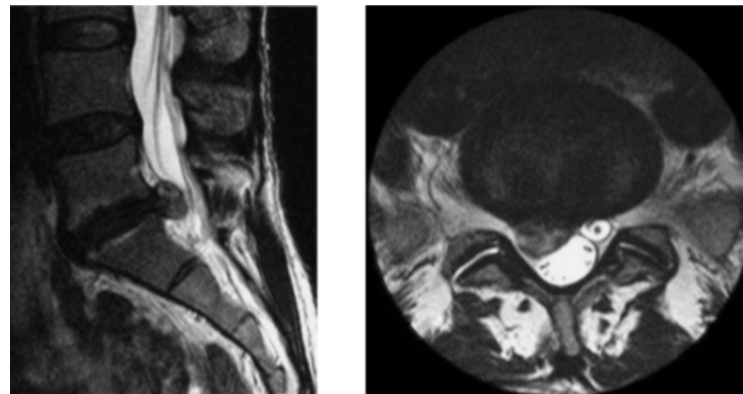
## Disc Extrusion



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## Disc Extrusion




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## Herniated disc




- Herniated discs in the cranio-caudal direction through a break in one or both vertebral end plates are referred to as “intra-vertebral herniation”
- (AKA “Schmorl’s nodes”.
- They are often surrounded by reactive bone marrow changes known as “Modic Changes”.















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## Modic changes



<b>Type I</b> Normal endplate, with no interruption.	No Modic changes	HEALTHY		
<b>Type II</b> Thinning of the endplate, no obvious break.		AGING		
<b>Type III</b> Focal endplate defect with established disc marrow contact but with maintained endplate contour.				
<b>Type IV</b> Endplate defects <25% of the endplate area.	Associated with Modic changes	DEGENERATIVE		
<b>Type V</b> Endplate defects up to 50% of the endplate area.				
<b>Type VI</b> Extensive damaged endplates up to total destruction.				

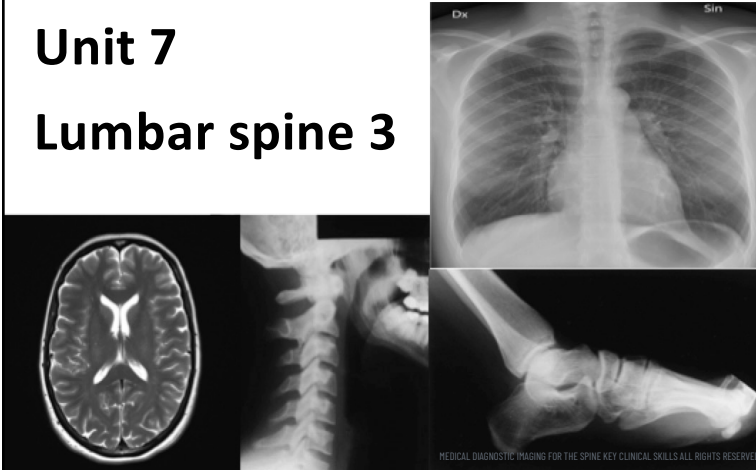
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## Medical Imaging for the spine

### Unit 7

### Lumbar spine 3



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## Lumbar Stability

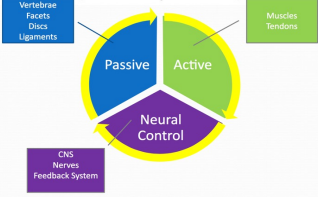
### Clinical Stability

“The capacity of the stabilizing system of the spine to maintain the intervertebral neutral zones within the physiological limits so that there is no neurological dysfunction, no major deformity and no incapacitating pain”

*Panjabi 1992*



Stabilization System  
(3 Subsystems)



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## Lumbar Instability

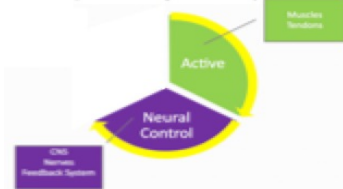
### Clinical Instability

“A significant decrease in the capacity of the stabilizing system of the spine to maintain the intervertebral neutral zones within the physiological limits so that there is no neurological dysfunction, no major deformity and no incapacitating pain”

*Panjabi 1992*



### Stabilization System (3 Subsystems)



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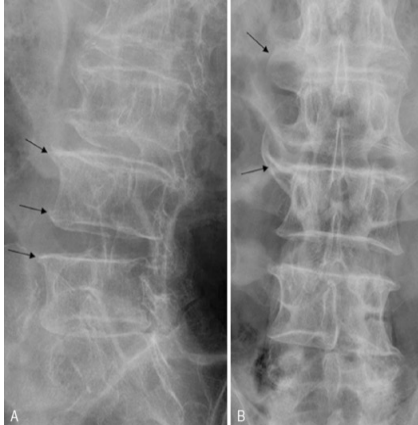
## X-ray signs of “instability”

### Indirect signs

- Disc space narrowing
- Sclerosis of end plates
- Traction spurs
- Osteophytes
- Vacuum sign

### Direct signs

- Translational abnormalities on dynamic films



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## Vacuum sign



### Central vacuum phenomenon

- Gas collection that fills large neo-cavity occupying both annulus & nucleus

### “Knuttson’s sign”

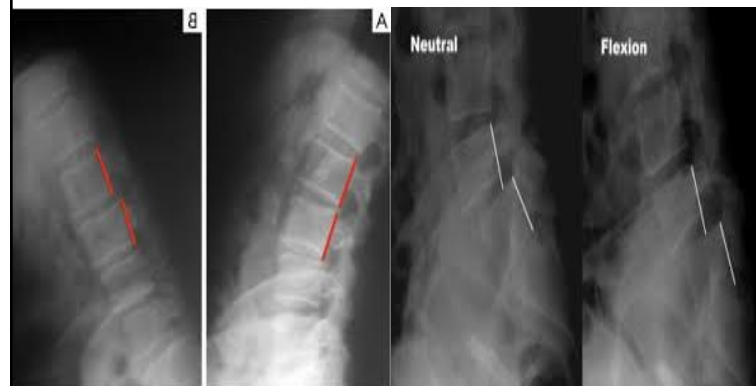
- Radiolucent defect
- Presence of nitrogen gas accumulations in annular fissures



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## Dynamic imaging



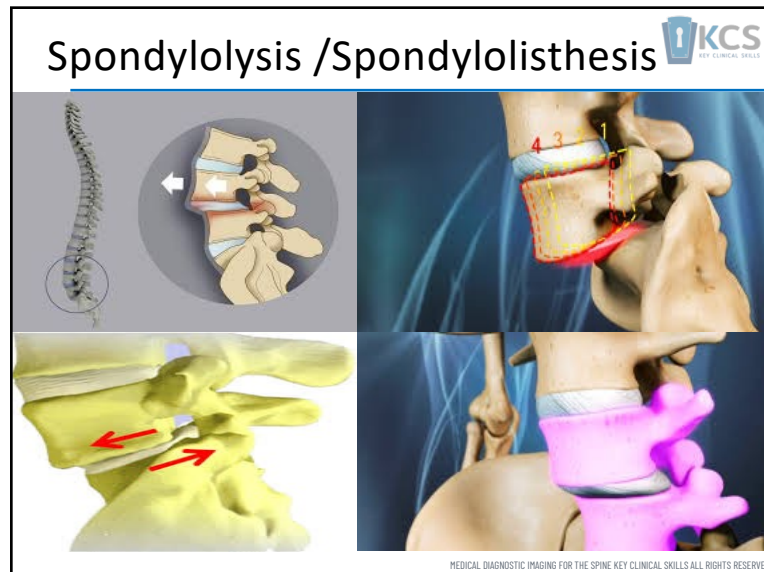
Mechanically “stable”

“Mechanically unstable”



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### Spondylolysis /Spondylolisthesis

- A lateral view is often sufficient to reveal a spondylolisthesis
- Significantly less radiation exposure than oblique views

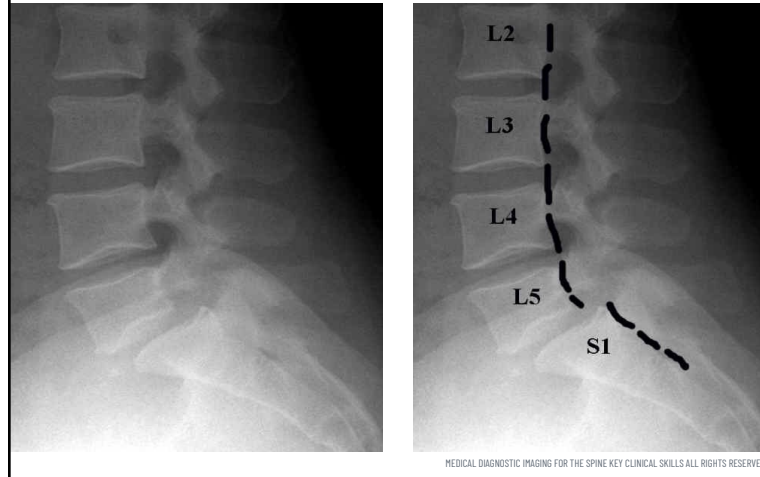


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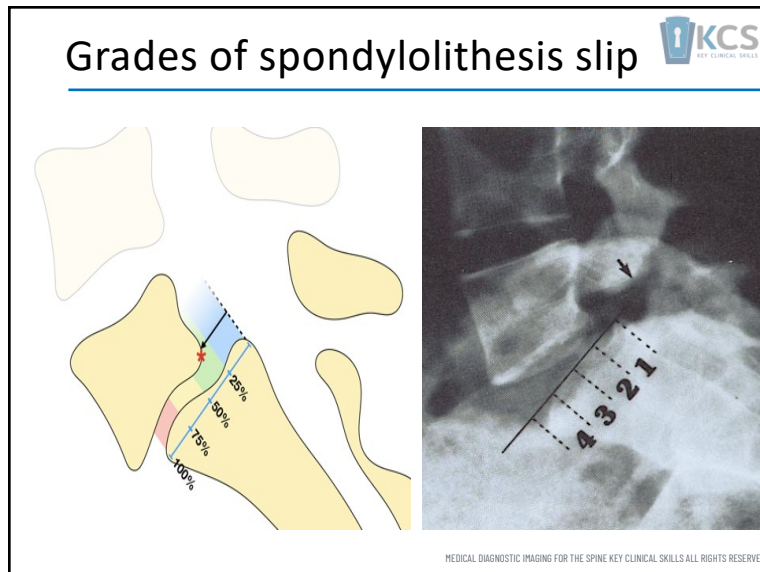
# What do you see?



