

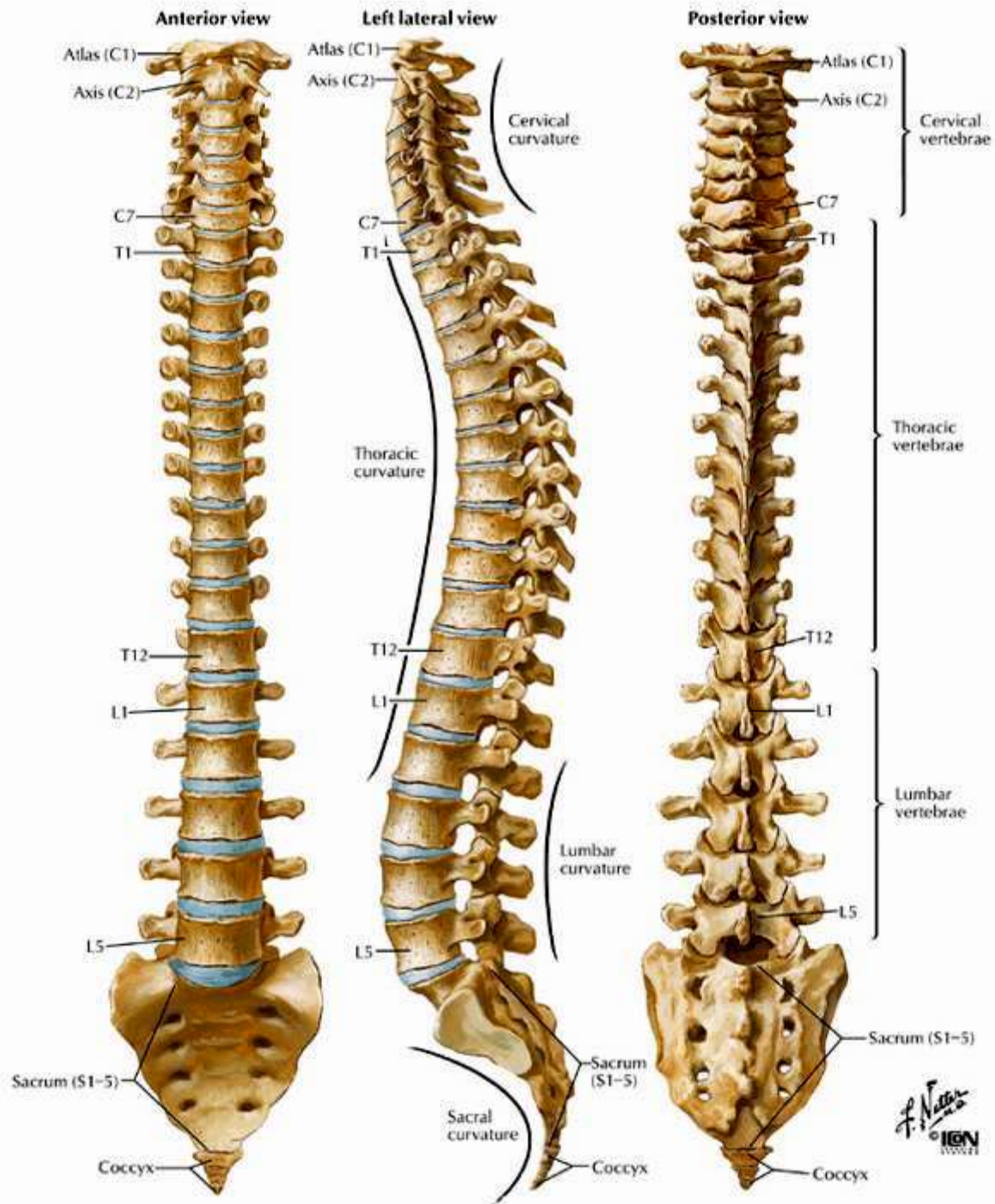


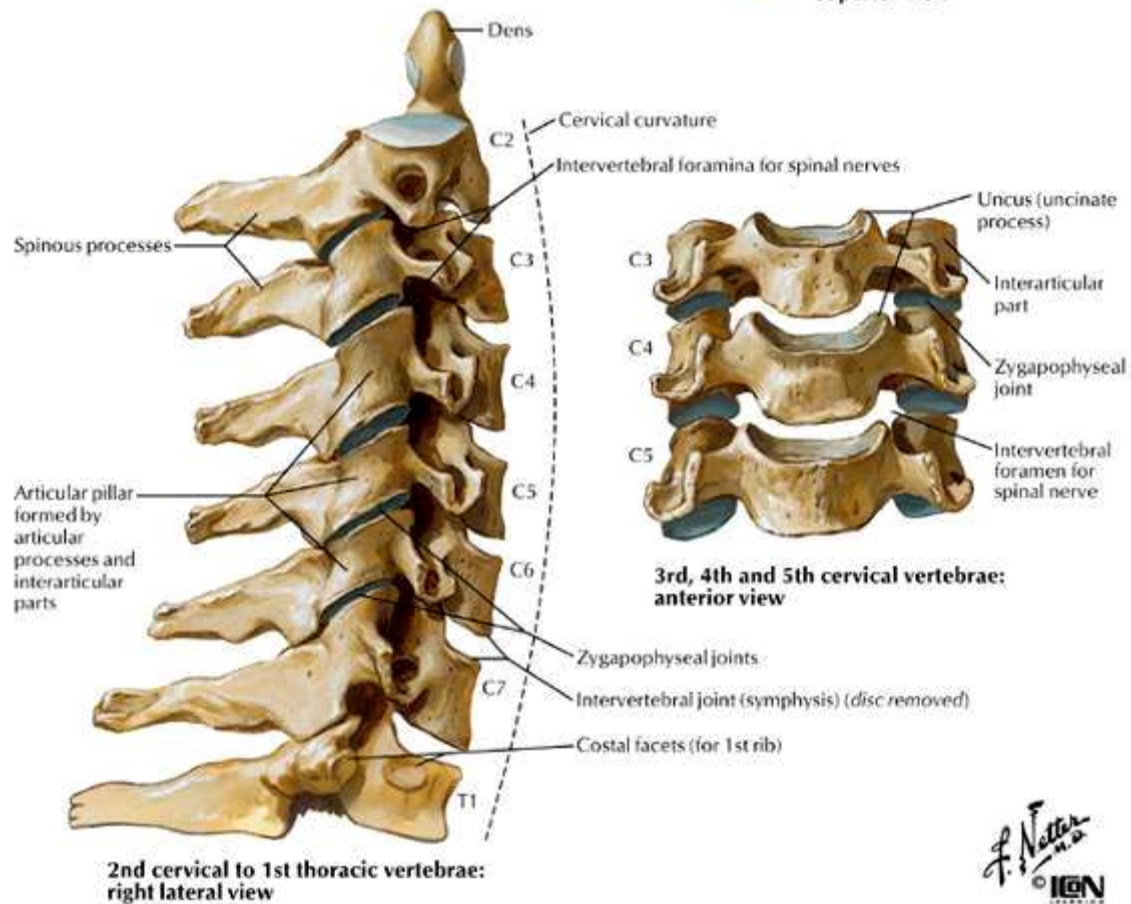
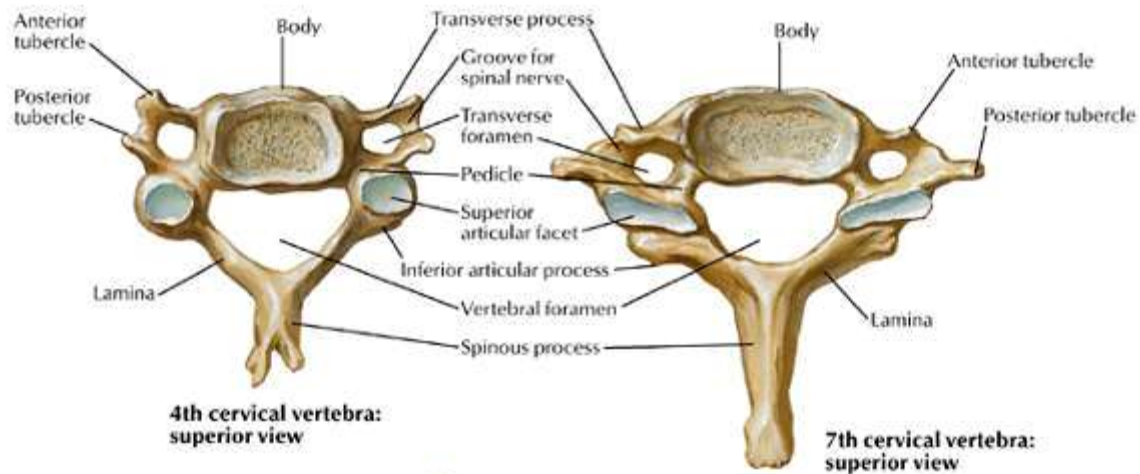
Introduction to Neuroimaging SPINE

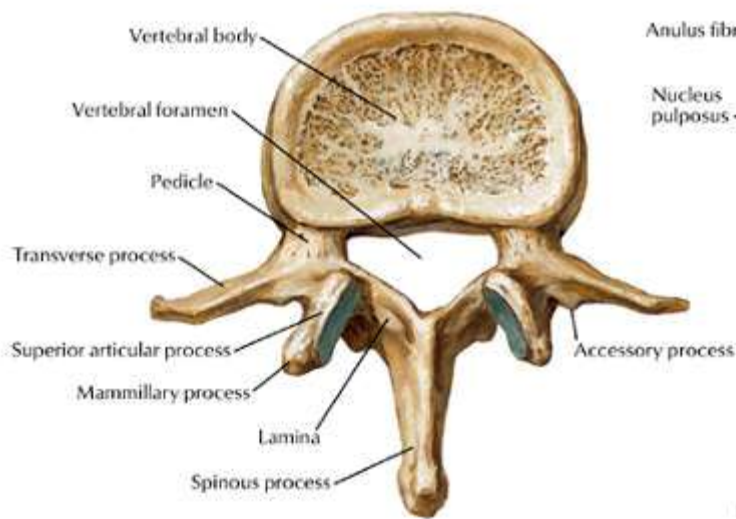


Aaron S. Field, MD, PhD
Neuroradiology
University of Wisconsin–Madison

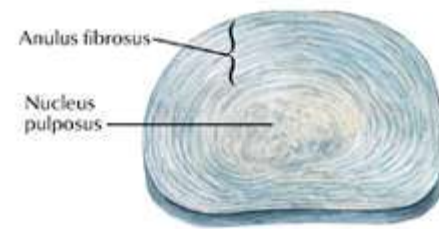
Anatomy



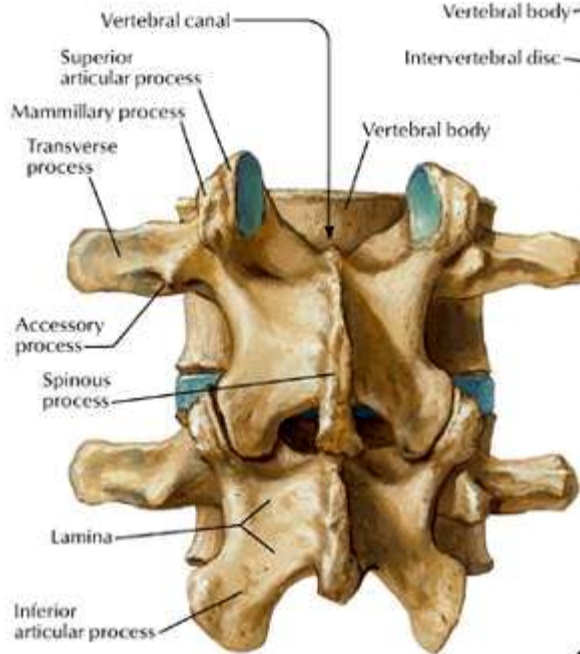




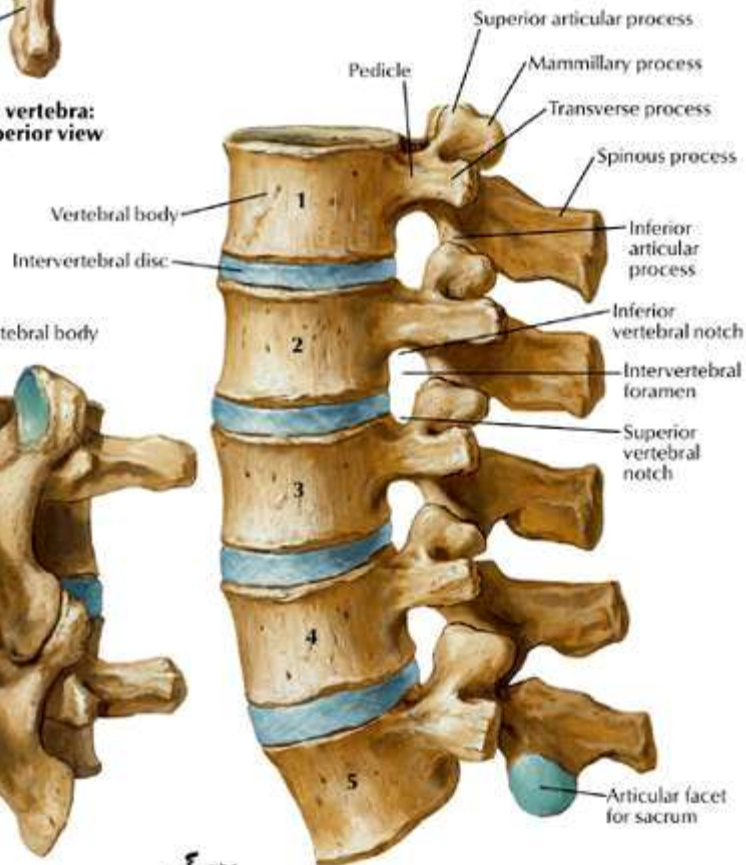
**L2 vertebra:
superior view**



Intervertebral disc



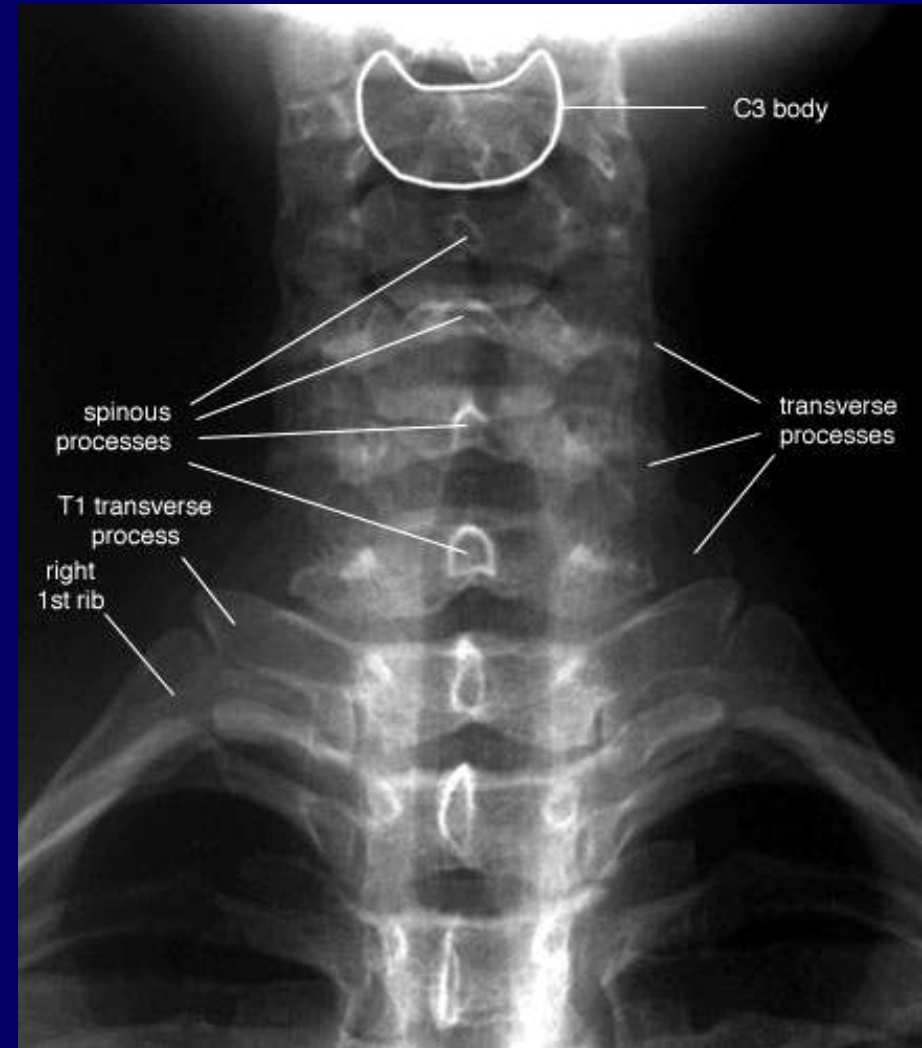
**L3 and L4 vertebrae:
posterior view**



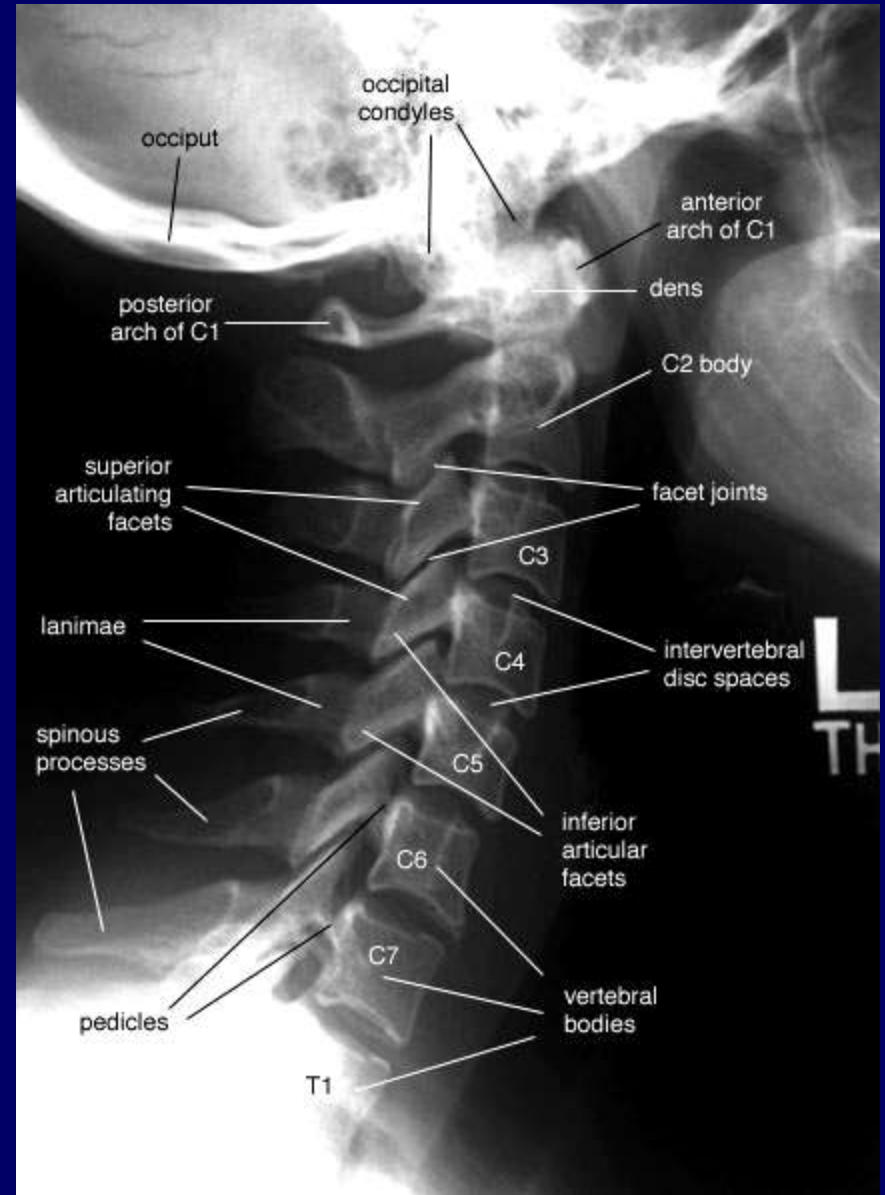
**Lumbar vertebrae, assembled:
left lateral view**

Radiographic Anatomy

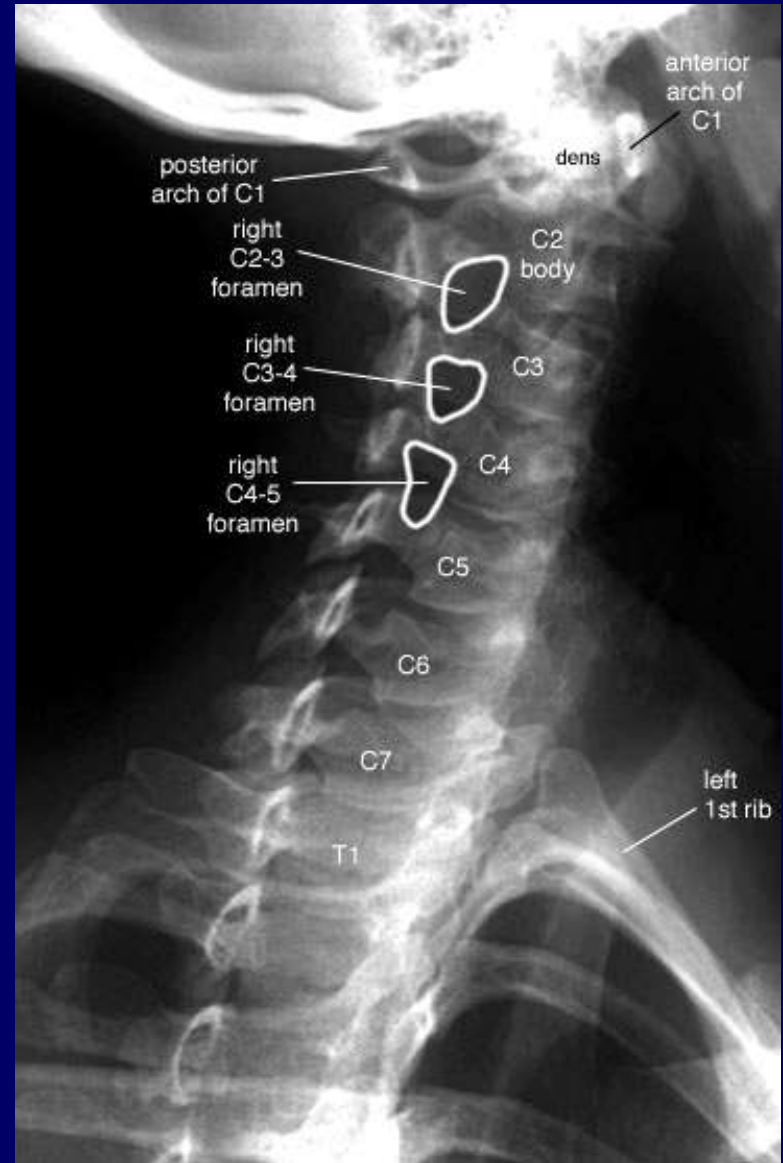
Cervical Spine – AP View



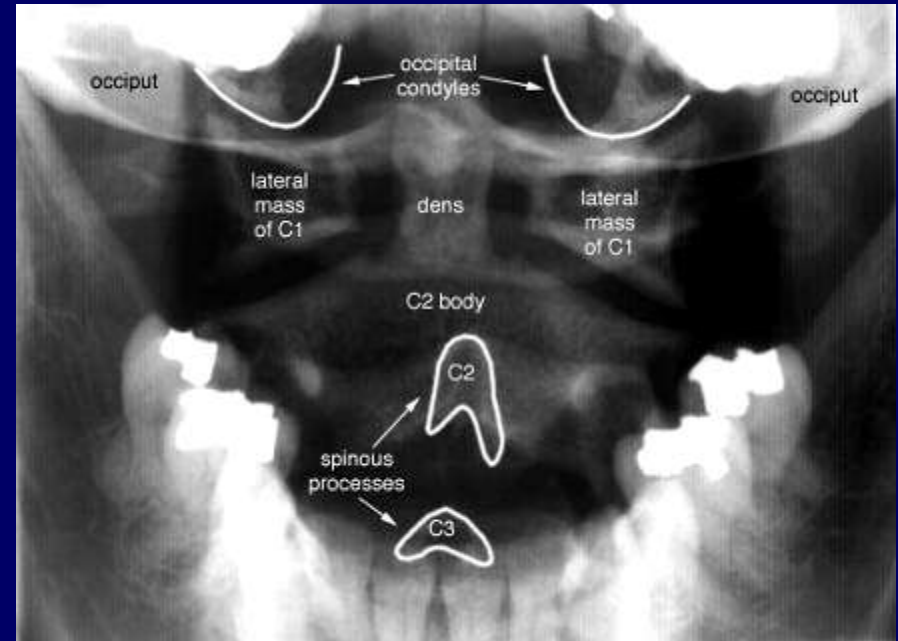
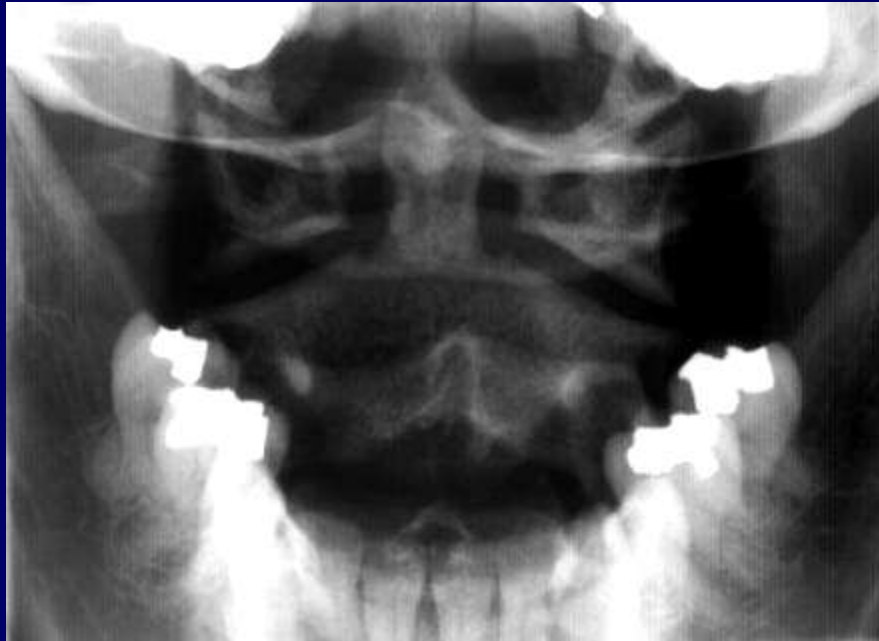
Cervical Spine – Lateral View