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# Grades of spondylolisthesis slip



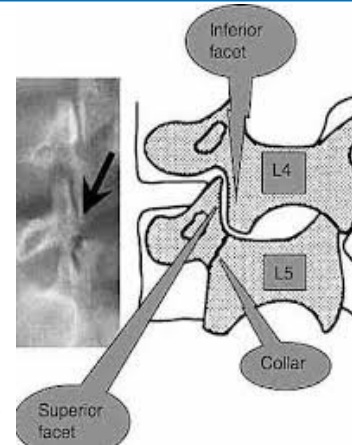
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## Oblique View



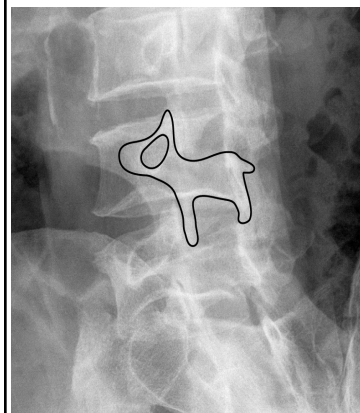
- Lateral view usually demonstrates spondylolysis (fracture) and/or spondylolisthesis (slippage)
- Oblique views show “collar on the Scotty dog”
- Involves significantly more radiation exposure



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## Oblique View



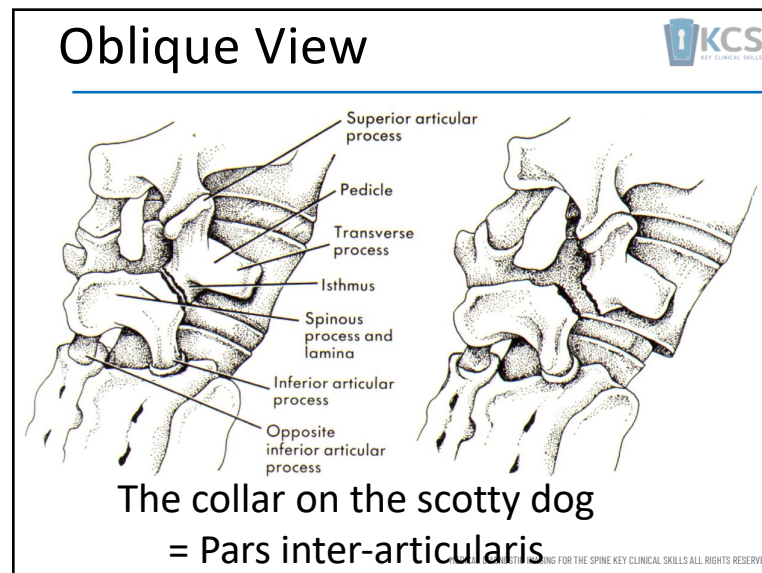
The “scotty dog”



The collar on the dog

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## Sub-types of spondylolithesis

### Dysplastic

- This occurs because of the malformation and abnormalities of the spinal joints.
- It is a rare type of spondylolithesis but tends to be rapidly progressive.

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## Sub-types of spondilolithesis

### Traumatic

- A very rare type which is associated with acute fracture of the interior facets.
- This may be treated in the same manner as other spinal fractures.



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## Sub-types of spondilolithesis

### Pathologic

- This type may occur following damage from an infection or metabolic bone disease.



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## Sub-types of spondilolithesis

### Iatrogenic

- Usually occurs in patients who underwent previous spinal surgery.



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## Sub-types of spondilolithesis

### Degenerative

- Caused by degenerative disc disease and facet arthritis.
- This type occurs in the L4 and L5 levels.



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## Sub-types of spondilolithesis

### Isthmic

- The most common form of spondylolisthesis
- Usually acquired between the ages 6-16 years of age.

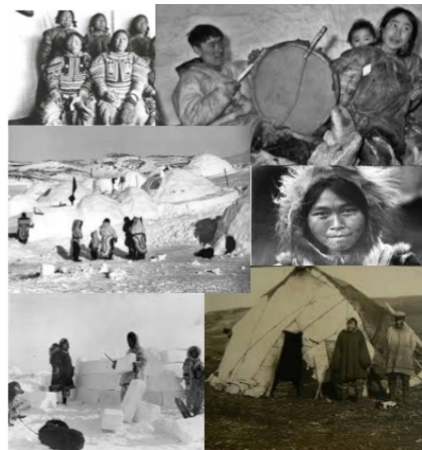


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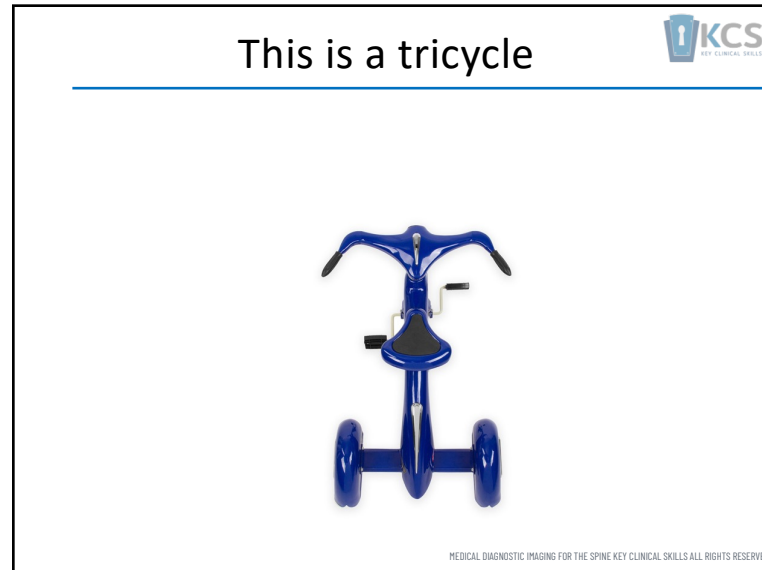
## Incidence of lytic Spondylololthesis

- Typically runs at 7%
- Normal levels in Inuit living non-traditional lifestyle
- However in nomadic Inuit skeletons estimated to be up to 50%

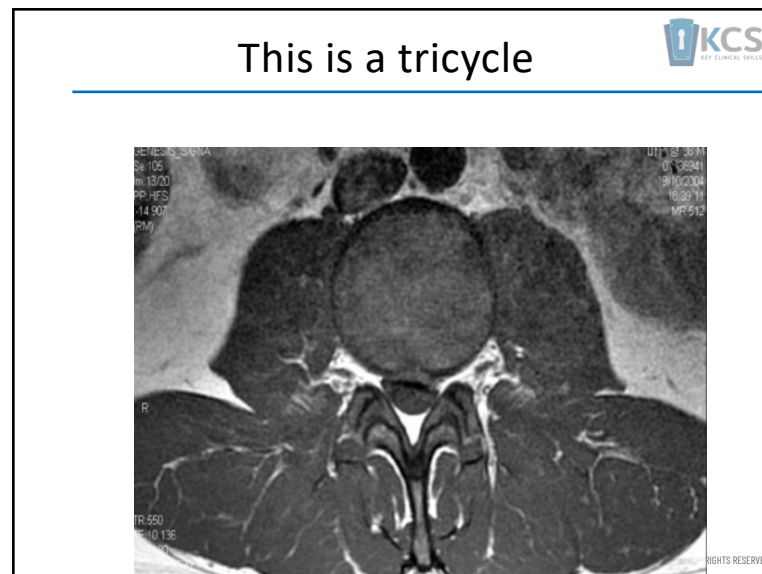


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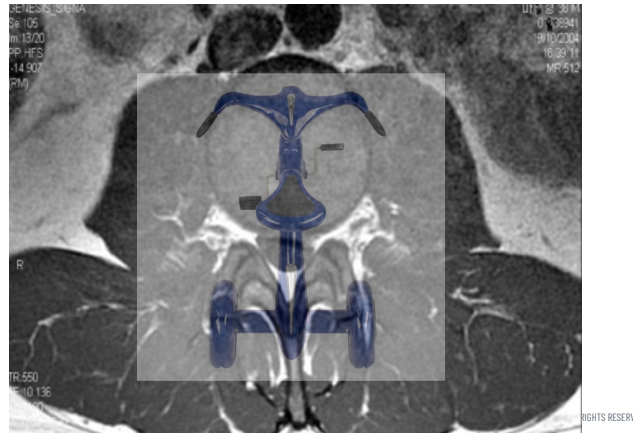


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This is a tricycle



295

This is a tricycle



Can you move the tricycle such that only one wheel turns?