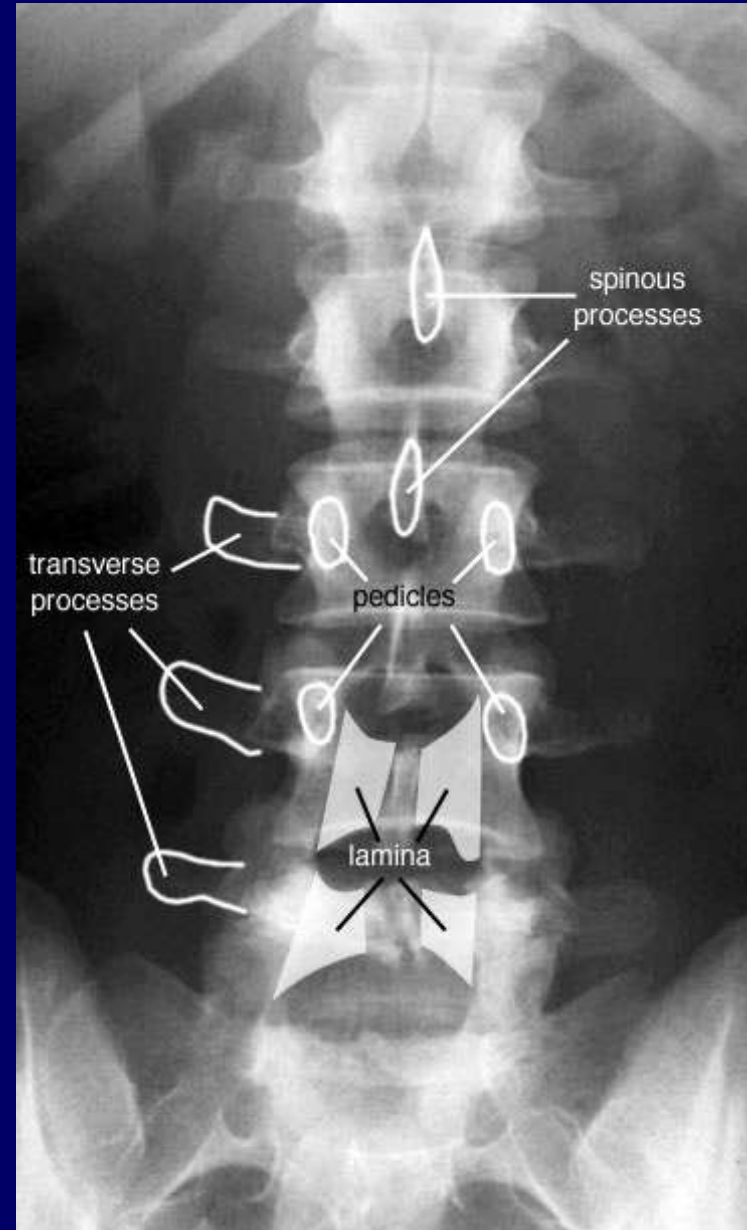
Cervical Spine – Oblique View



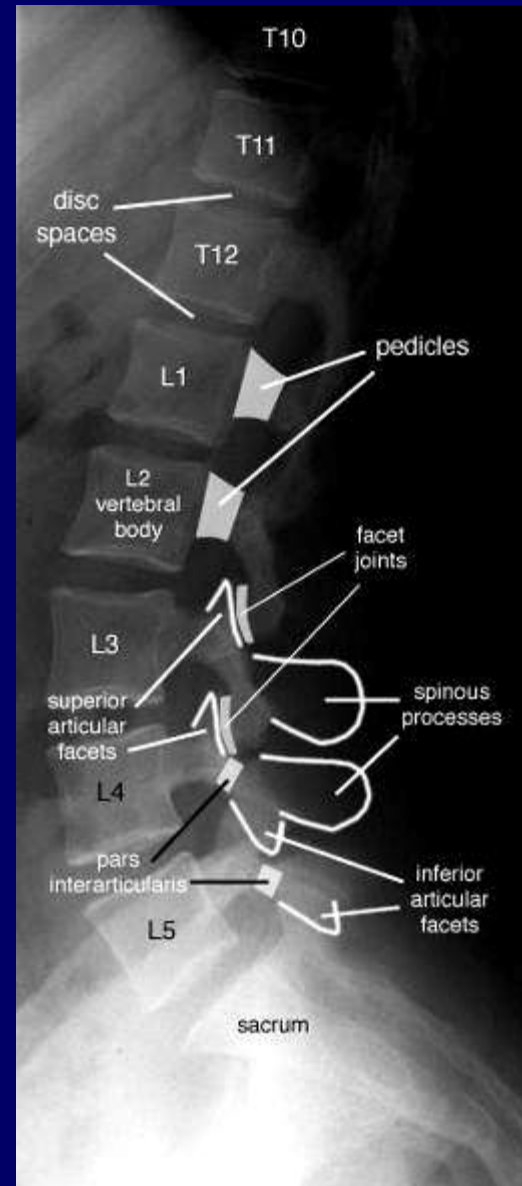
Cervical Spine – Open-Mouth (Dens) View



Lumbar Spine – AP View

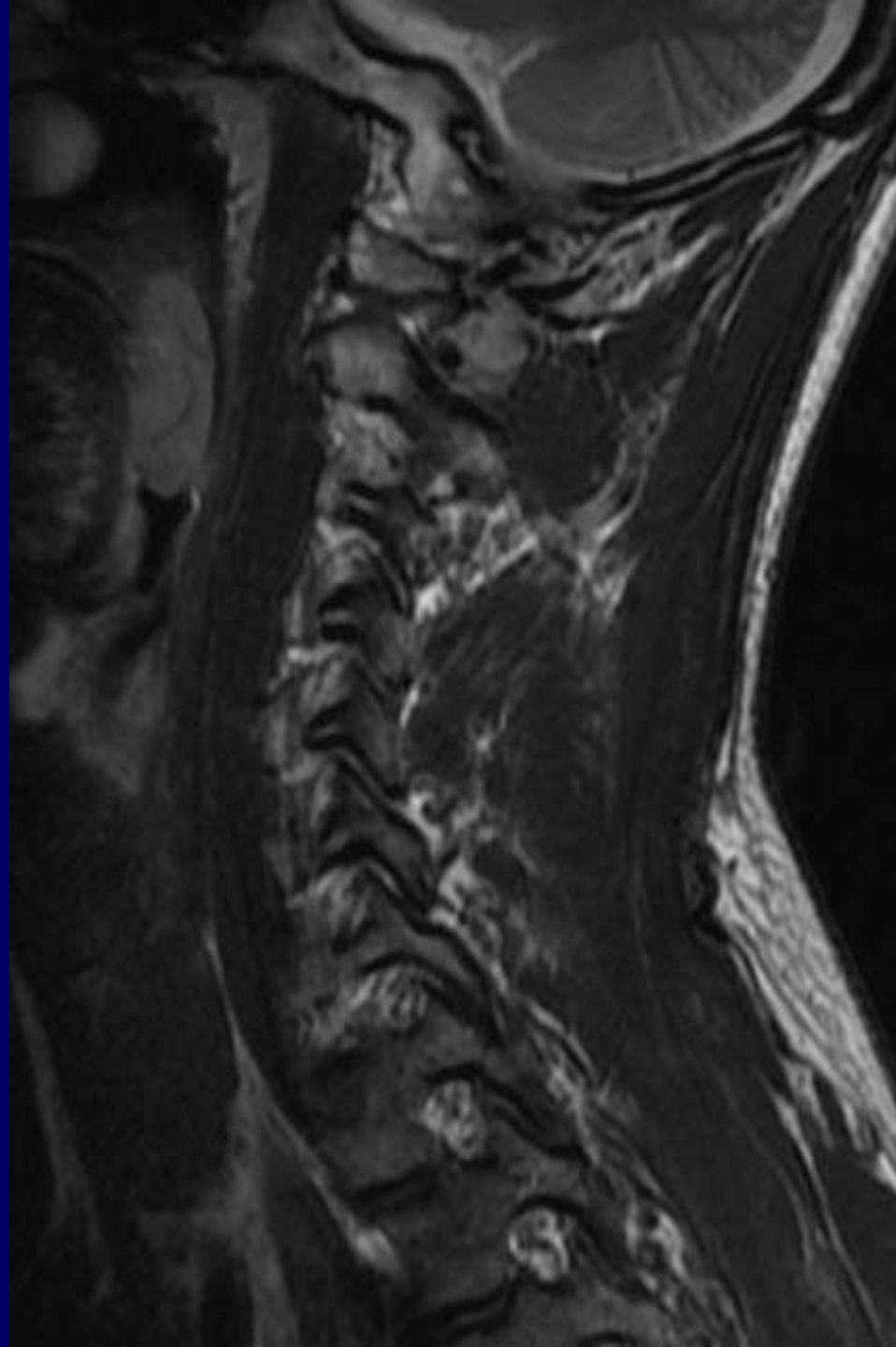


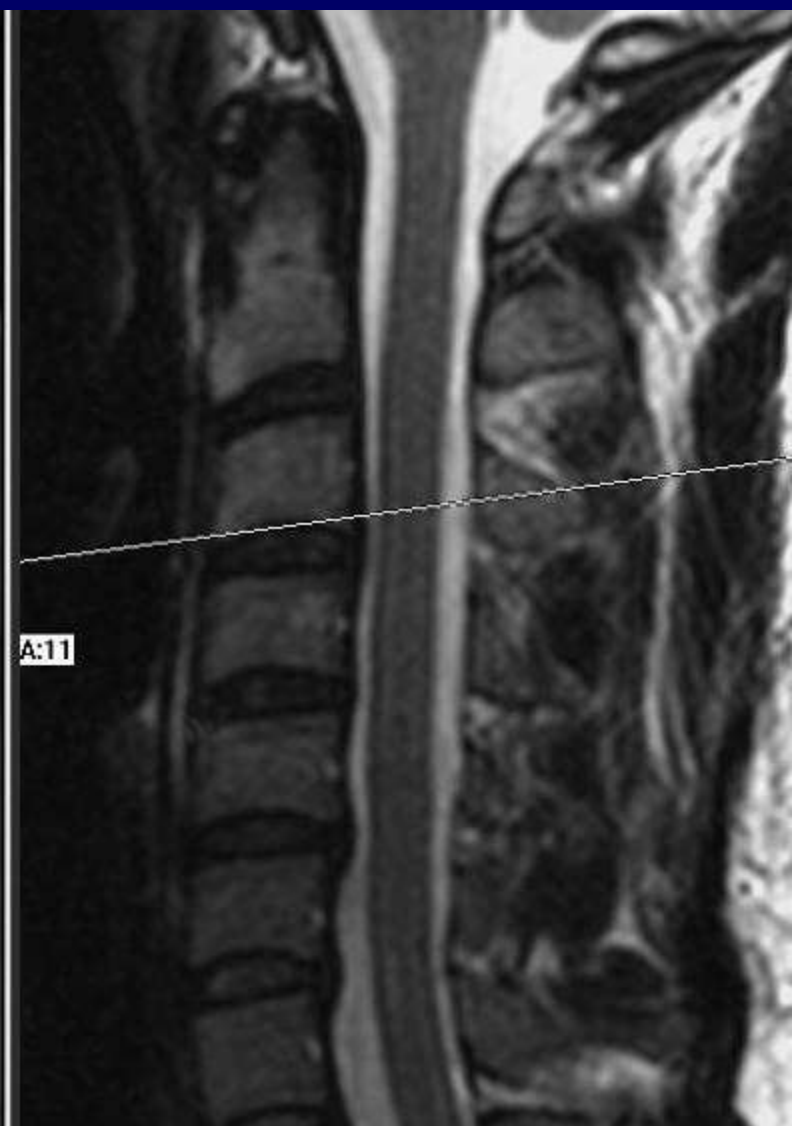
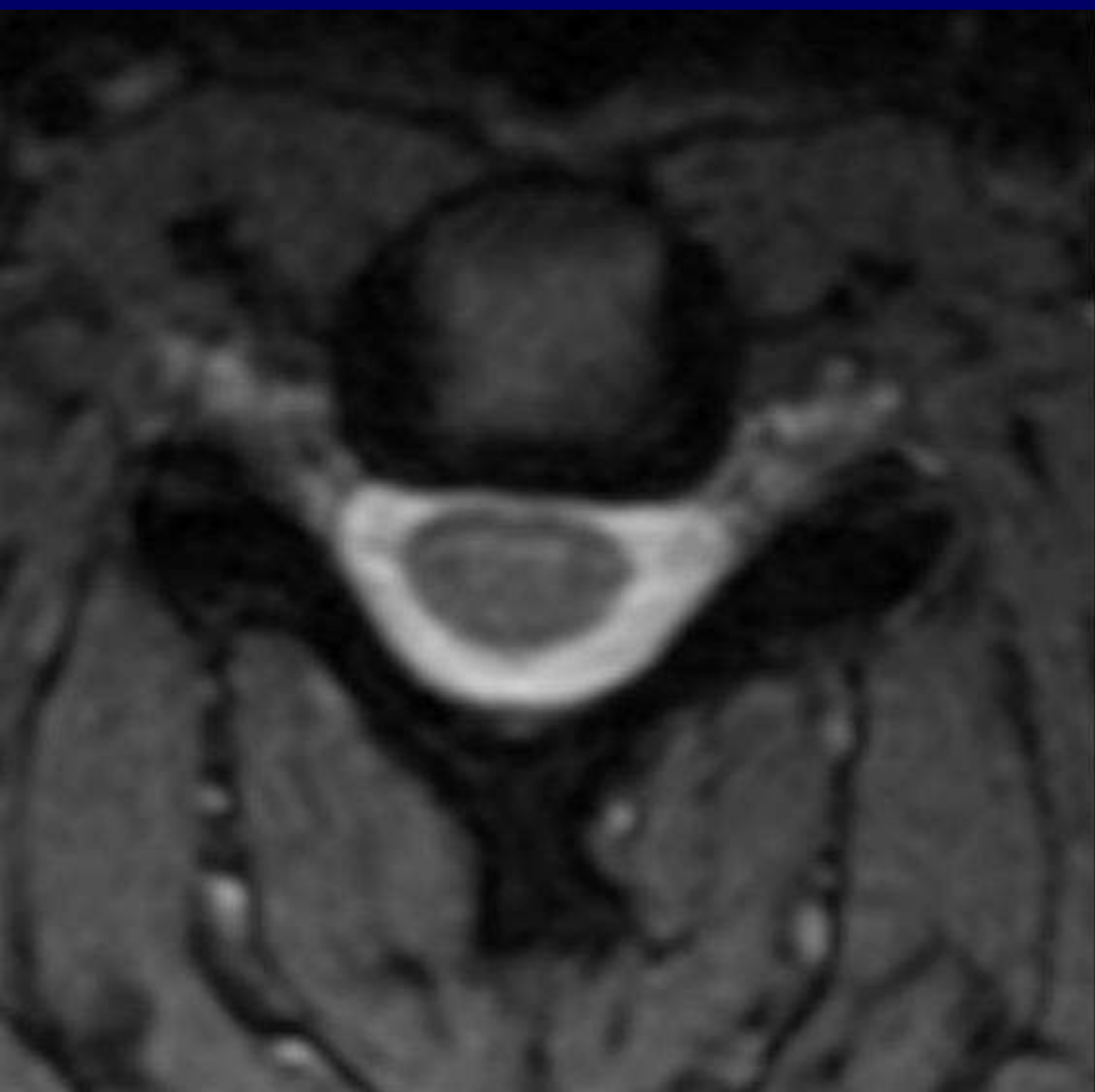
Lumbar Spine – Lateral View



MRI Anatomy











Sagittal Lumbar Spine



Cauda equina

Ligamentum flavum

Epidural fat

Spinous process

Intraspinous ligament

Dura

Retrovertebral venous plexus

Posterior longitudinal ligament

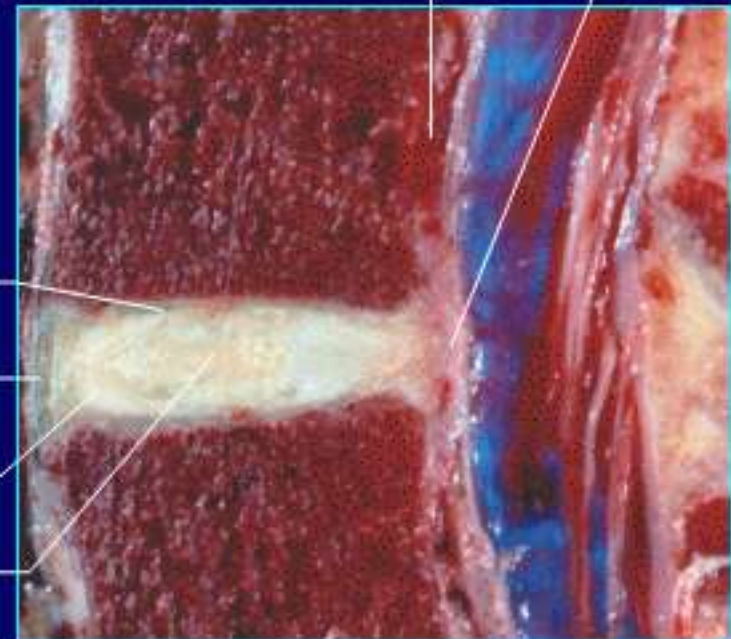
Vertebral end plate

Anterior longitudinal ligament

Anulus fibrosus

Nucleus pulposus

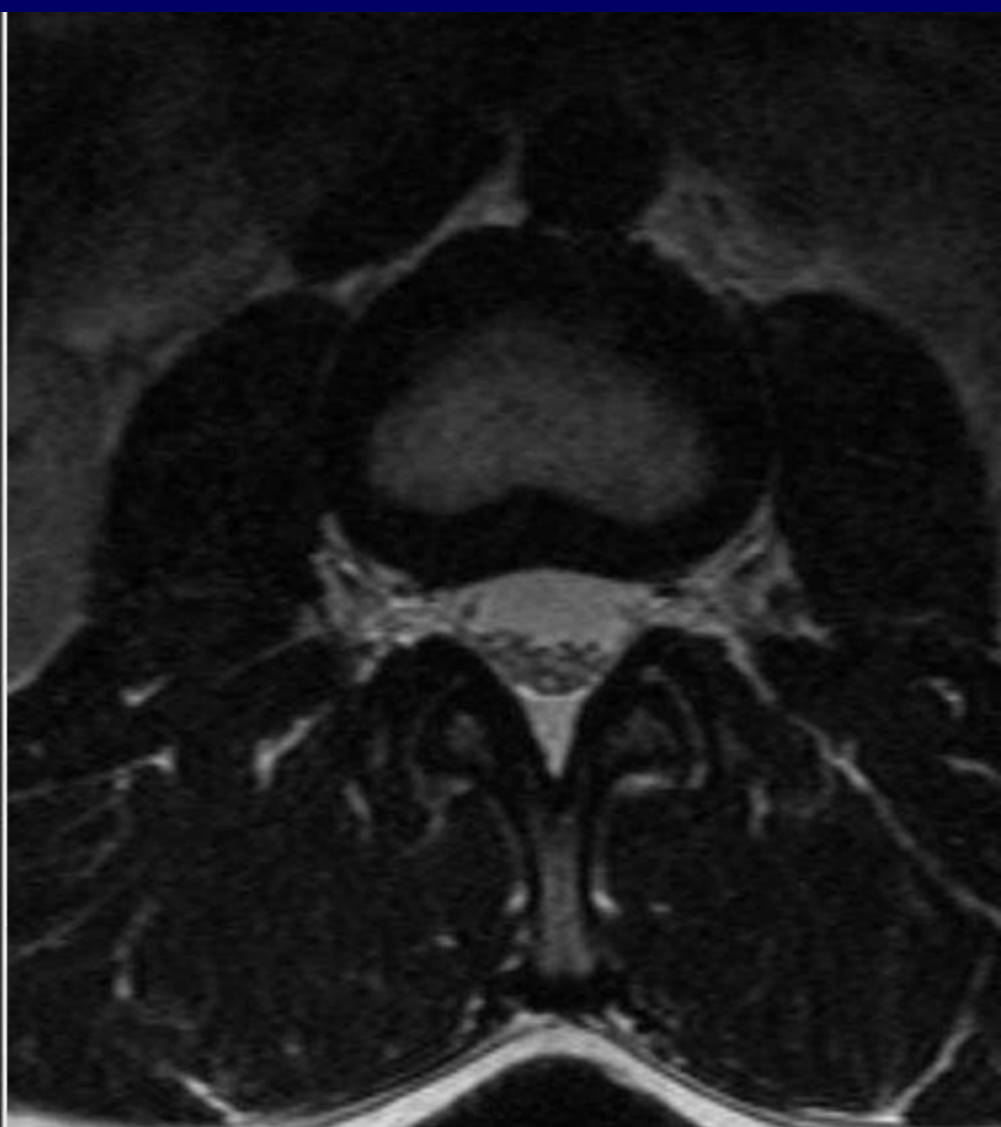
The Intervertebral Disk











Spine Pathology

- Trauma
- Degenerative disease
- Tumors and other masses
- Inflammation and infection
- Vascular disorders
- Congenital anomalies

Trauma

Evaluating Trauma

- **Fracture** – plain film / CT
- **Dislocation** – plain film / CT
- **Ligamentous injury** – MRI
- **Cord injury** – MRI
- **Nerve root avulsion** – MRI

**Plain film findings may be
very subtle or absent!**

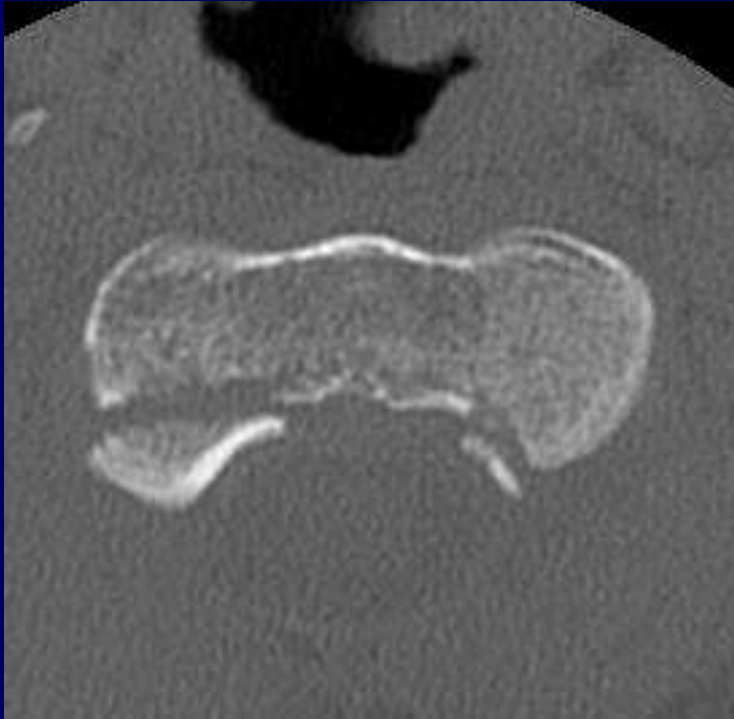
**Anterolisthesis of
C6 on C7
(Why??)**



**Fractures of C6 left
pedicle and lamina**



CT – 2D Reconstructions

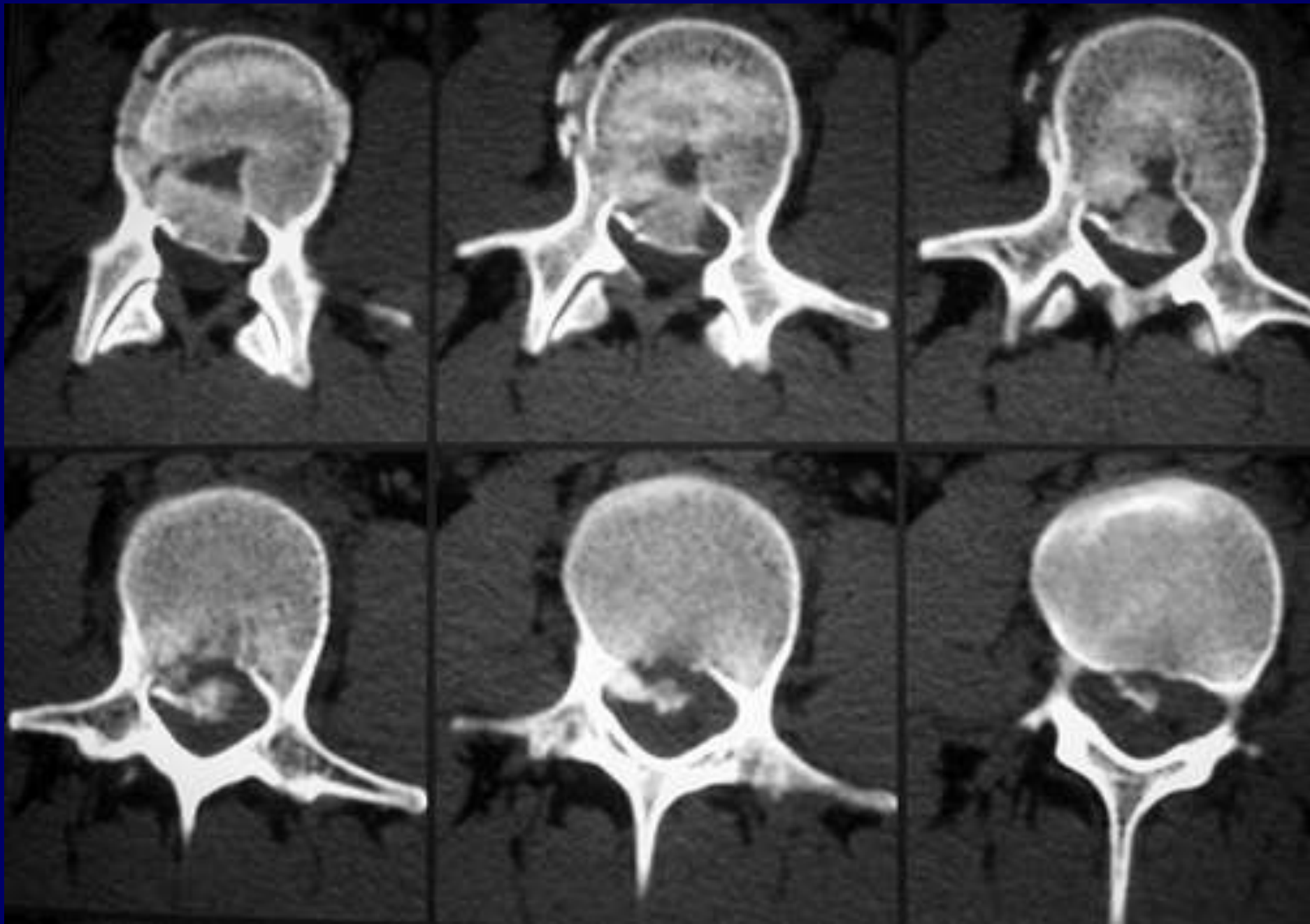


Acquire images axially...