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## Facet joint degeneration

Grade	Criteria	
0	Normal joint space (2-4 mm)	 <p style="font-size: 24px; margin-top: 10px;">Grade 1</p>
1	Narrowing of the joint space (<2mm) and/or small osteophytes and/or mild hypertrophy of the anterior processes	
2	Narrowing of the joint space and/or moderate osteophytes and/or moderate hypertrophy of the articular processes and/or mild sub-articular bone erosions	
3	Narrowing of the joint space and/or large osteophytes and/or severe hypertrophy of the articular processes and/or severe sub-articular bone erosions and/or sub-chondral cysts	


Parthea 1987
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## Facet joint degeneration



Grade 2



Grade 3

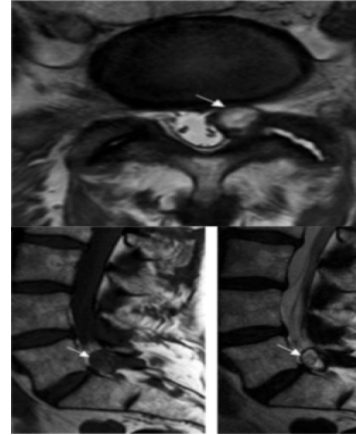
Parthea 1987
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## Synovial Cysts



- Peri-articular cysts of synovial membrane
- Filled with mucinous fluid +/- gas
- High T2 signal intensity = CSF
- High T1 signal intensity = blood
- May be related to thickening of ligamentum flavum
- May further narrow spinal canal



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## Spinal stenosis



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## Spinal stenosis

**Part of the normal aging process**

- Does not have to be symptomatic
- No clear relationship between symptoms and; race, occupation sex or body type

**Primary stenosis:**

- Congenital
- Relatively uncommon, patients generally younger

**Acquired stenosis:**

- Degenerative
- May become symptomatic over age of 50 yrs

**Etiology of Lumbar Stenosis**

Developmental

Degenerative Spondylolisthesis

Isthmic Spondylolisthesis

Adult scoliosis

Congenital

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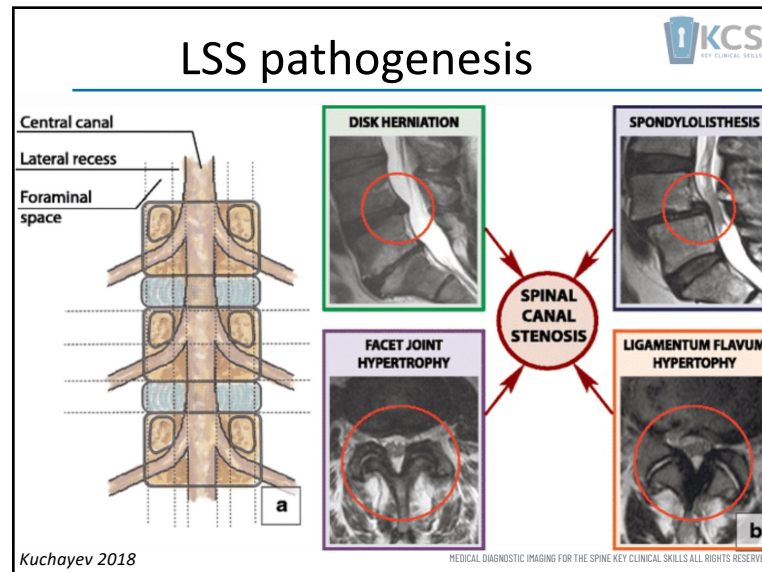
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## Spinal Stenosis - differentials

- Nonspecific back pain from spondylolysis without LSS
- OA of hips and knees
- Peripheral vascular disease “vascular claudication”
- Distal polyneuropathy
- Spinal cord vascular malformations
- Arachnoiditis
- Chronic inflammatory demyelinating polyneuropathy
- Sarcoiditis
- Carcinomatous meningitis
- Inflammatory conditions involving the:
  - Lumbosacral roots
  - Cauda equina

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## Stenosis Imaging


### Plain film radiographs

- Useful in excluding fracture, spondylolysis or neoplasm
- Lateral view of the spine is the most useful
- Not the most sensitive imaging study to show stenosis from degenerative disease
- Flexion- extension views useful to demonstrate instability

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## Myelography

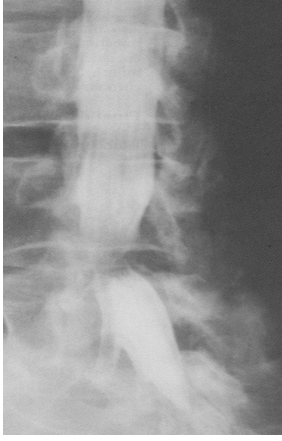


Injection of contrast dye into sub-arachnoid space  
A-P & lateral x-ray views taken

**Indications**

- Suspicion of an intra-spinal lesion
- Patients with spinal instrumentation
- Questionable Dx resulting from conflicting clinical findings & other studies
- Marked bony degenerative change that may be understated in MR


*Pomerantz 2016*



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## Myelography



**Risks**

- Allergic reaction to contrast
- Infection
- Headache
- Dural leak


**Benefits**

- Accurate diagnosis of obstruction
- Minimal radiation
- Radiation = normal background radiation over 16 months

**Limitations**

- Only views spinal canal & proximal nerve roots
- Injection is invasive
- Not appropriate in pregnancy

*Pomerantz 2016*



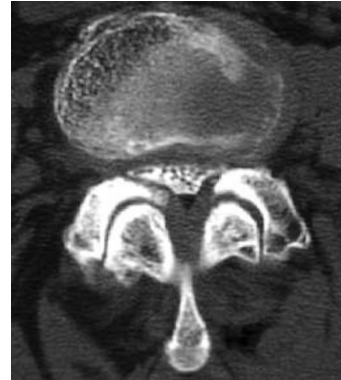
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## CT Scan in stenosis



- Allows direct visualization of the offending agents such as osteophytes
- It can be combined with myelogram to obtain more details
- Sagittal reconstructions useful in assessing foraminal stenosis
- Loss of epidural fat can be fairly well delineated



Highsmith 2018

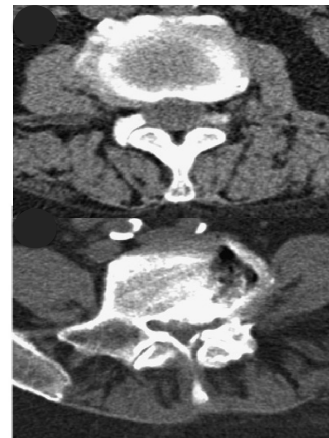
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## CT Scan in stenosis



- In patients with pacemakers or other metal implants contraindicating MRI
- CT myelogram is the only reliable imaging study before surgery



Highsmith 2018

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## Advantages of MR



- Most accurate and sensitive modality for subtle spinal pathologies
- Gives useful information about size and contour of the foramen and conus
- Helps to assess the extradural CSF interface and central canal dimensions
- There is no radiation exposure
- Entire lumbar spine is imaged



Highsmith 2018

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## Advantages of MR



- Greater contrast resolution for soft tissue imaging
- No artifacts from interfering bone
- Less risk of missing disease as pathology missed on T1 is found on T2 and vice versa
- Greater image quality in non-axial planes



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## CT & MRI in stenosis



### CT scan

- Alone is not as helpful
- Osseous and calcified structures well identified
- CT preferred if wishing to view bony anatomy



### MRI

- Imaging studies of choice
- MRI preferred as CT myelogram is invasive

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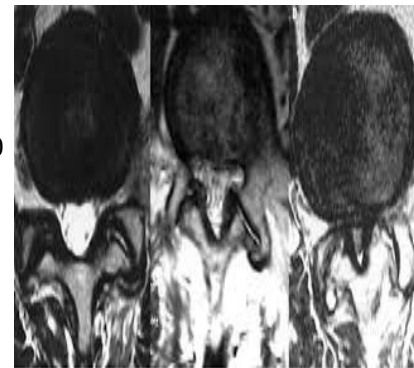
## Criteria used to define “Stenosis”



**Severe** -Intra spinal canal area is less than 76 mm<sup>2</sup>

**Moderate** – Intra spinal canal area less than 100<sup>2</sup>

- AP diameter less than 10 mm also useful cut off



No stenosis      Early lateral stenosis      Severe stenosis

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## Criteria used to define “Stenosis”

**Severe** -Intra spinal canal area is less than 76 mm<sup>2</sup>

**Moderate** – Intra spinal canal area less than 100<sup>2</sup>

- AP diameter less than 10 mm also useful cut off

**BUT**

- Prevalence 30% of asymptomatic adults > 60 yrs
- Almost zero correlation of imaging and symptom severity or prognosis

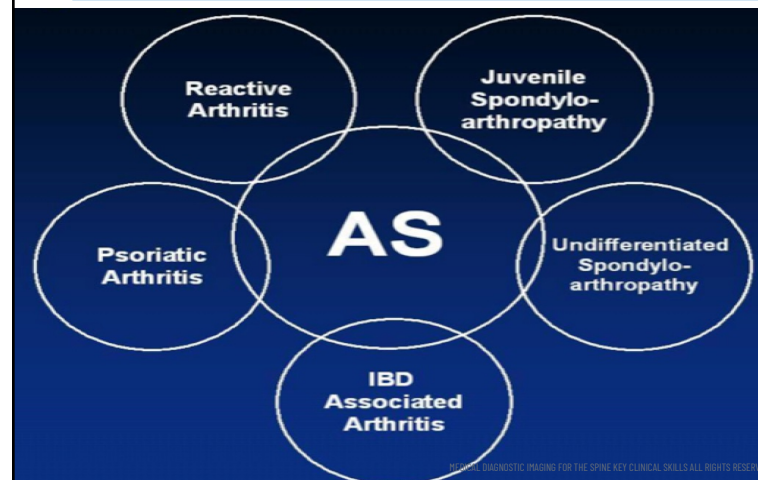


No stenosis    Early lateral stenosis    Severe stenosis

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## Family of arthropathies



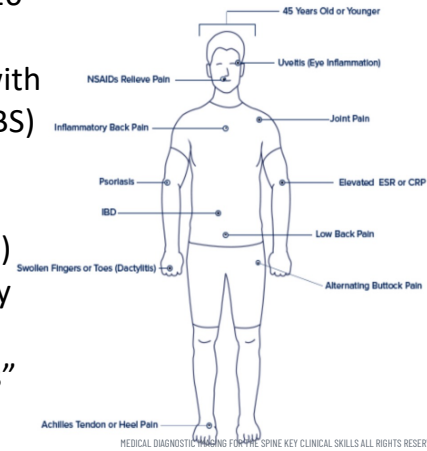
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## Ankylosing spondylitis



- Young males (age 20 yrs)
- Often associated with ulcerative colitis (IBS)
- HLA-B27 antigen screen positive in 95% (but low spec.)
- Plain film X-ray may show “Bamboo spine”, “sacro-illitis”



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## Ankylosing spondylitis



### Clinical Prediction Rule

1. Morning stiffness > 30 min. duration
2. Improvement in back pain with exercise but not rest
3. Awakening because of back pain in second ½ of night only
4. Alternating buttock pain

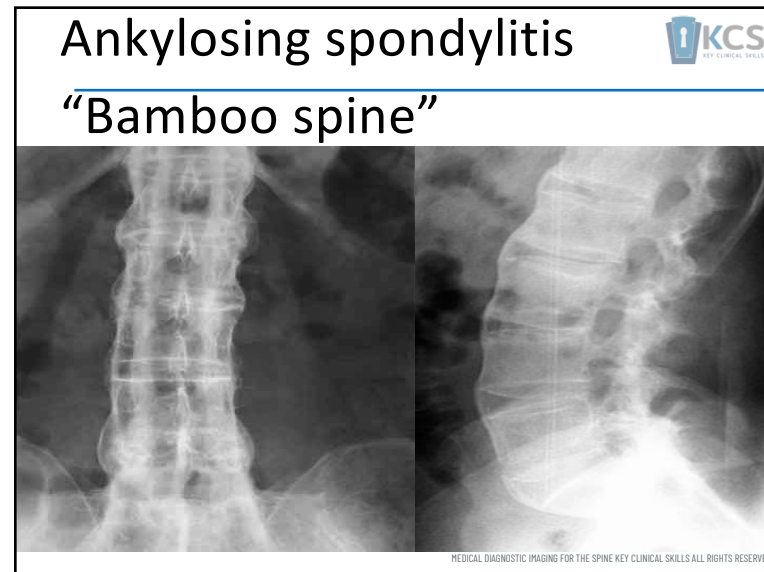
**If 3 or more present**  
**+ve LR = 12.4**

*Rudwaleit 2006*

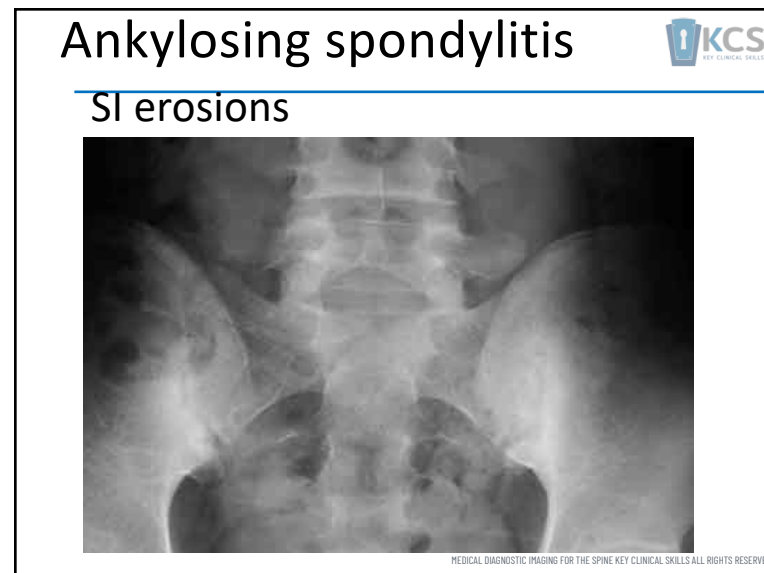


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## Spine Neoplasms



**EARLY DETECTION OF CANCER CAN SAVE LIVES**  
**Know the 10 warning signals**

**1**  
A sore that does not heal, changed color, ulcerates or bleeds.

**2**  
Unusual bleeding or discharge from any opening in the body, example, blood in the urine, stool, frequent or heavy menstruation.

**3**  
A lump or swelling that has progressively enlarged which may or may not be associated with pain.

**4**  
Indigestion or difficulty in swallowing.

**5**  
Change in bowel or bladder habits consistently for a duration of 2-3 months.

# 10

**6**  
Obvious change in size or texture in a wart or mole.

**7**  
Non smokers' cough or hoarseness of voice that persist for more than 2 weeks. Smokers' cough that becomes intense.

**8**  
Unexplained tiredness and /or weight loss of 10% or more within a period of 3-6 months.

**9**  
Persistent pain or discomfort in the abdomen.


**10**  
Unexplained fever.

**REDUCE CANCER RISK. ADOPT A HEALTHY LIFESTYLE**

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## Spine Neoplasms



The intervertebral space not crossed  
If disc space is obliterated, infection is more likely

**Plain radiography may reveal**

- Bony destruction
  - Osteolytic lesions
  - Osteoblastic lesions
- Vertebral collapse
- Calcification (associated with a meningioma)



**Roughly 50% of the bone must be destroyed to be visible on plain films.**

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## Spine Neoplasms

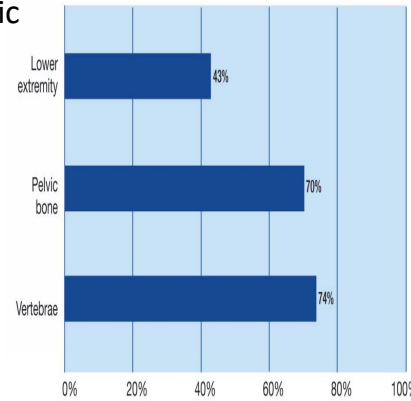


Most common neoplasm of the spine is metastatic disease from cancer somewhere else.

Most spine tumors spread from:

- Breast
- Prostate
- Lung
- Kidney
- Thyroid

Most common sites of metastases



Maccaro 2011, Finucane 2013, Chin 2015

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## Spine Neoplasms



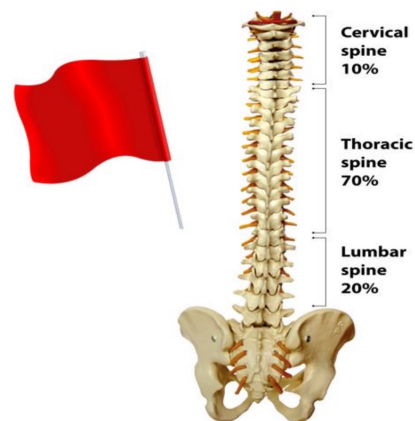
**Malignant:**

- Osteosarcoma
- Ewing's sarcoma

**Others:**

- Multiple myeloma
- Lymphoma
- Metastasis

Percent of metastatic bone cancer by region



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## Spine Neoplasms



Systematic review found only 4 clinical features used in isolation were useful to raise the probability of malignancy

- A previous history of cancer  
+ve LR 23.7
- Reduced Hematocrit  
+ve LR 18.2
- Elevated ESR  
+ve LR 18.0
- Overall clinical judgment  
+ve LR 12.1

*Henschke 2007*

2433 patients in outpatient Physio clinics

Cancer	No Subjects	% of sample
Skin	110	4.5
Breast	27	1.1
Prostate	16	0.7
Colon	15	0.7
Lung	6	0.2
Brain	6	0.2
Leukemia	5	0.2
Kidney	5	0.2
Lymphoma	4	0.2
Bone	4	0.2
Thyroid	4	0.2
Oropharangeal	2	0.1
Bladder	2	0.1
Stomach	1	0.05
Testicular	1	0.05

*Boissonnault 1999* MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Spine Neoplasms



### Night pain

Prospective study of 482 consecutive healthy patients with back pain

- 213 some night pain
- 90 pain every night
- Those with night pain typically reported waking 2.5 times/night



*Harding 2005*

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## Spine Neoplasms



### Patients who:

- Are under 50
- Have no unexplained weight-loss
- Have no history of cancer
- Respond to conservative care- PT

**DO NOT have Cancer**  
(note the necessity of a trial of conservative care!)

**100% sensitivity**

*Deyo 1988*



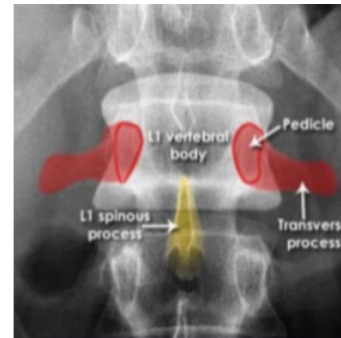
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## Spine Neoplasms