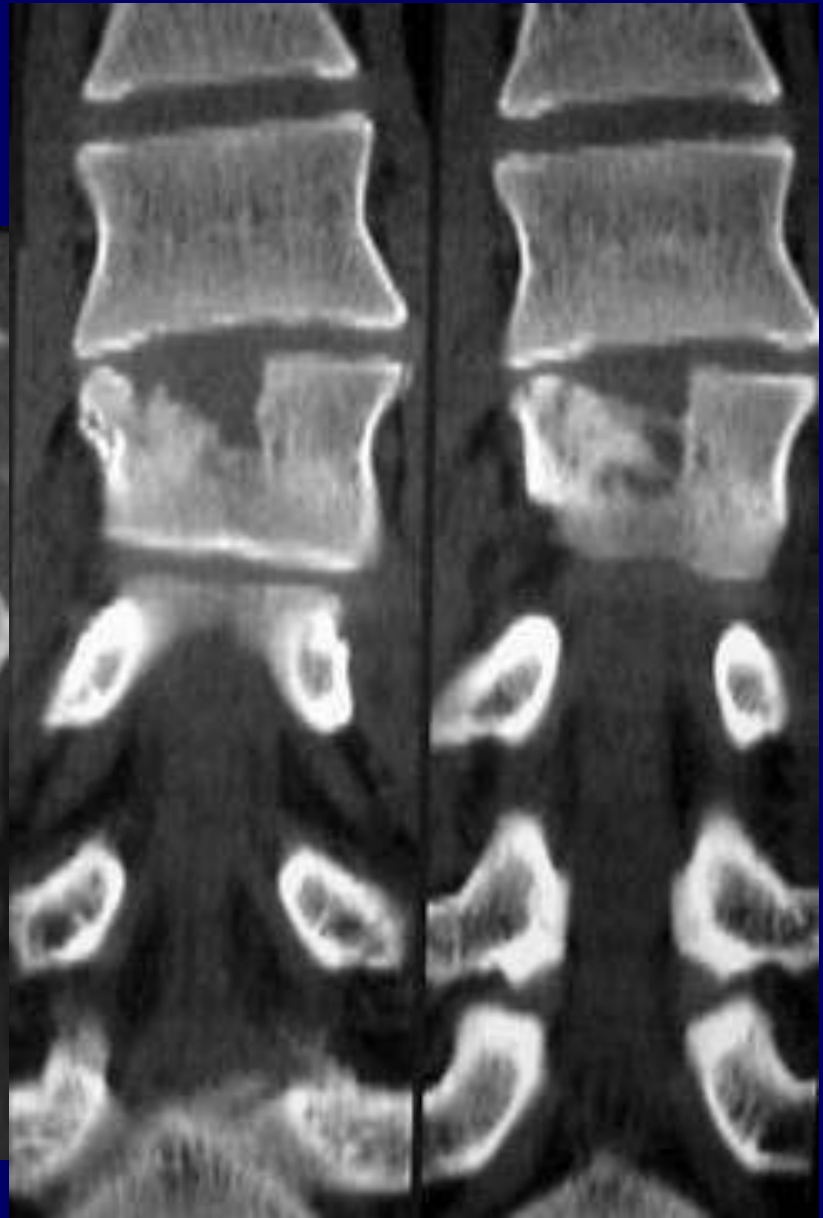
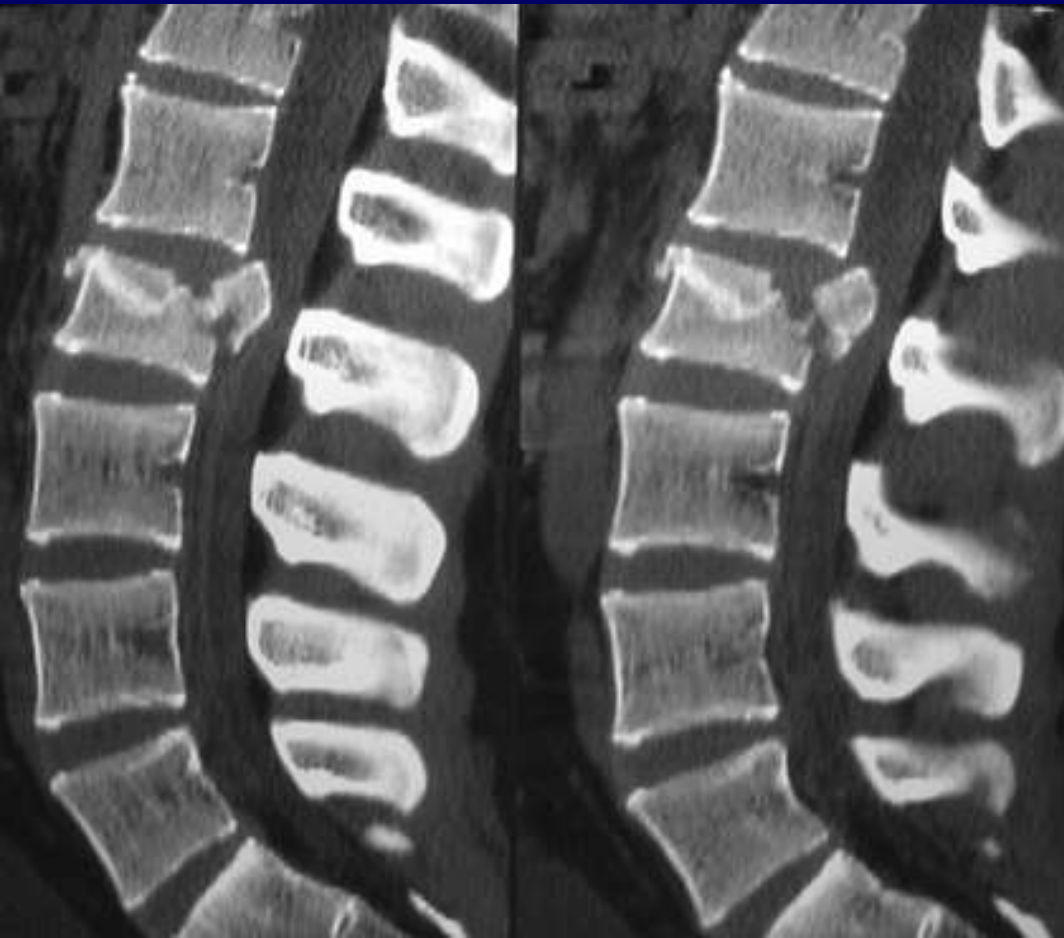


...reconstruct sagittal / coronal

26M MVA

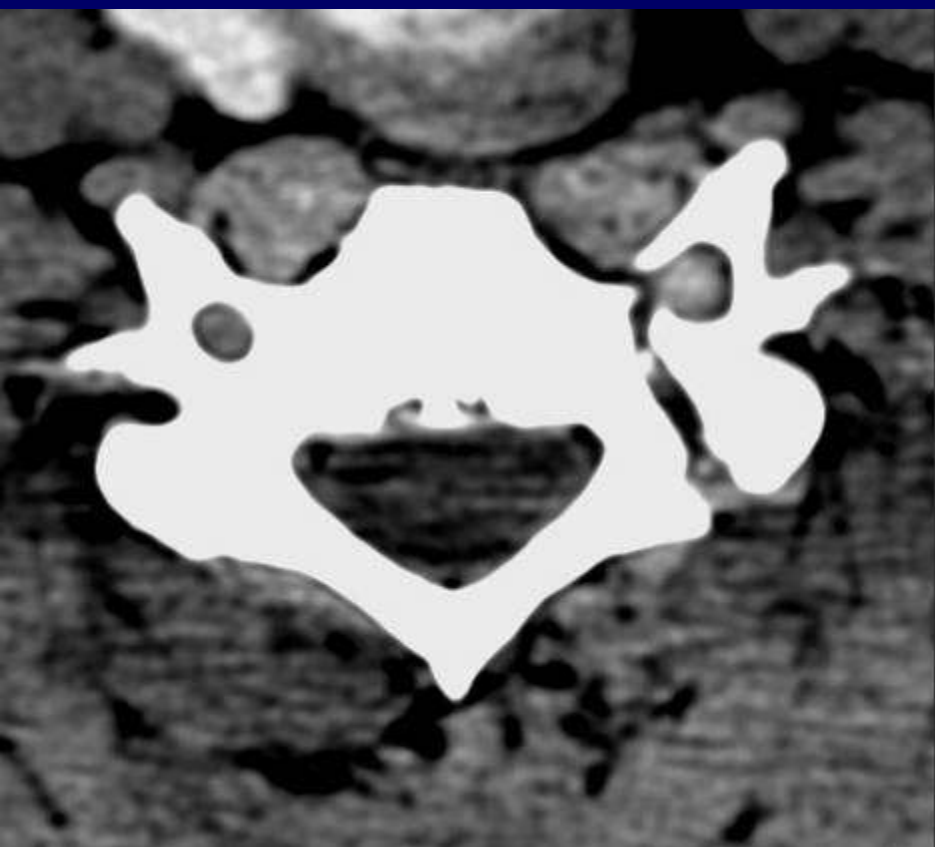


Vertebral body burst fx with retropulsion into spinal canal

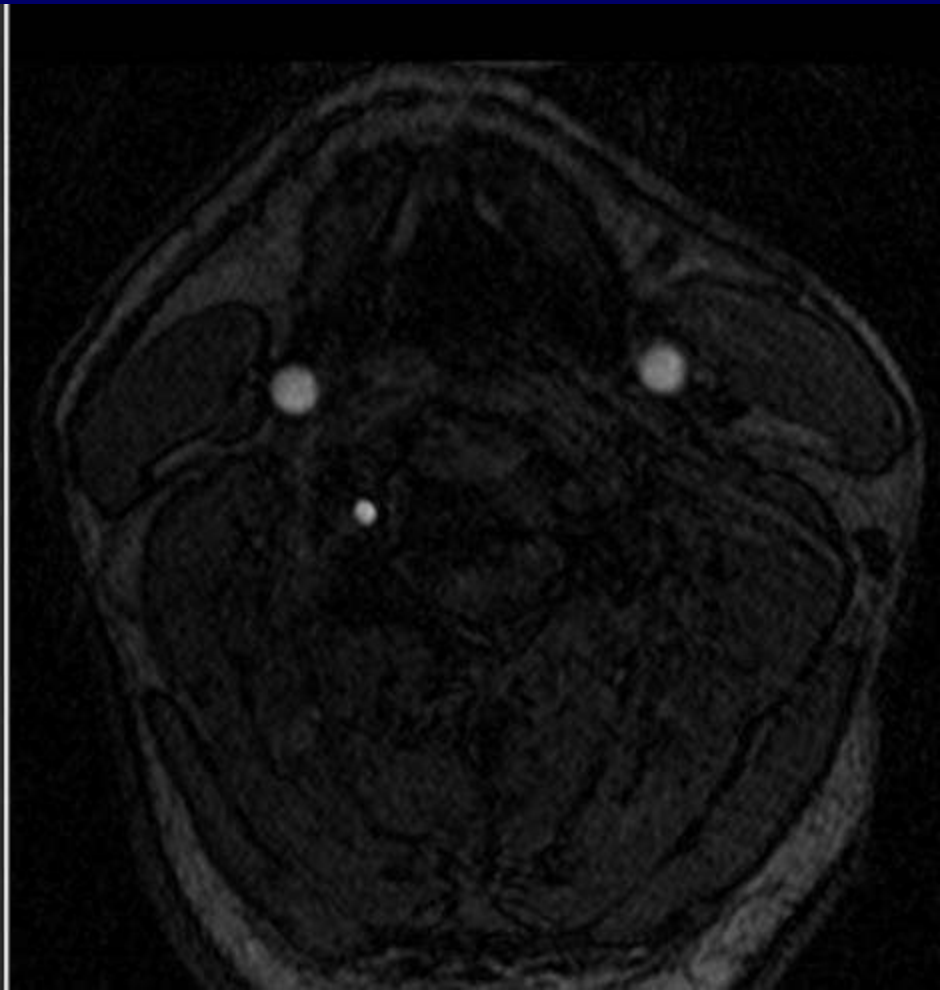


2D Reformats





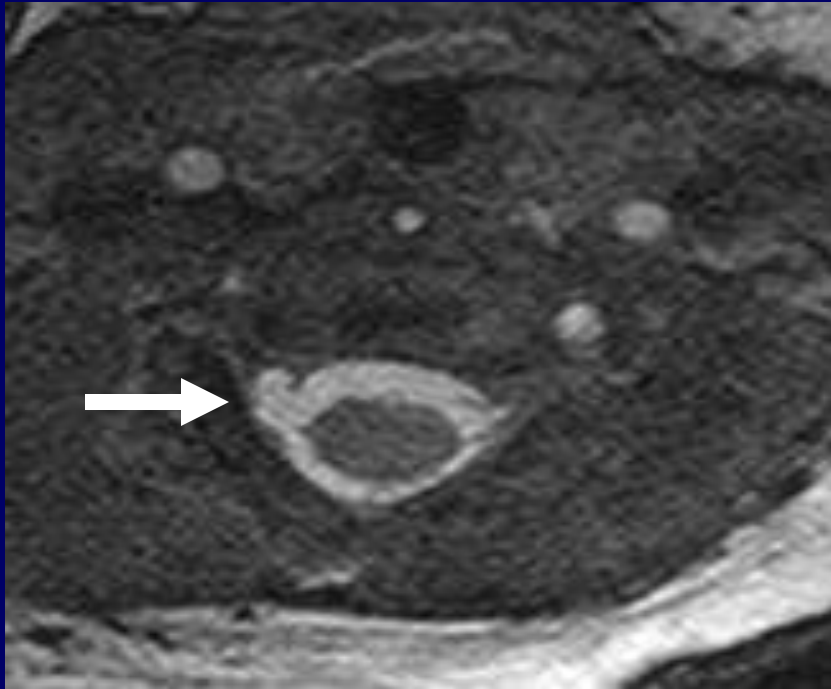
Vertebral Artery Dissection/Occlusion Secondary to C6 Fracture