### “The owl”



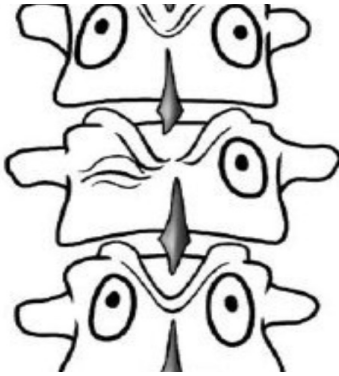

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## Spine Neoplasms




### “The winking owl”

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## Spine Neoplasms

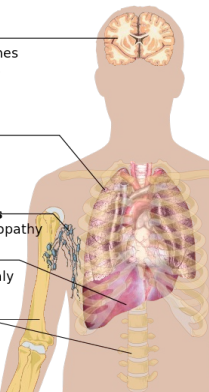


**MRI**  
Diffusion-weighted MR imaging may be useful in evaluation of epidural neoplastic lesions.

**Primary vs secondary**  
Most common neoplasm of the spine is metastatic disease from cancer somewhere else.

<p><b>Lytic lesions:</b></p> <ul style="list-style-type: none"> <li>Lung</li> <li>Renal</li> <li>Breast</li> <li>Multiple myeloma</li> </ul>	<p><b>Sclerotic lesions</b></p> <ul style="list-style-type: none"> <li>Prostate</li> <li>Breast</li> </ul>
--	--

Common sites and symptoms of Cancer metastasis



- Brain**
  - Headaches
  - Seizures
  - Vertigo
- Respiratory**
  - Cough
  - Hemoptysis
  - Dyspnea
- Lymph nodes**
  - Lymphadenopathy
- Liver**
  - Hepatomegaly
  - Jaundice
- Skeletal**
  - Pain
  - Fractures
  - Spinal cord compression

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## Spine Neoplasms

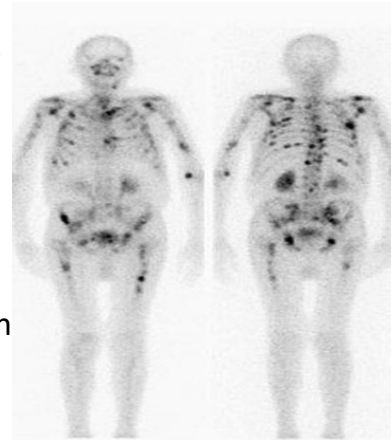


### Indications:

Best screening study if initial diagnosis involves;

involves;

- Lung
- Breast
- Prostate
- Un-resolving bone pain
- Elevated alkaline phosphate



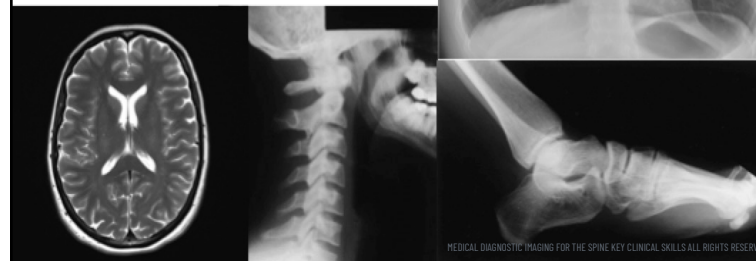
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## Medical Imaging for the spine



### Unit 8

### Pelvis



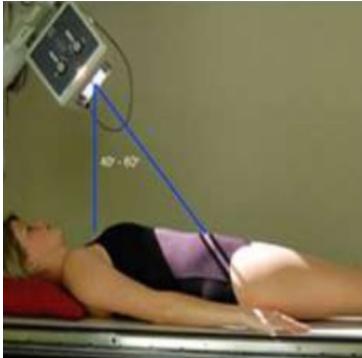

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## Pelvis views

Pelvic inlet





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## Pelvis views


Judet (oblique right & left)




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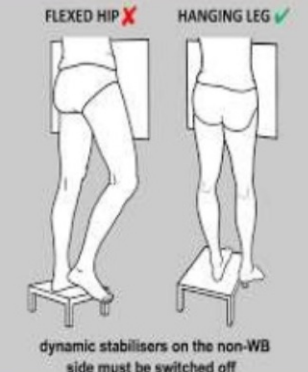
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## Pelvis views



### Flamingo







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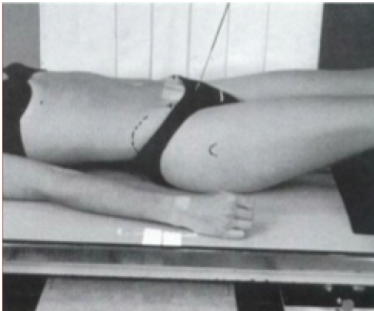
337

## Pelvis



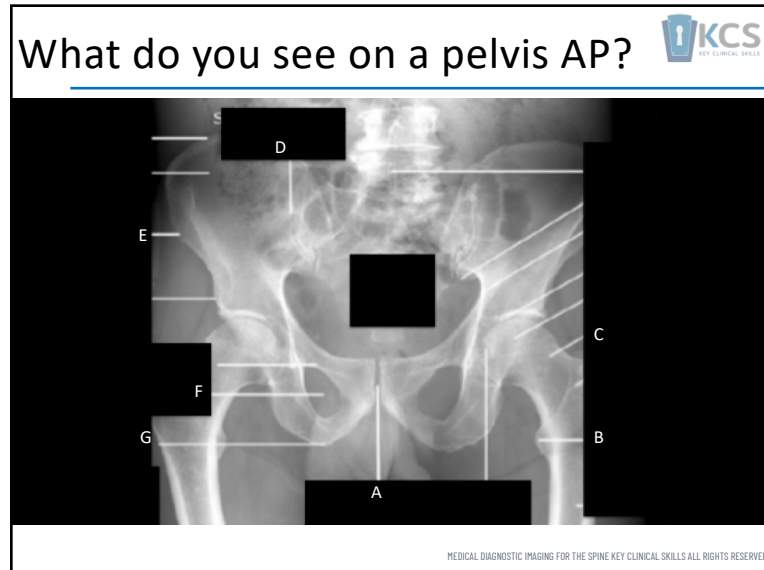
### Sacroiliac AP View



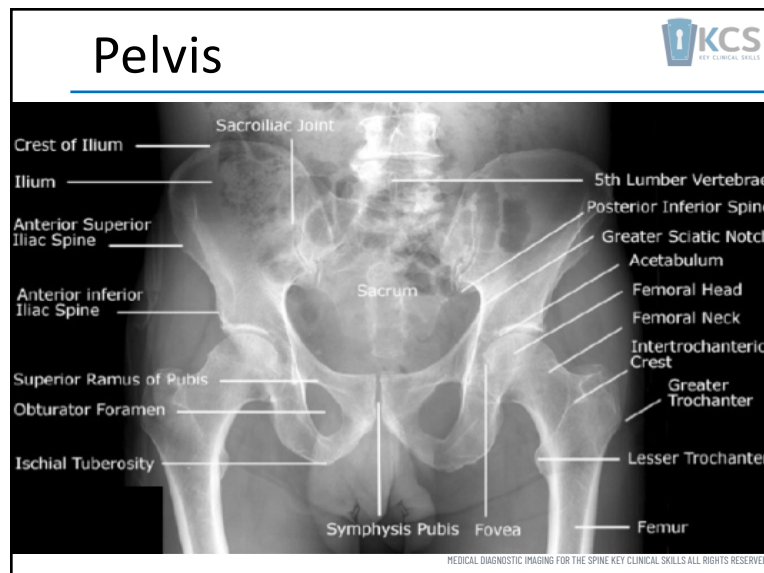


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## Pelvic fractures



Pelvic fractures account for  
< 5% of all fractures

- Generally stable

But are associated with:

- Soft tissue injuries

Because of these mortality  
rate is 10%

**Pelvis is a ring and  
mechanically fractures in  
2 places**



MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

341

## Pelvic fractures



### Isolated

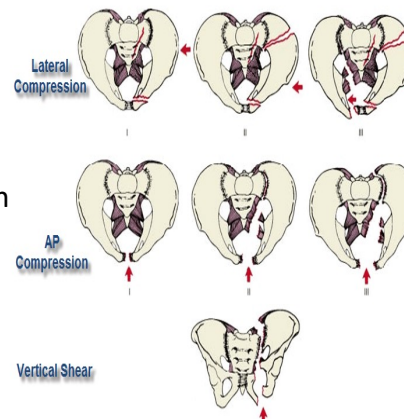
- Avulsion
- Direct
- Stress

### Pelvic ring

- Anterior compression
- Lateral compression
- Vertical shear
- Combined forces

### Acetabulum

### Sacro-Coccygeal




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

342

## Pelvic fractures

Pubic ramus




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The image is an AP radiograph of the pelvis. A clear, transverse fracture line is visible on the right side, extending through the middle section of the pubic ramus. The rest of the pelvic girdle, including the iliac wings, ischial rami, and acetabula, appear intact.