Hyperflexion fx with ligamentous disruption and cord contusion



Nerve root avulsion



Axial



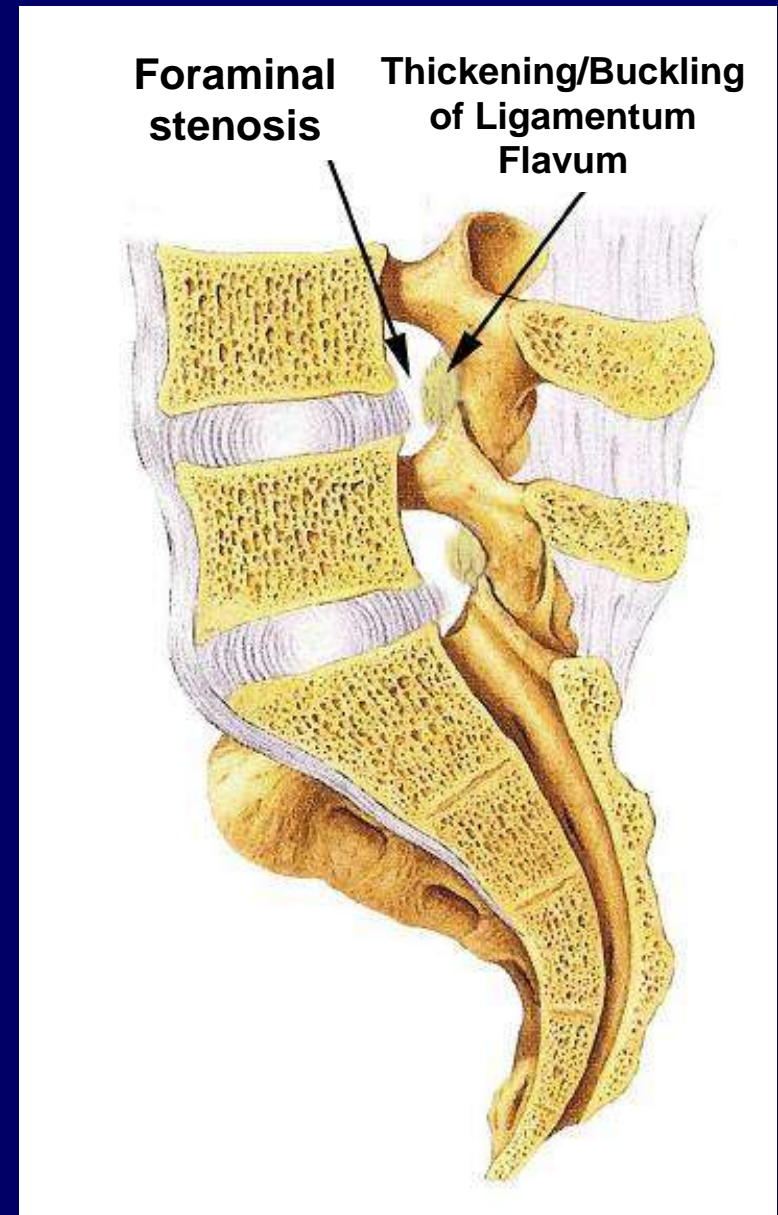
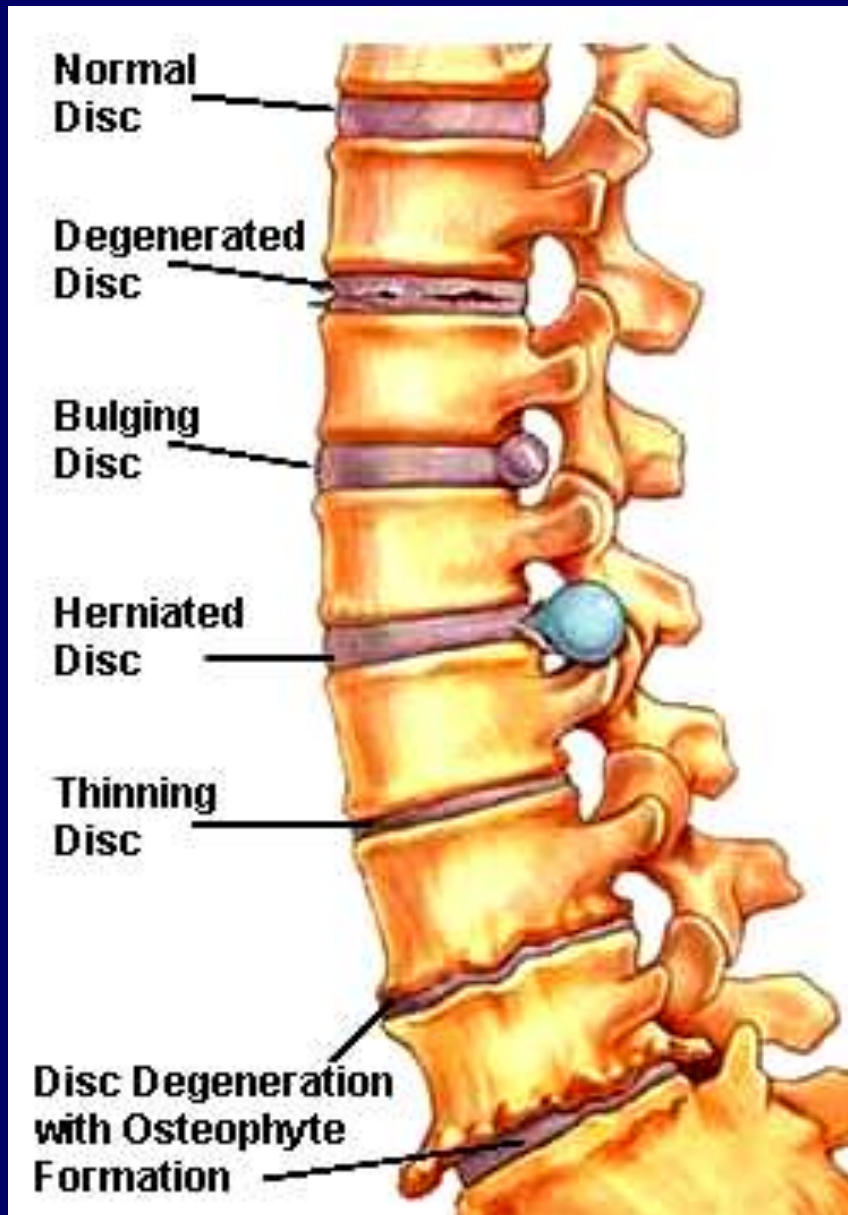
Coronal



Sagittal

Degenerative Disease

Degenerative Disc (and Facet Joint) Disease



Degenerative Disc (and Facet Joint) Disease



Degenerative Disc (and Facet Joint) Disease

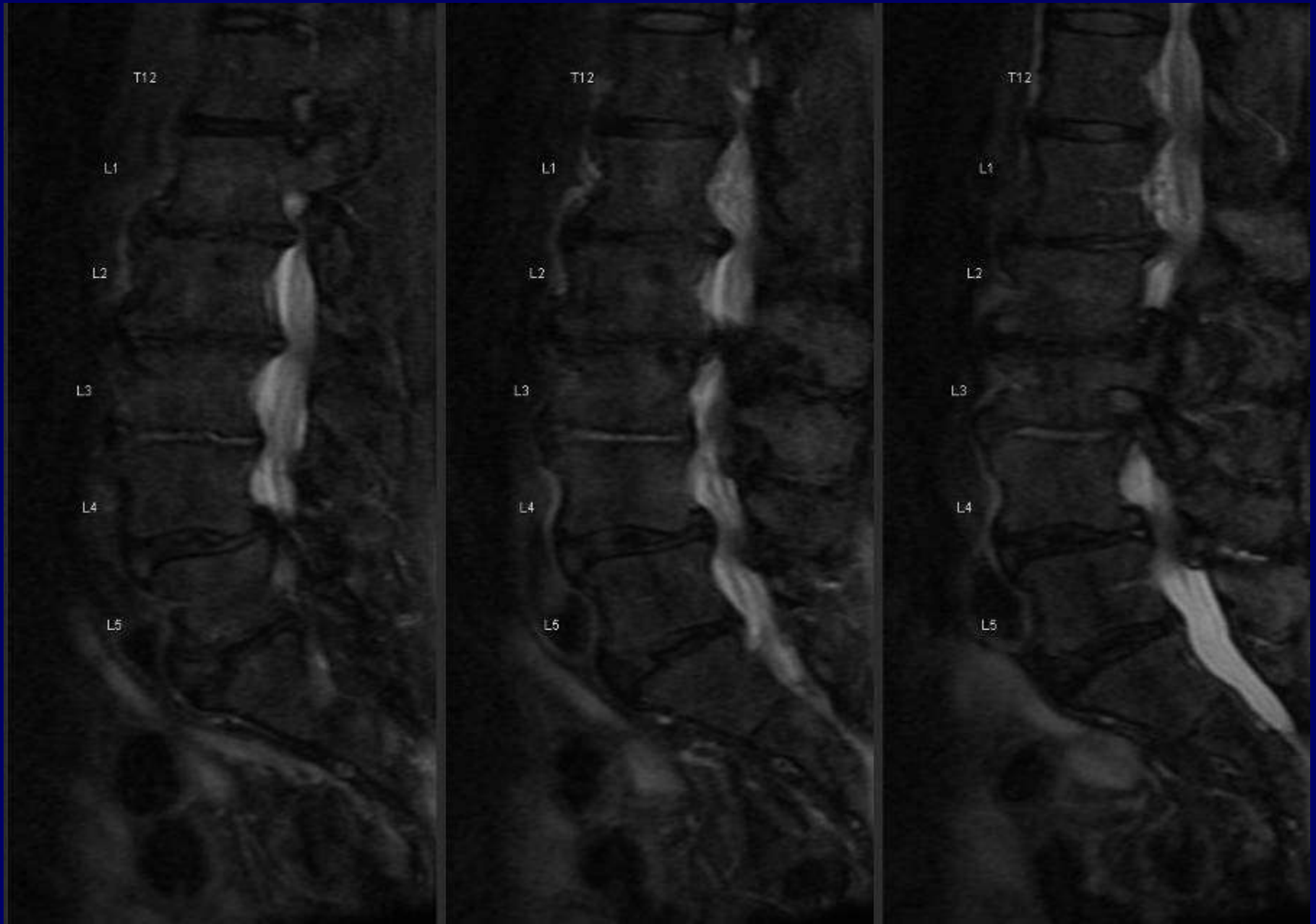




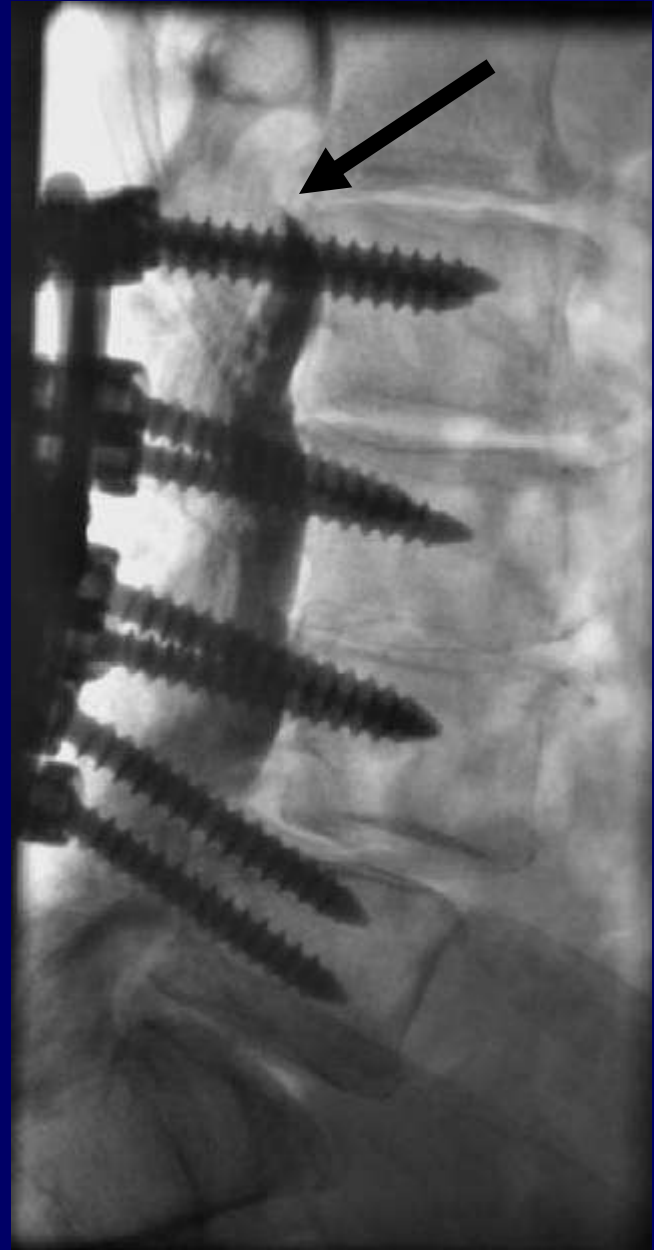
Lumbar Spinal Stenosis



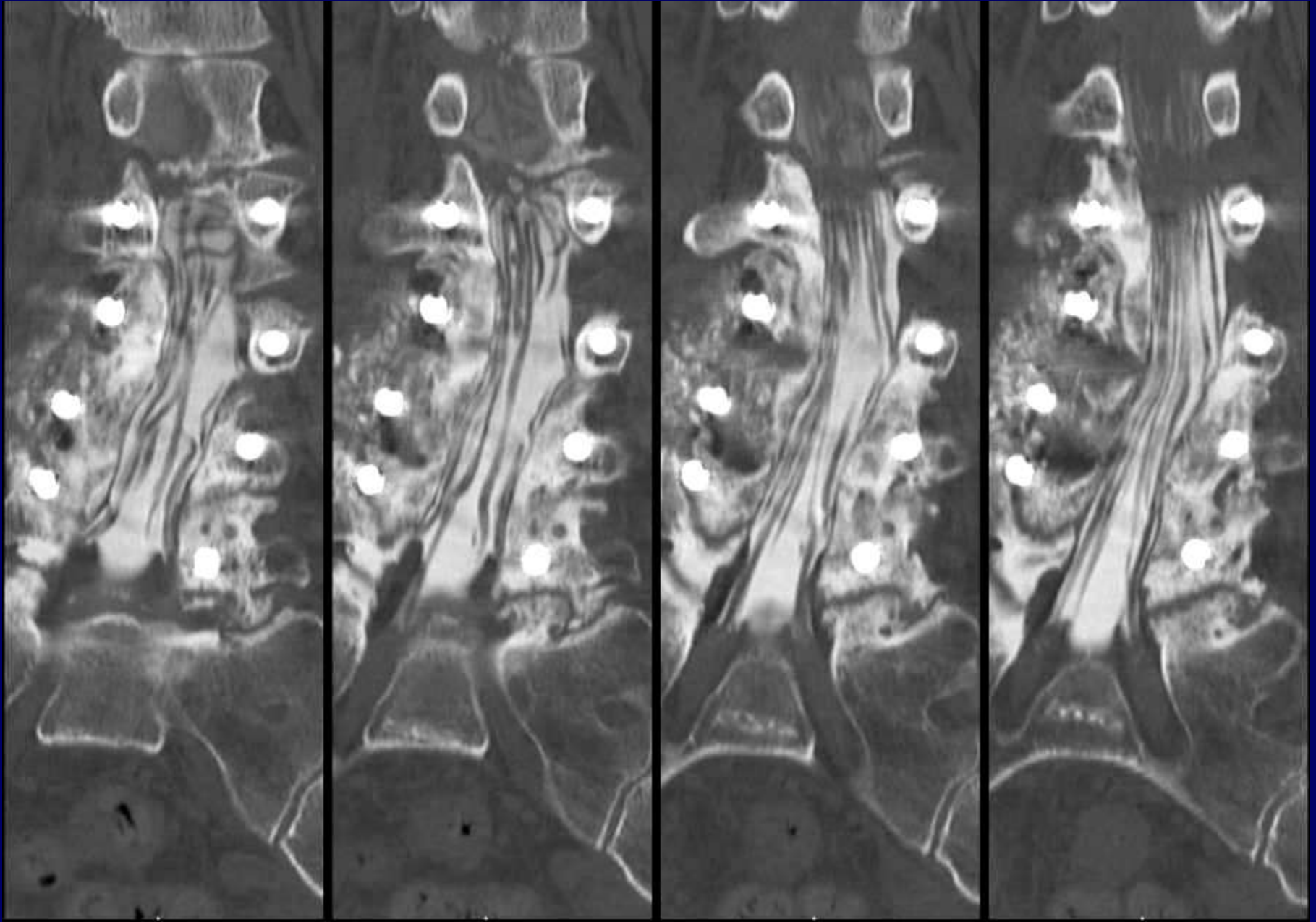
Lumbar Spinal Stenosis



Lumbar Spinal Stenosis



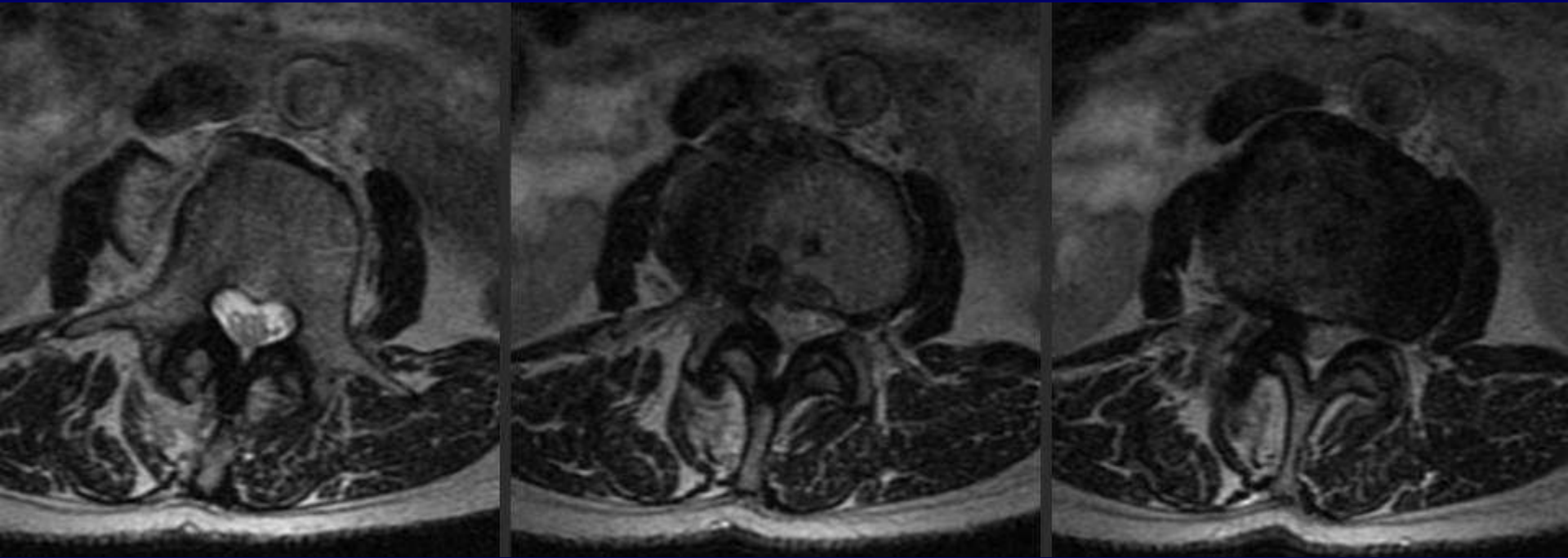
Lumbar Spinal Stenosis



Lumbar Spinal Stenosis

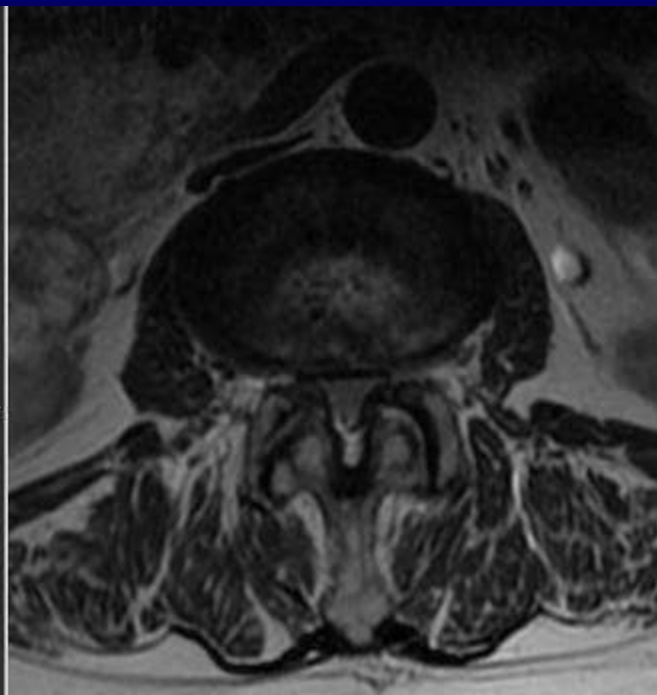
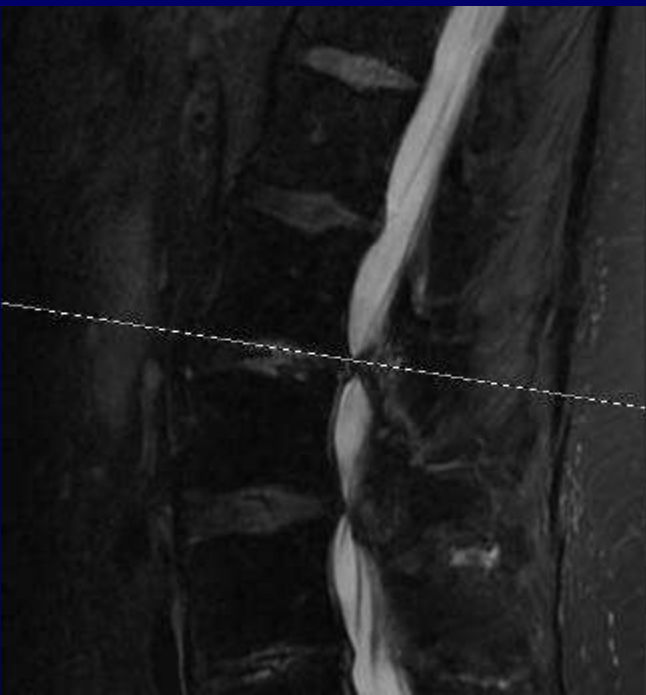
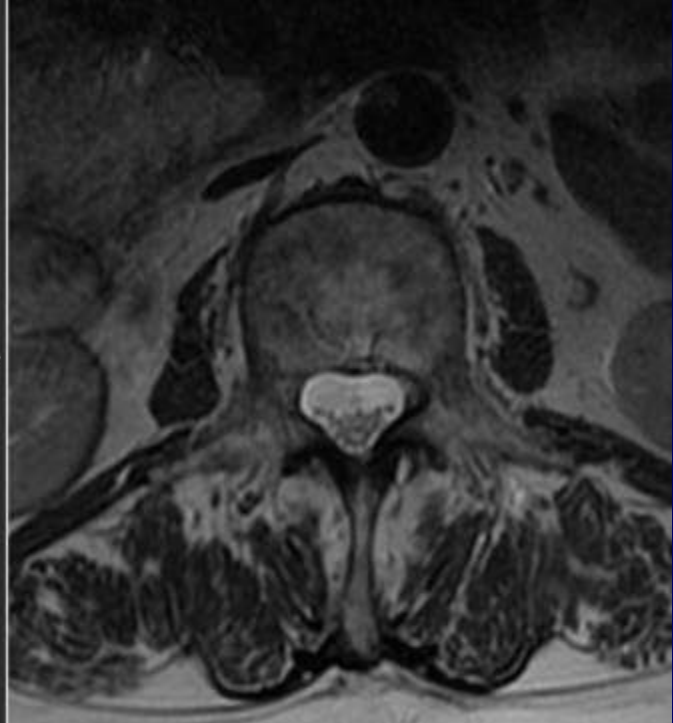
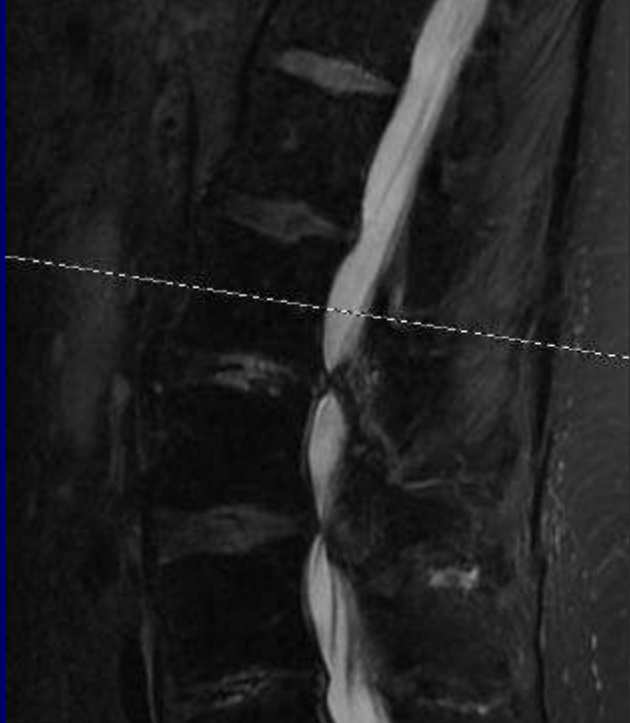


Lumbar Spinal Stenosis

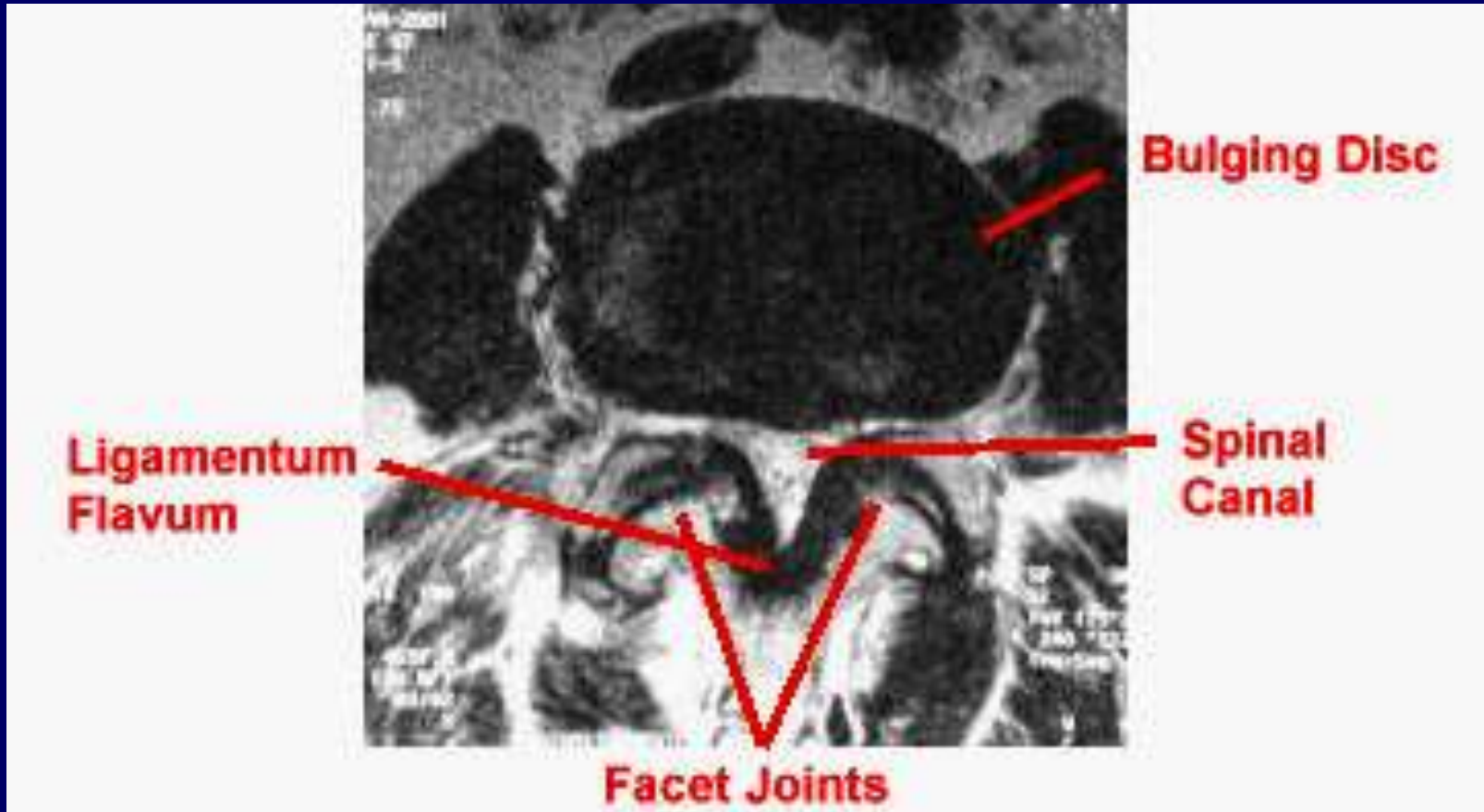


Disc bulge, facet hypertrophy and flaval ligament thickening frequently combine to cause central spinal stenosis

Note the trefoil shape of stenotic spinal canal



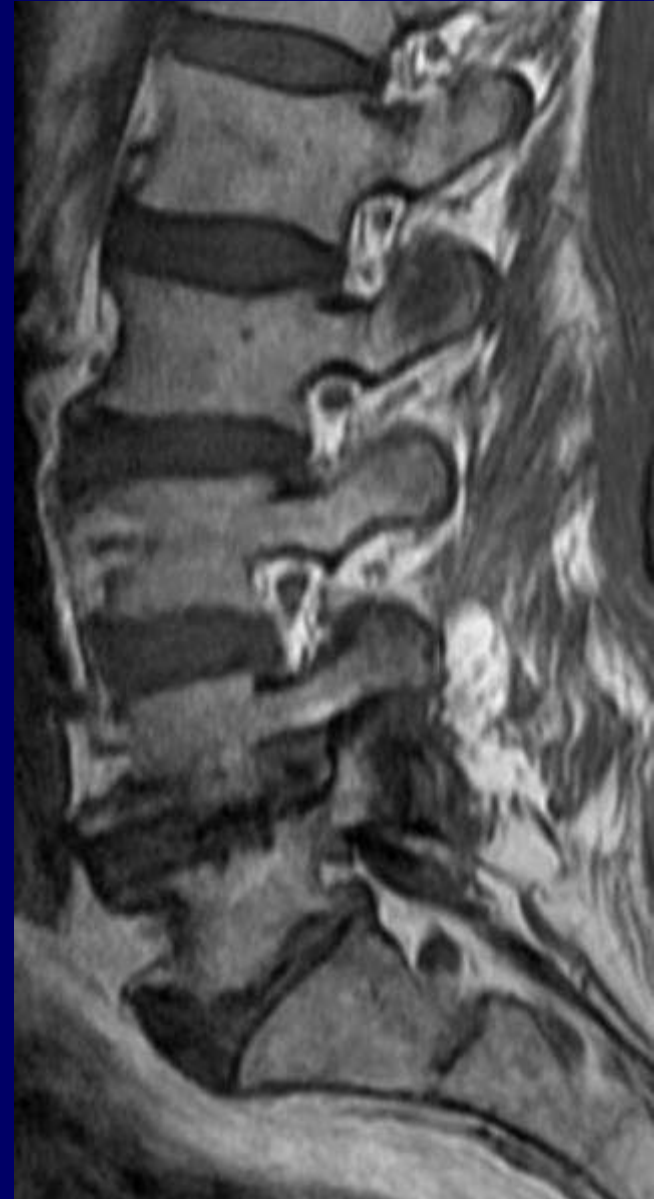
Lumbar Spinal Stenosis



Disc bulge, facet hypertrophy and flaval ligament thickening frequently combine to cause central spinal stenosis

Note the trefoil shape of stenotic spinal canal

Foraminal Stenosis



Cervical Spinal Stenosis



Healthy Cervical Spine



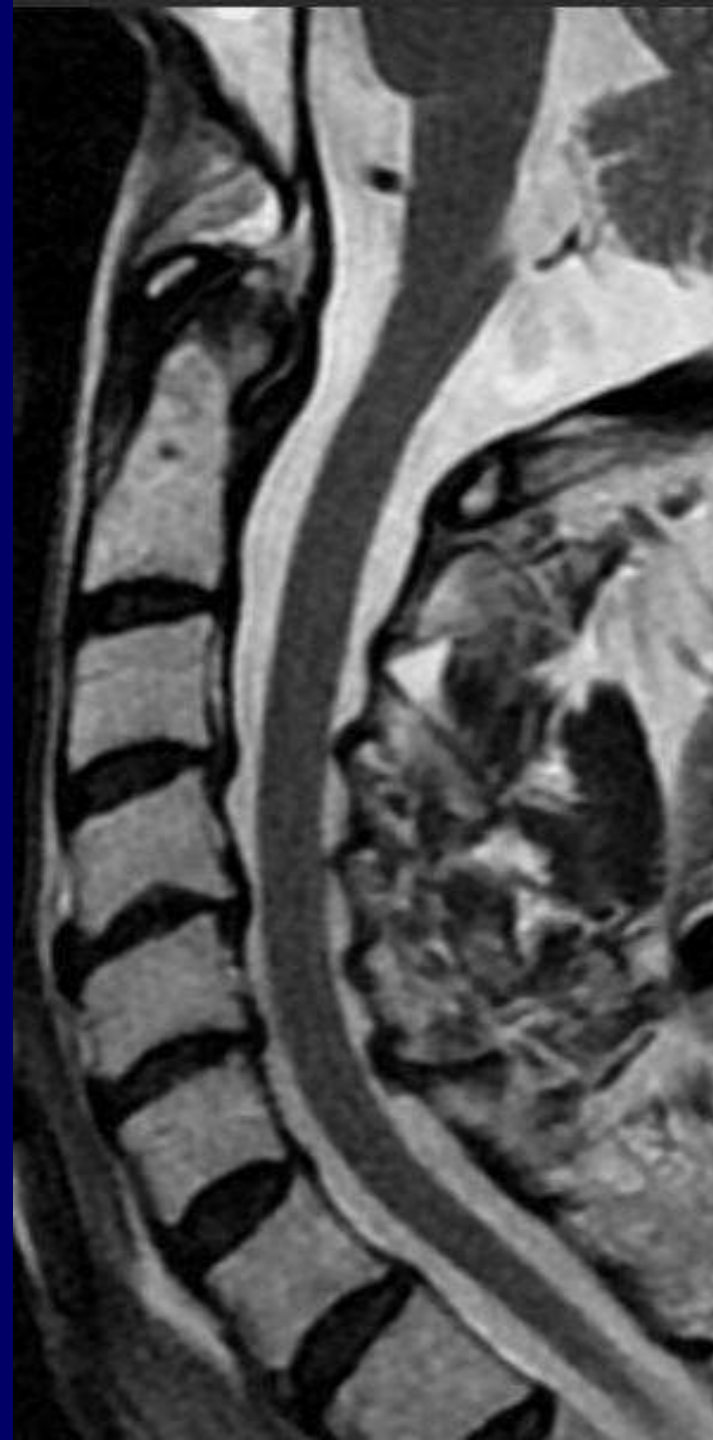
Central Stenosis



Foraminal Stenosis



Herniated Disk



MRI - Degenerative Disc Disease

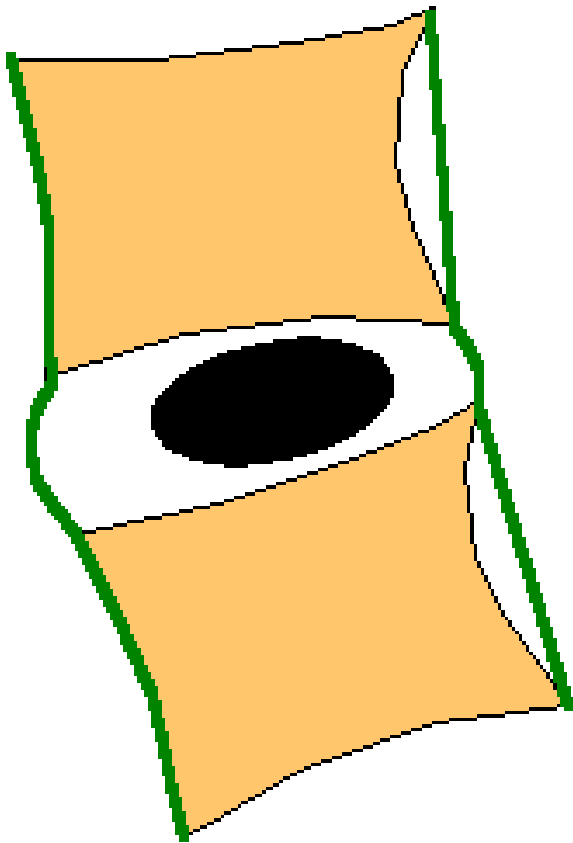
Age:

- **20-40 36% have degenerated disc**
- **50 85-95% have degenerated disc**
- **60-80 98% have degenerated disc**
- **<60 20% have asymptomatic disc herniation**

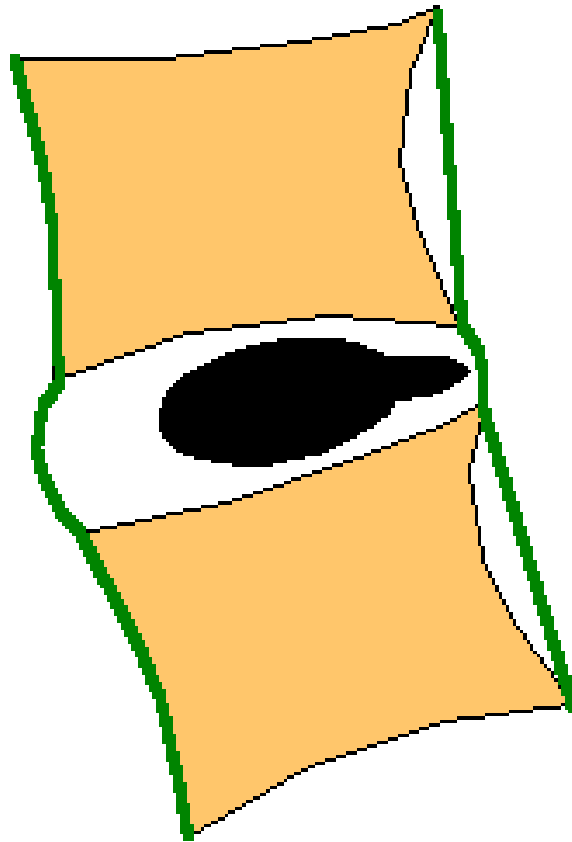
Conclusion: Abnormal findings on MRI frequently DO NOT relate to symptoms (and vice versa) !!

MRI – Herniated Disc Levels

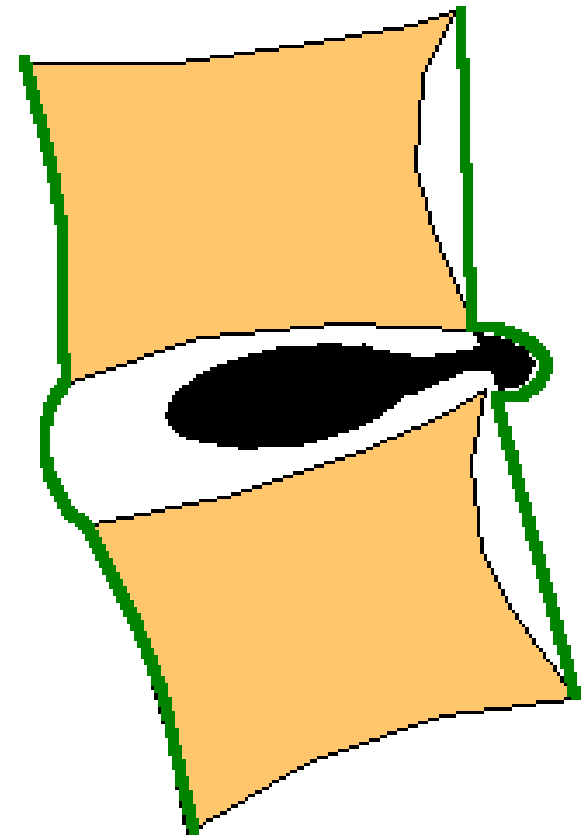
- **85-95% at L4-L5, L5-S1**
- **5-8% at L3-L4**
- **2% at L2-L3**
- **1% at L1-L2, T12-L1**
- **Cervical: most common C4-C7**
- **Thoracic: 15% in asymptomatic pts. at multiple levels, not often symptomatic**



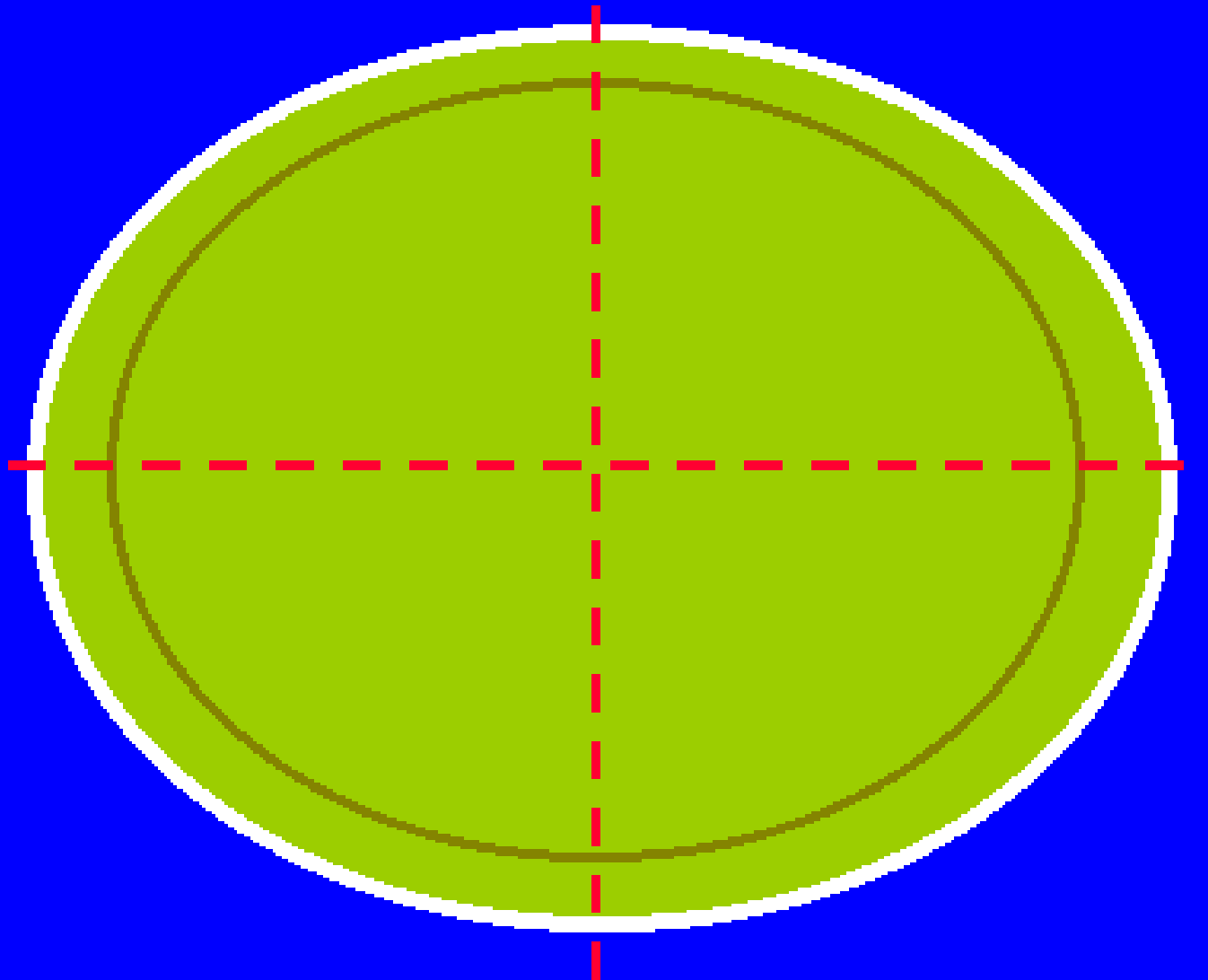
Normal Disc



Annular Tear

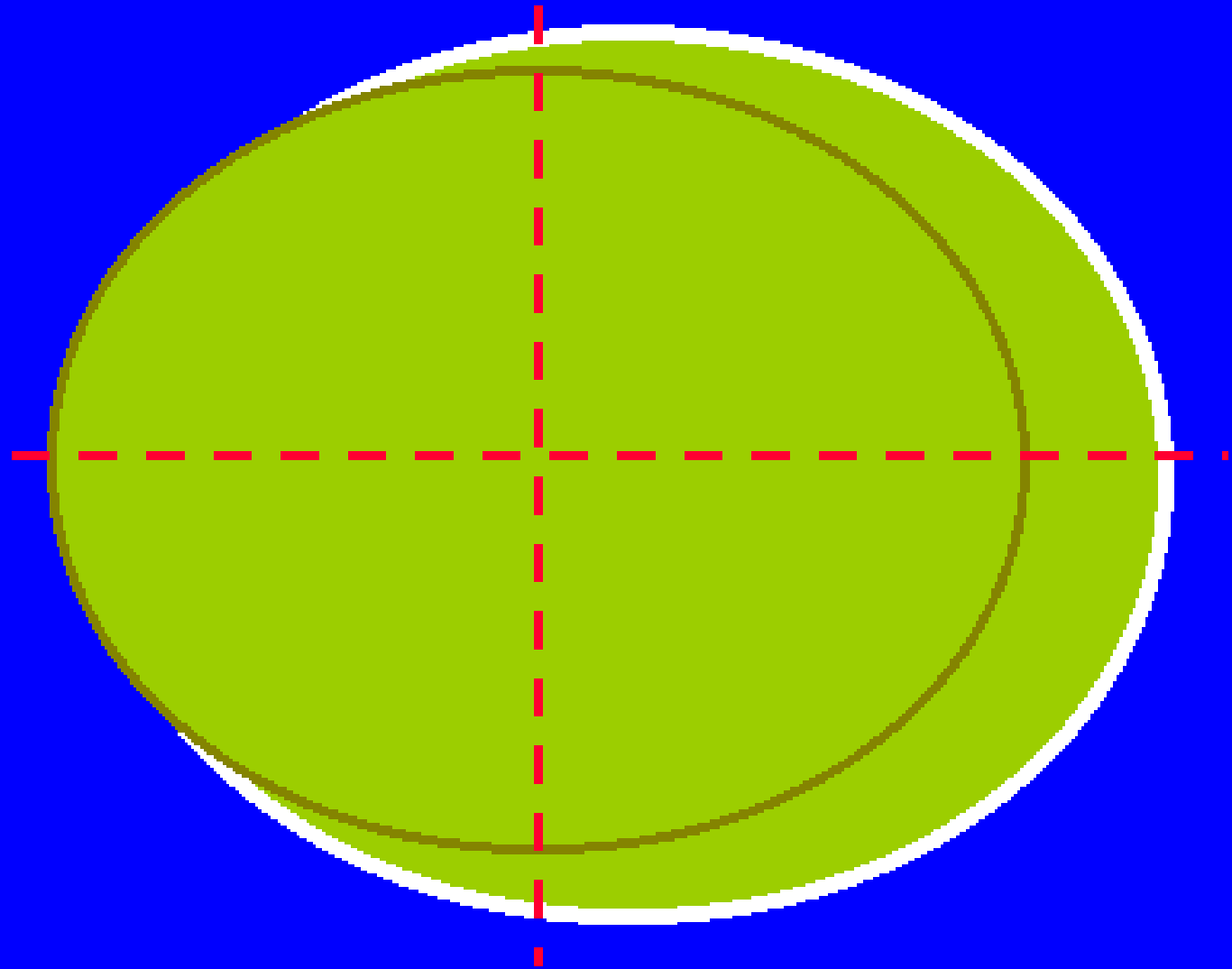


Herniated Disc



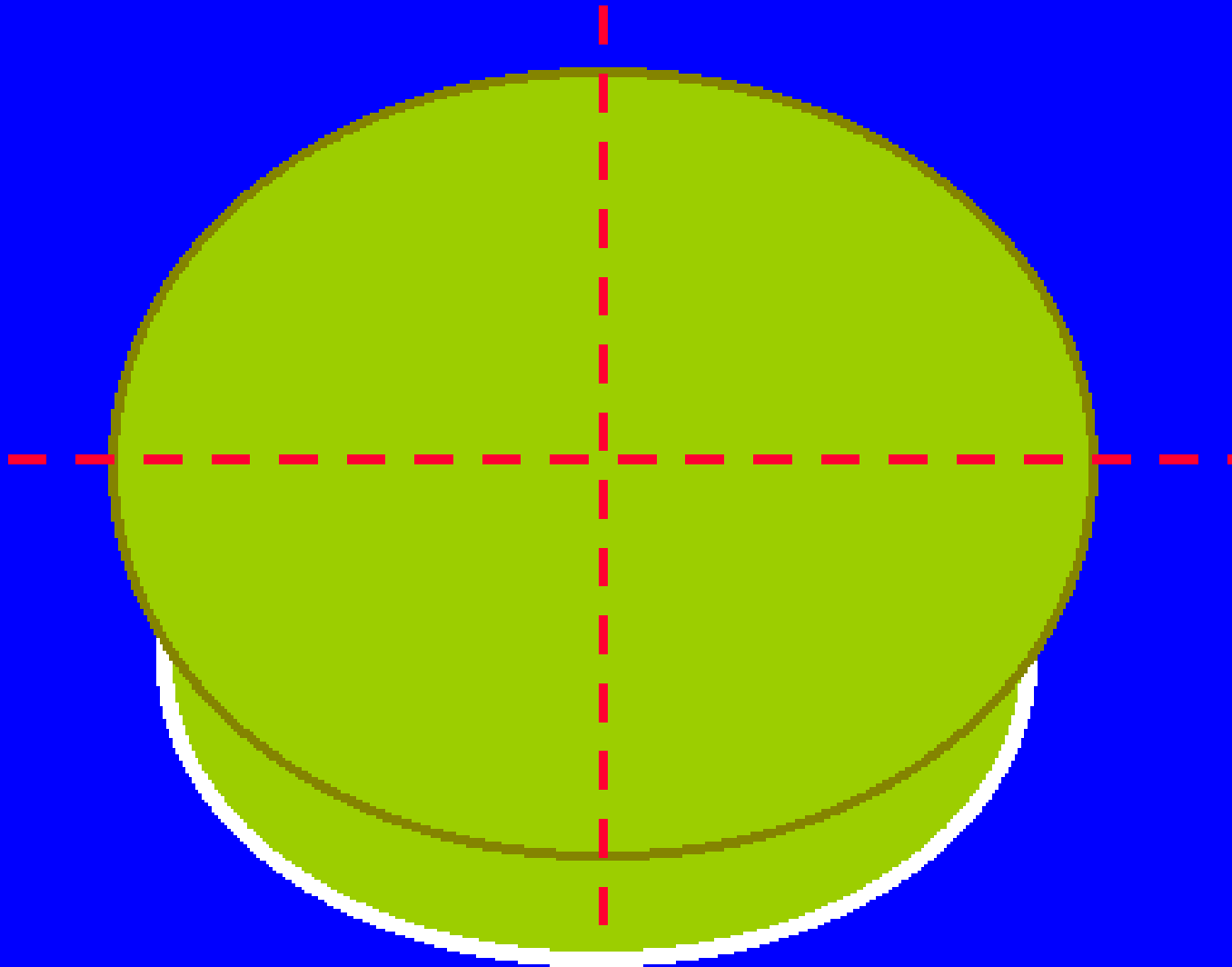
"Symmetrical Bulging Disc"

Adapted from: "Nomenclature and Classification of Lumbar Disc Pathology: Recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology," 2001.