343

## Pelvic fractures

Ischeal rami

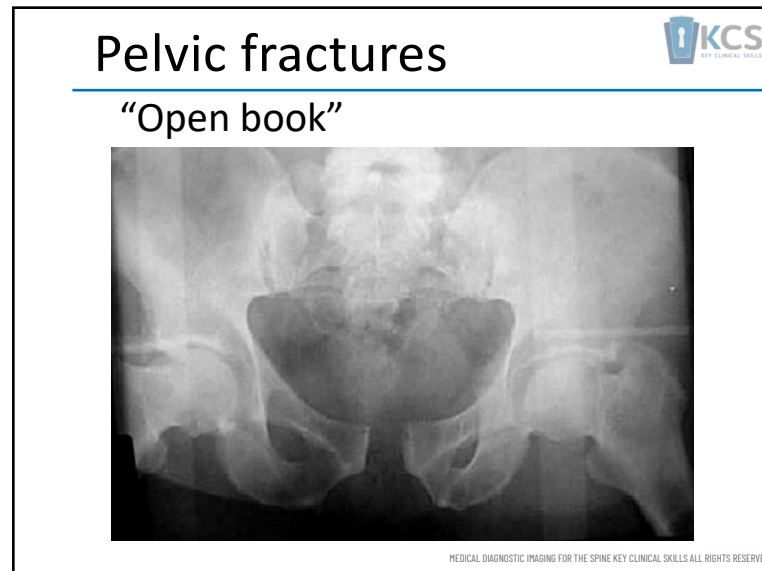


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

The image is an AP radiograph of the pelvis. A clear, transverse fracture line is visible on the right side, extending through the middle section of the ischeal ramus. The rest of the pelvic girdle, including the pubic rami, iliac wings, and acetabula, appear intact.


344





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## The Reliability of clinical examination in detecting pelvic fractures in blunt trauma patients



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<p><b>Systematic review</b></p> <ul style="list-style-type: none"> <li>• 12 Studies,</li> <li>• 5235 Subjects</li> <li>• Only 3 of 441 clinically relevant pelvic fractures missed</li> <li>• <b>Sn = 0.99</b></li> <li>• <b>Sp = 0.90</b></li> </ul> <p><i>Sauerland 2004</i></p>	<p><b>Criteria to rule out pelvic Fx:</b></p> <ul style="list-style-type: none"> <li>• Age &gt; 3 yrs</li> <li>• No impairment of consciousness</li> <li>• No other major distracting injuries</li> <li>• No complaints of pelvic pain</li> <li>• No signs of fracture on clinical exam</li> <li>• No pain on pubic or iliac compression</li> <li>• Pain-free hip flexion and rotation</li> </ul>
--	---

MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Pelvic stress fractures



- History of overuse
- Recent significant increase in millage
- Relief with non-weight bearing
- Insidious onset
- Local pain, tenderness, swelling
- Typical site is pubic ramus
- Bone scan to diagnose early



MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

347

## Pelvic stress fractures



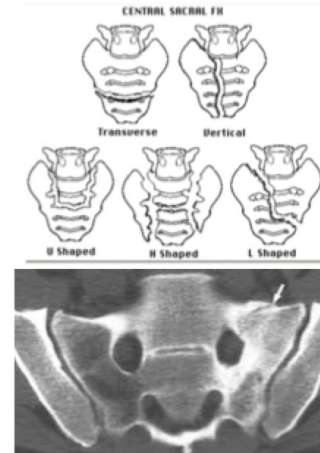
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## Sacral fractures



- Transverse fractures most common
- Usually at S2/3 level
- High transverse fractures from fall from heights
- Vertical fractures usually indirect trauma to pelvis
- May be missed by radiographs
- CT best modality



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## Pelvis pathologies



### Paget's disease



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## Pelvis pathologies



### Osteolytic bone metastases



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## X ray grading of sacro iliac joints



Grade	Description	
0	Normal	
1	Suspicious changes	
2	Minimal definitive changes: circumscribed areas with erosions or sclerosis with no changes of the sacroiliac joint space	
3	Distinct changes, sclerosis. Change of joint space (narrowing or widening), partial ankylosis	
4	Ankylosis	

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# Ankylosing spondylitis



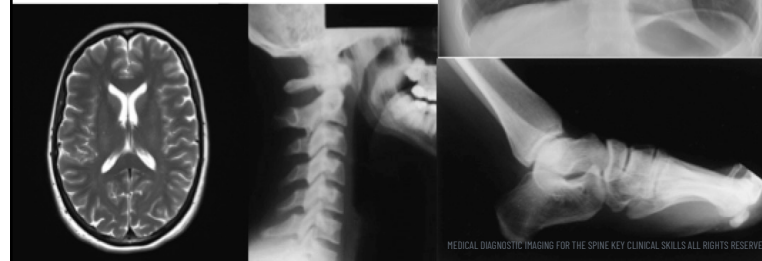
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353

# Medical Imaging for the spine




## Unit 9 Practice integration 1



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## Practice integration




Where's Waldo?

- Structure identification



Question mark



- Imaging Quiz




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## Practice integration



What's the view?





- Antero-postero open mouth

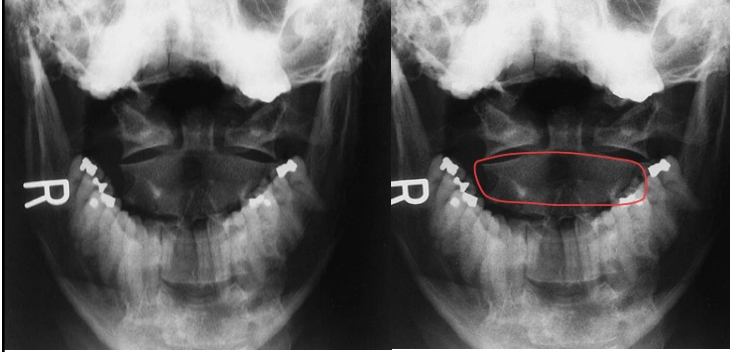
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## Practice integration




 **Body of C2**




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED


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## Practice integration



 **What does the white arrow indicate?**


A. Osteophytes at the vertebral endplates  
B. Schmorl's nodes  
C. Facet joint dislocation




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration



**?**




A. Osteophytes at the vertebral endplates

- Osteophytes at the vertebral endplates result from degenerative changes at the intervertebral segment.


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration



**?**




**What pathology is present at C5-C6?**


- A. Rheumatoid arthritis
- B. Disk space infection
- C. Degenerative disk disease

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360




**Practice integration** 




**C. Degenerative disk disease**


- Radiographic hallmarks of DDD include decreased intervertebral joint space with osteophytosis at the vertebral endplates

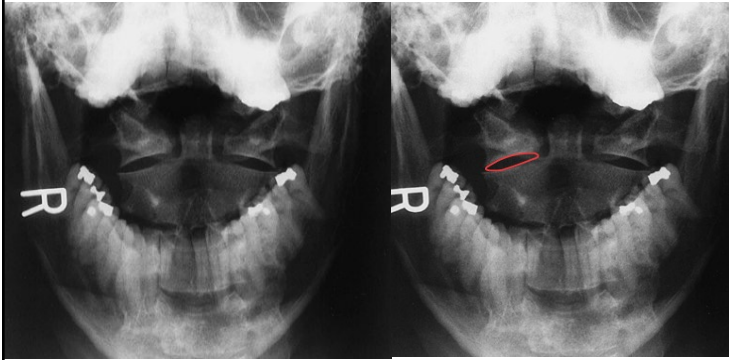


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361


**Practice integration** 


 **right atlantoaxial facet joint**




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362

**Practice integration** 


 **What's the view?**


- Antero-postero cervical spine

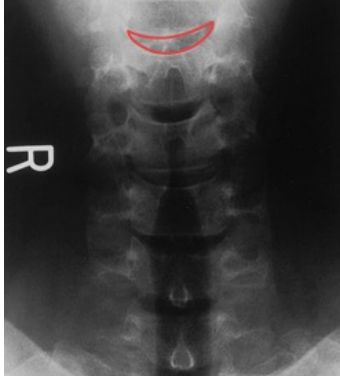



MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

363


**Practice integration** 


 **C2-C3 intervertebral disc space**

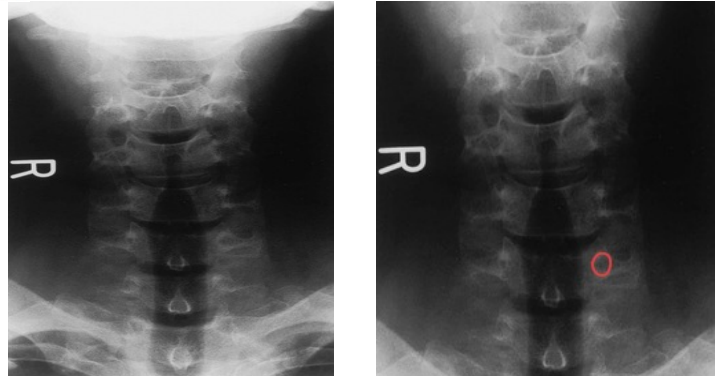


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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**Practice integration** 


 **left pedicle of C6**




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

365

**Practice integration** 


 **What's the view?**




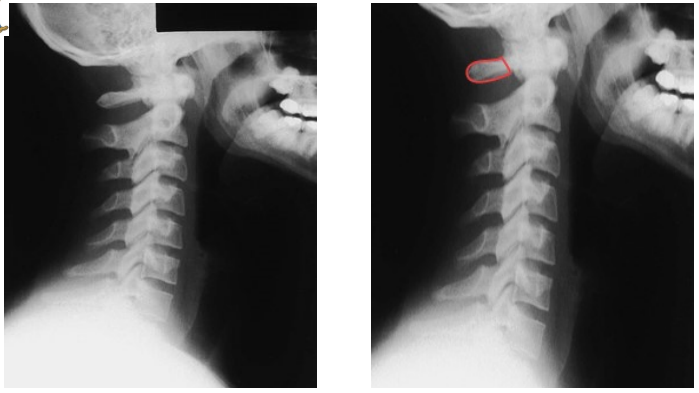
- Lateral cervical spine

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366


**Practice integration** 


 **posterior arch of C1**

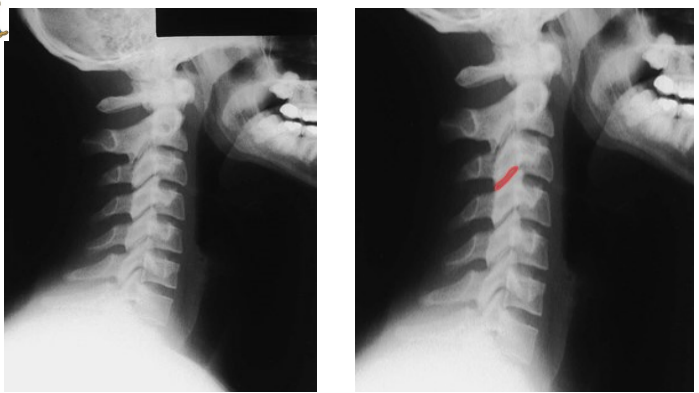


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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**Practice integration** 


 **paired C3-C4 facet joints**




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368

**Practice integration** 

 **What's the view?**


- Left oblique cervical spine




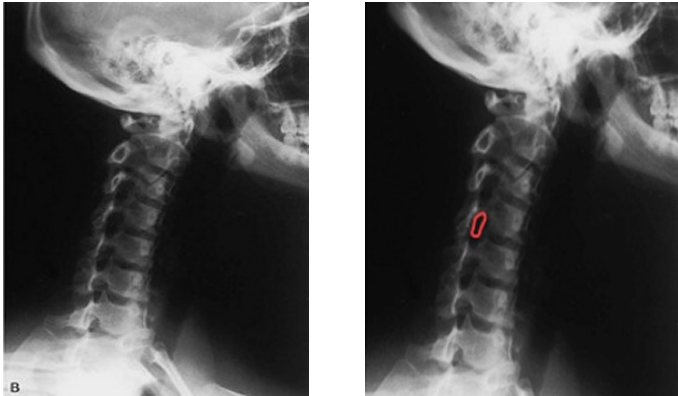
**B**

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369

**Practice integration** 


 **intervertebral foramen of C4-C5.**



**B**

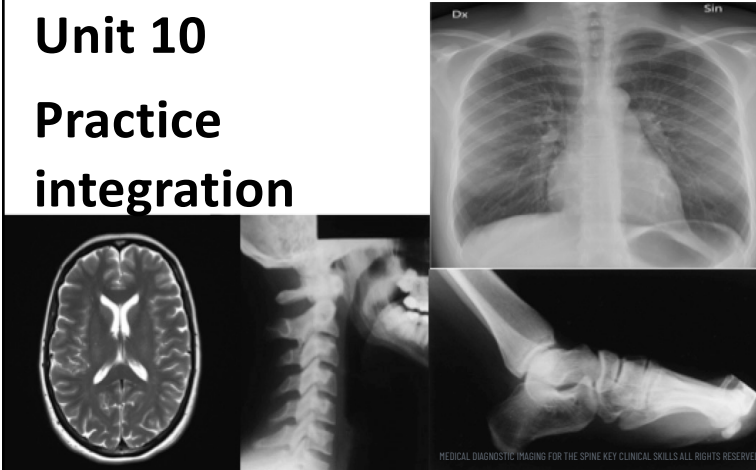
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Medical Imaging for the spine 


## Unit 10

### Practice integration





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371

Practice integration 


### What's the view?





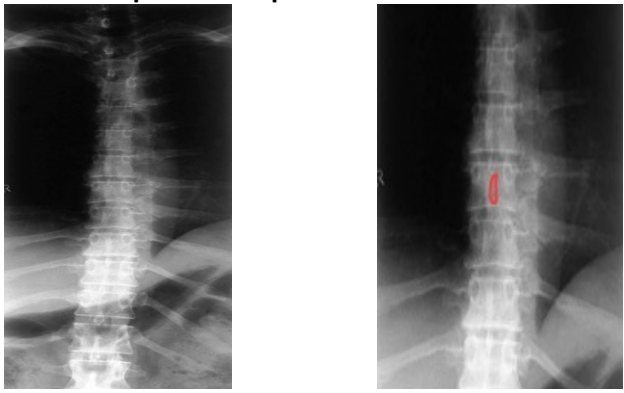
- Antero-postero thoracic spine

MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

372


**Practice integration** 


 **spinous process of T7**

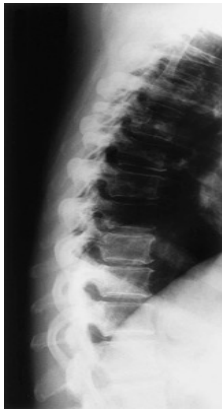


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

373

**Practice integration** 


 **What's the view?**




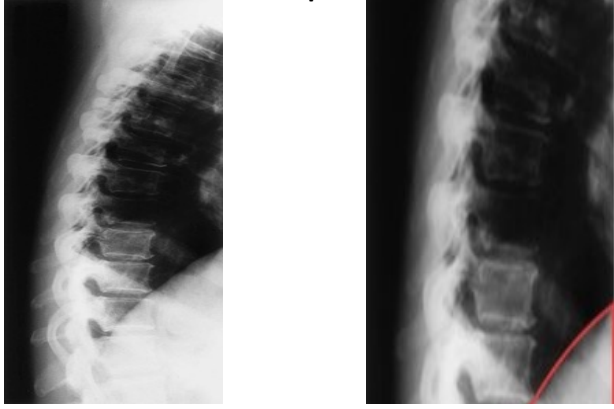
- Lateral thoracic spine

MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

374


**Practice integration** 


 **the diaphragm**

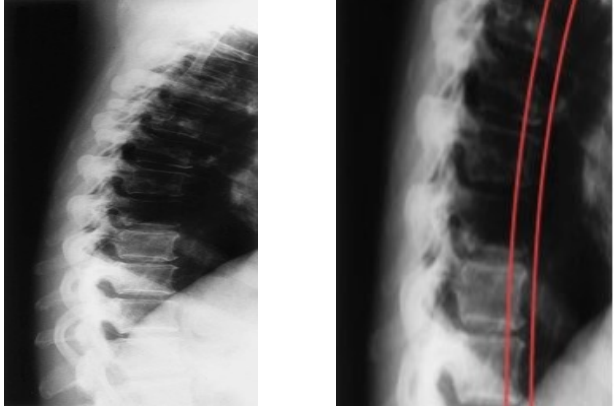


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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**Practice integration** 

 **anterior vertebral body line, at any vertebral level**




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED


376



## Practice integration



**?**




- **What view is this?**
- A. Antero-posterior
- B. Lateral
- C. Oblique
- D. Thoraco-lumbar


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration



**?**




- **D. Thoracolumbar**
- A thoracolumbar view is a “coned” or close-up view of the thoracolumbar vertebrae, which are often the site of traumatic injury.


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration



**?**




**What is the pathology?**

- A. Osteoporosis
- B. Vertebral body compression fractures
- C. Tuberculous osteomyelitis


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration



**?**




**B. Vertebral body compression fractures**



- Imposed compressive forces on the spine convert to flexion forces and can result in anterior shearing of the vertebral disk, which may avulse the bony rim of an endplate and displace it anteriorly.

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**Practice integration** 


**What's the view?**



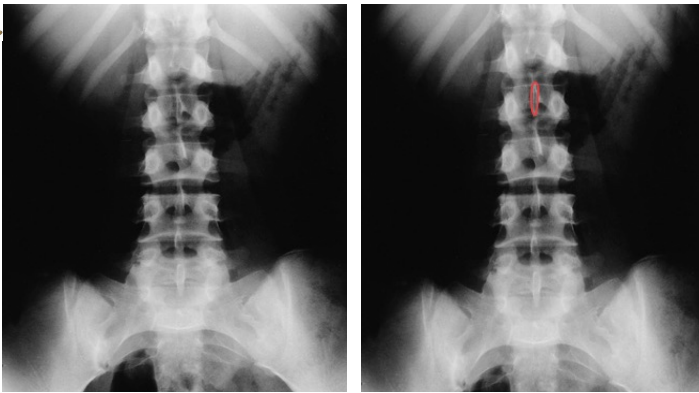

- Antero-postero lumbar spine

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**Practice integration** 


**spinous process of L2**

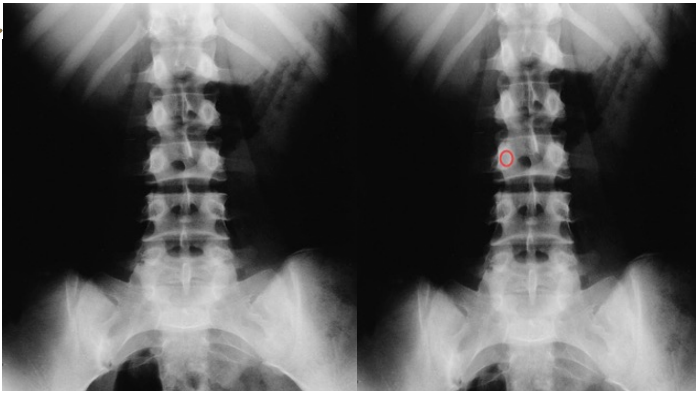


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

382


**Practice integration** 


 **Right pedicle of L3**

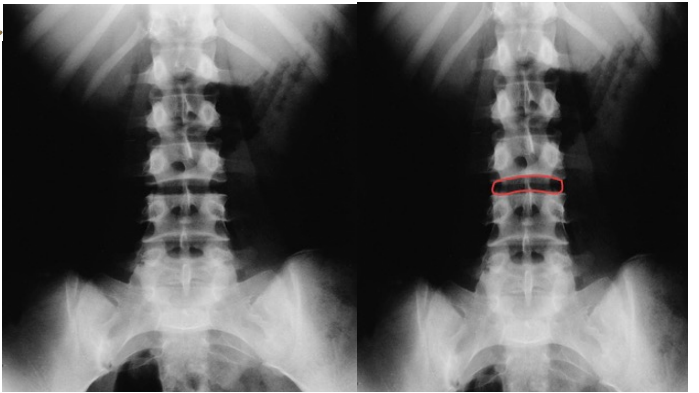


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

383

**Practice integration** 



 **L3/4 intervertebral disc space**



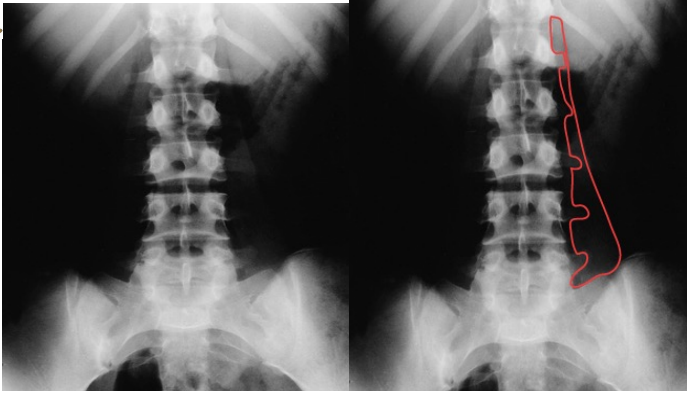
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## Practice integration



### Left psoas muscle




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration

### What's the view?




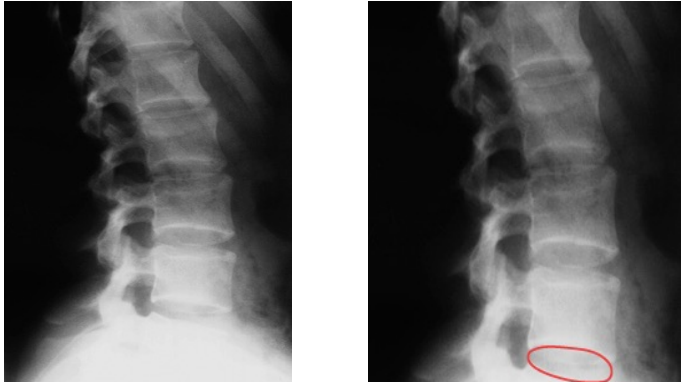
- Lateral lumbar spine

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386

### Practice integration


 **L4-L5 intervertebral disc space**

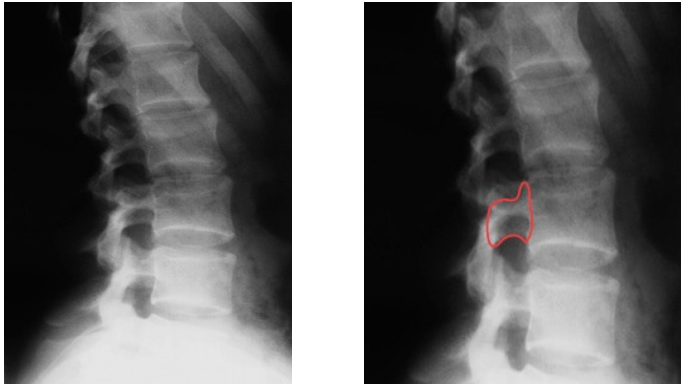


MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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### Practice integration

 **paired pedicles of L3**




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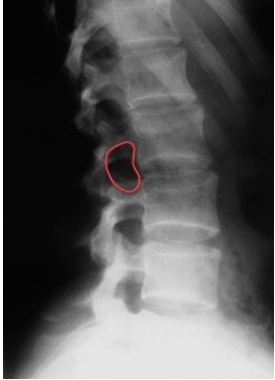
388



## Practice integration




### intervertebral foramen of L2-L3





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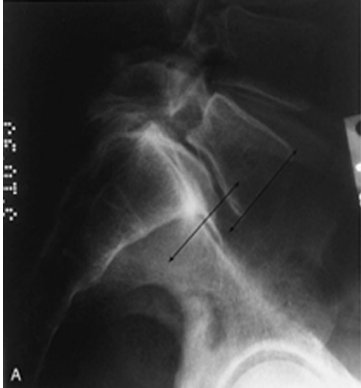
389



## Practice integration




### What view is this?




- A. Antero-posterior lumbar spine
- B. Lateral lumbar spine
- C. Lateral lumbo-sacral spine

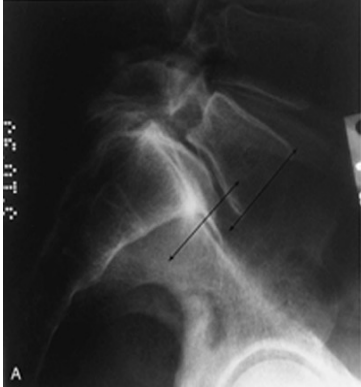
MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration

 What view is this?




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**C. Lateral lumbo-sacral spine**

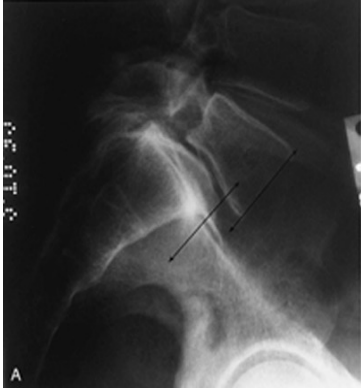
- This is a “coned”, or close-up, lateral view of the lumbo-sacral articulation.

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## Practice integration

 The *lined arrows* represent a disruption in the \_\_\_\_\_.




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED


A. anterior vertebral body line  
B. posterior vertebral body line  
C. lateral vertebral body line

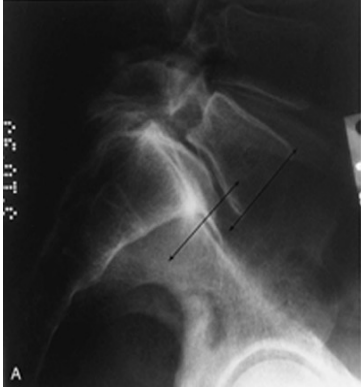
392



## Practice integration



 The *lined arrows* represent a disruption in the \_\_\_\_\_.




**A. anterior vertebral body line**


- The *anterior vertebral body line* represents the connected anterior borders of the vertebral bodies and normally forms a continuous lordotic curve.

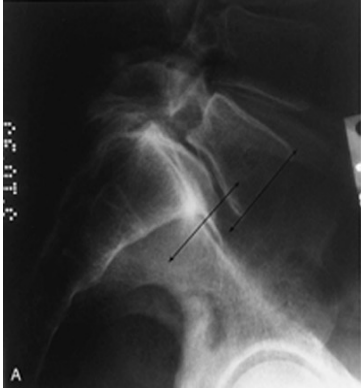
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## Practice integration



 This pathology is described as \_\_\_\_\_.




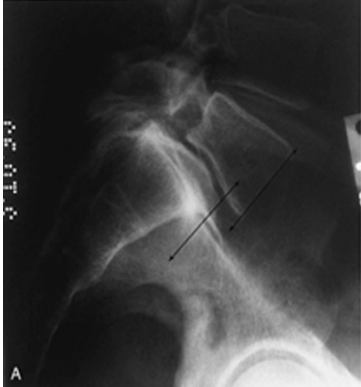
**A. a spondylolysis**  
**B. fracture spondylolisthesis, grade 1+**  
**C. degenerative spondylolisthesis, grade 1+**

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## Practice integration

 This pathology is described as \_\_\_\_\_.




**C. degenerative spondylolisthesis, grade 1+**


- This degenerative spondylolisthesis is differentiated from fracture spondylolisthesis by the intact vertebra. The grade is determined by the amount of forward displacement. L5 has translated forward by more than 25 percent of its depth, so the grade is 1+.

MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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## Practice integration


 What's the view?




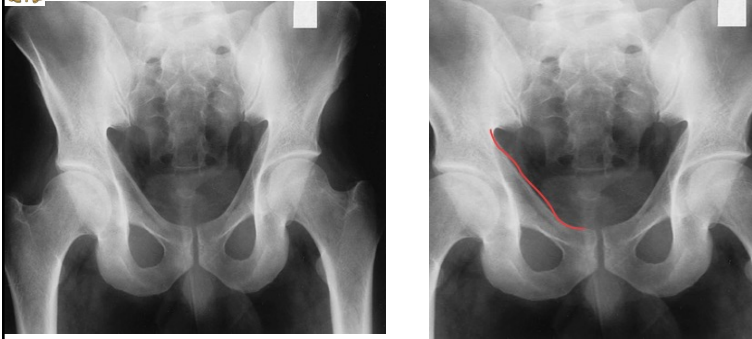
- Antero-postero pelvis / hips

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**Practice integration** 


 **right iliopubic line**




MEDICAL DIAGNOSTIC IMAGING FOR THE SPINE KEY CLINICAL SKILLS ALL RIGHTS RESERVED

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**Practice integration** 

 **left sacroiliac joint**



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