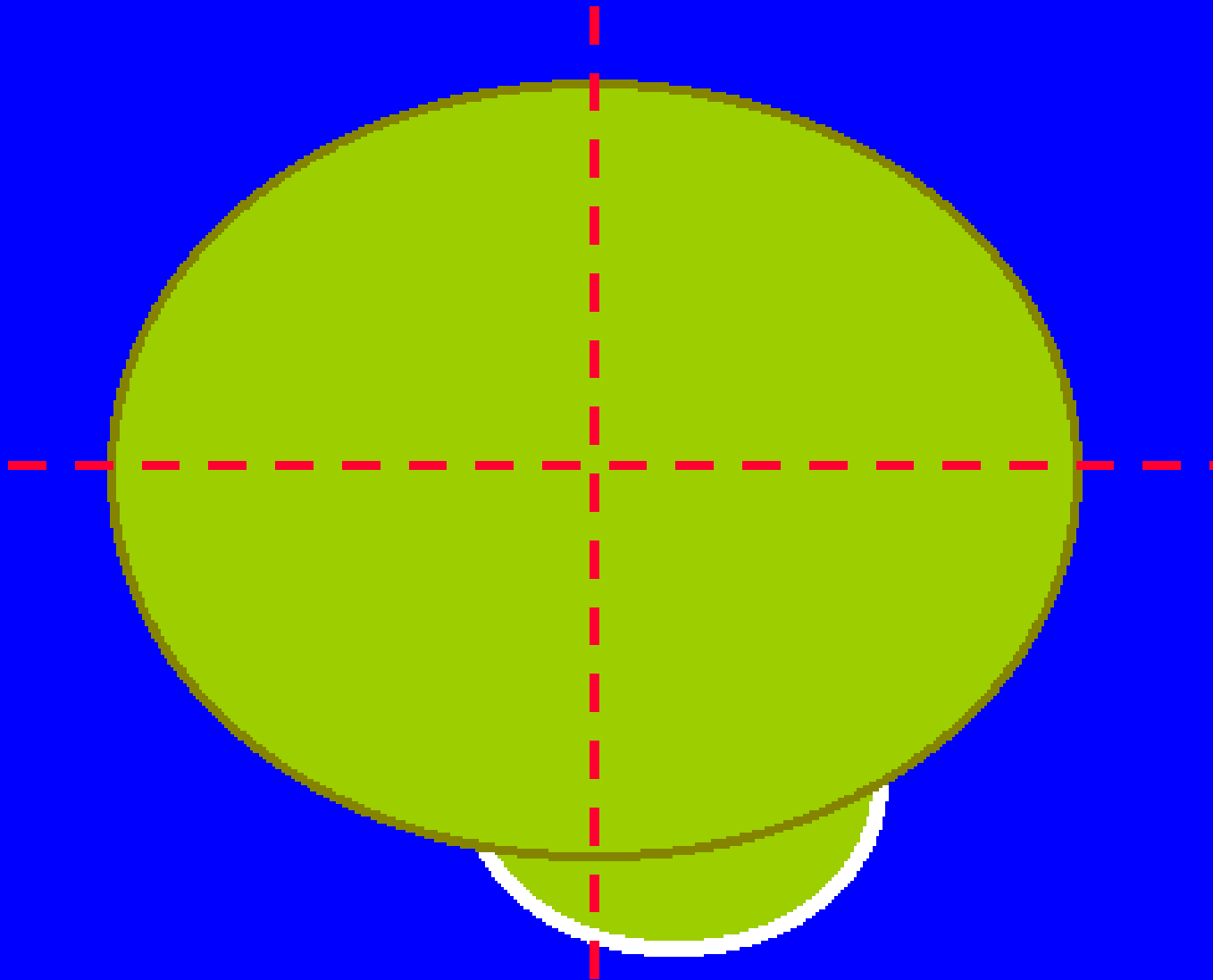
"Asymmetrical Bulging Disc"

Adapted from: "Nomenclature and Classification of Lumbar Disc Pathology: Recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology," 2001.



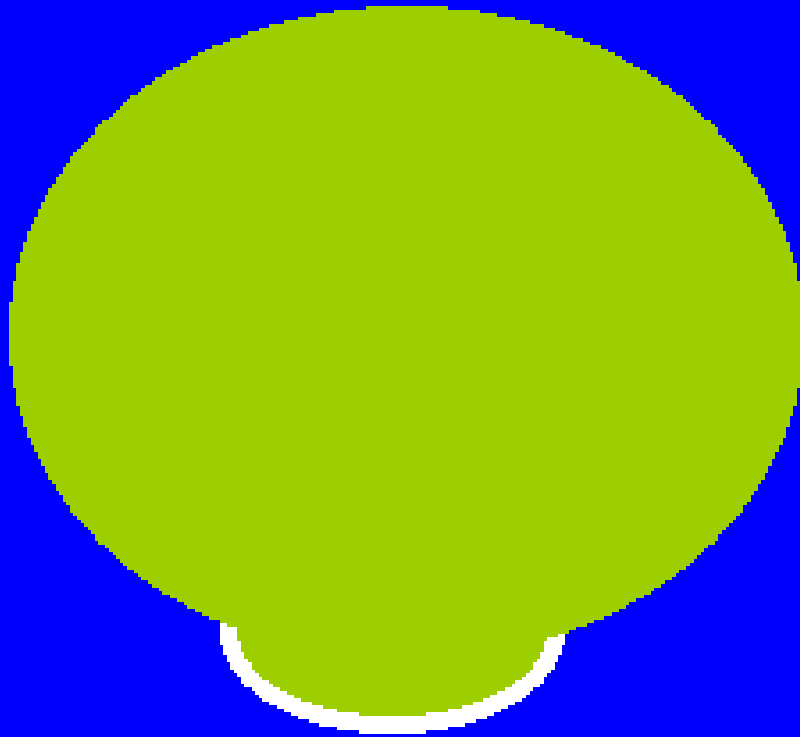
Broad-based Herniation

Adapted from: "Nomenclature and Classification of Lumbar Disc Pathology: Recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology," 2001.

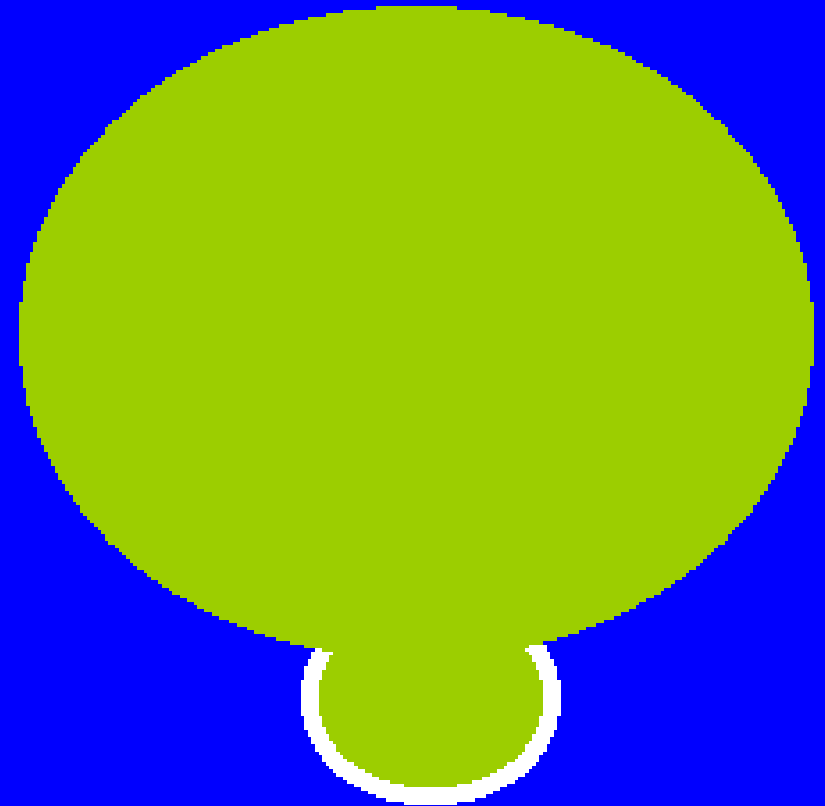


Focal Herniation

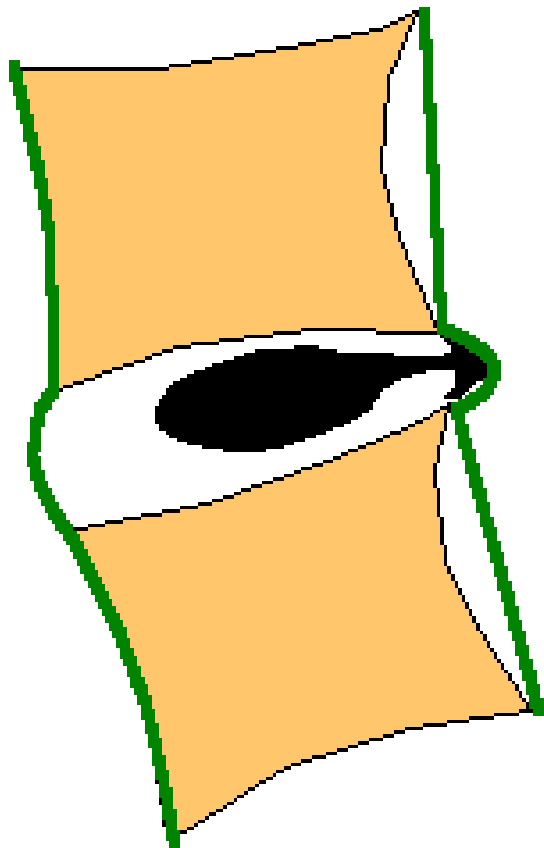
Adapted from: "Nomenclature and Classification of Lumbar Disc Pathology: Recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology," 2001.



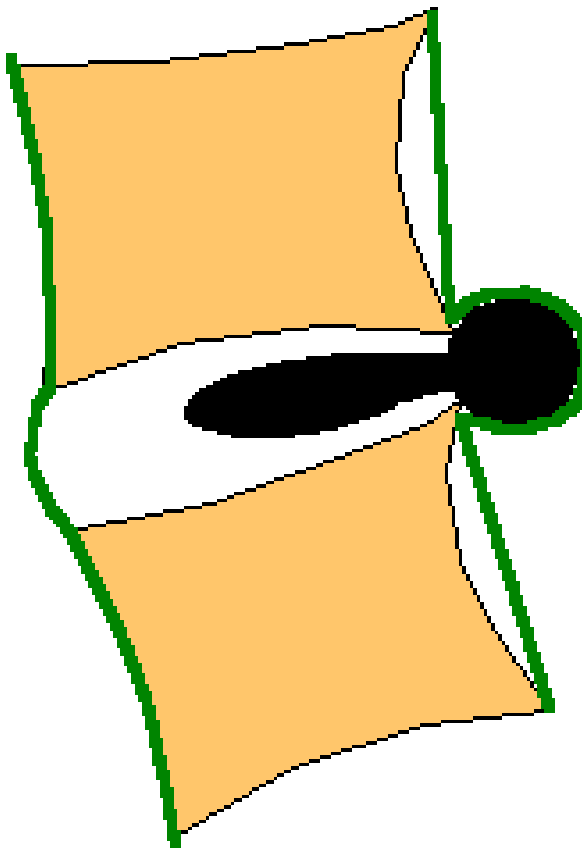
Protrusion



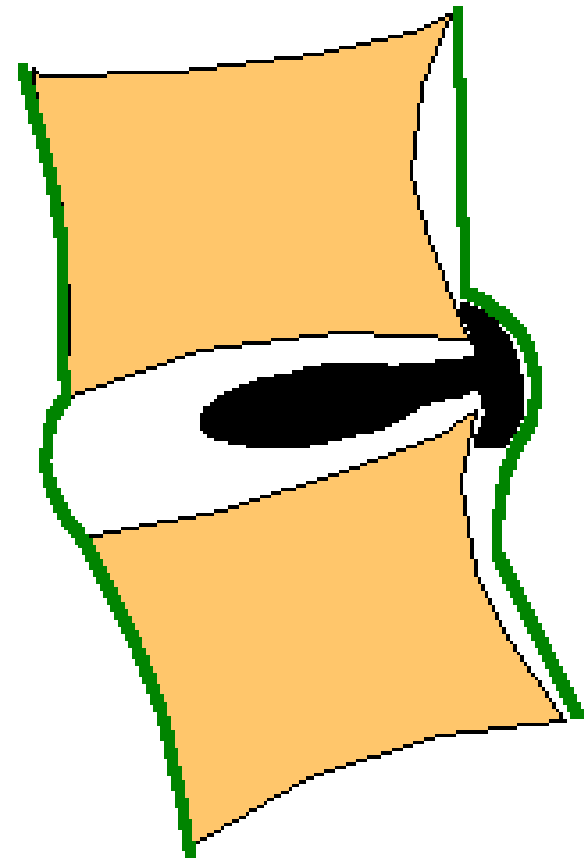
Extrusion



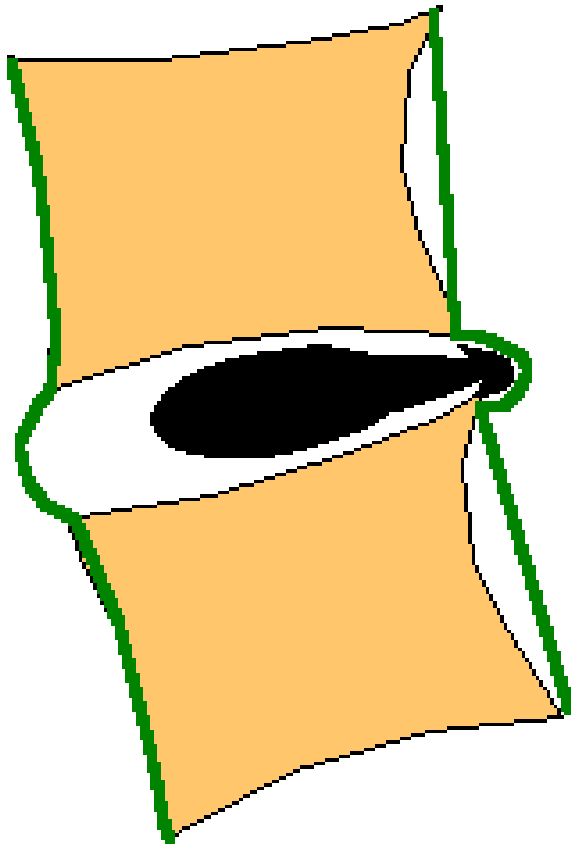
Protrusion



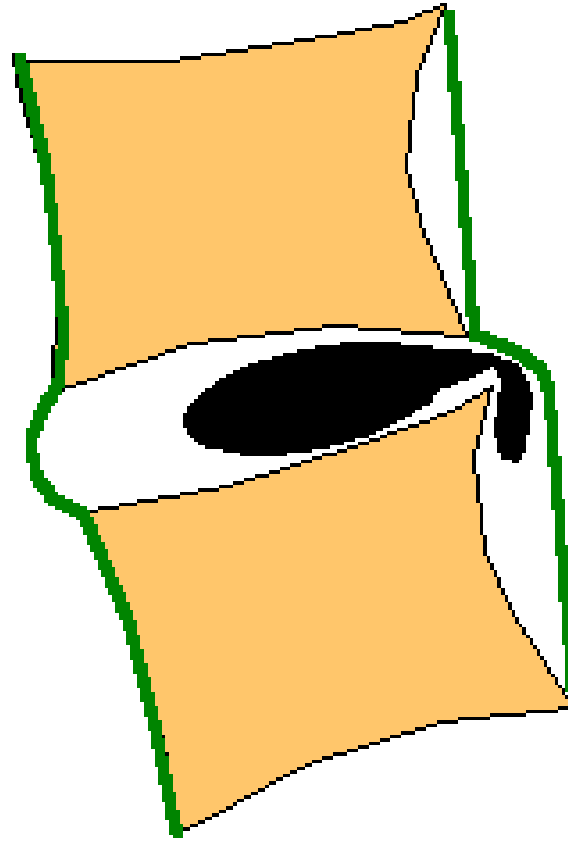
Extrusion



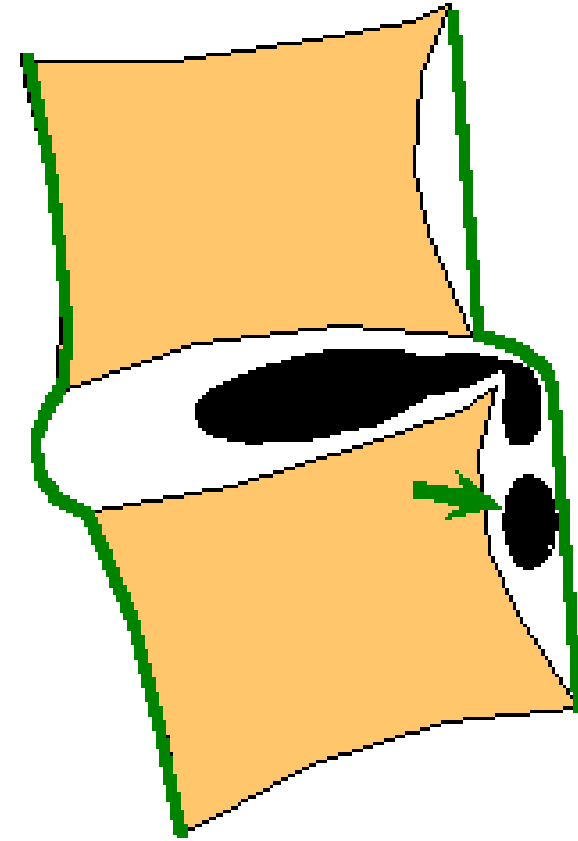
Extrusion



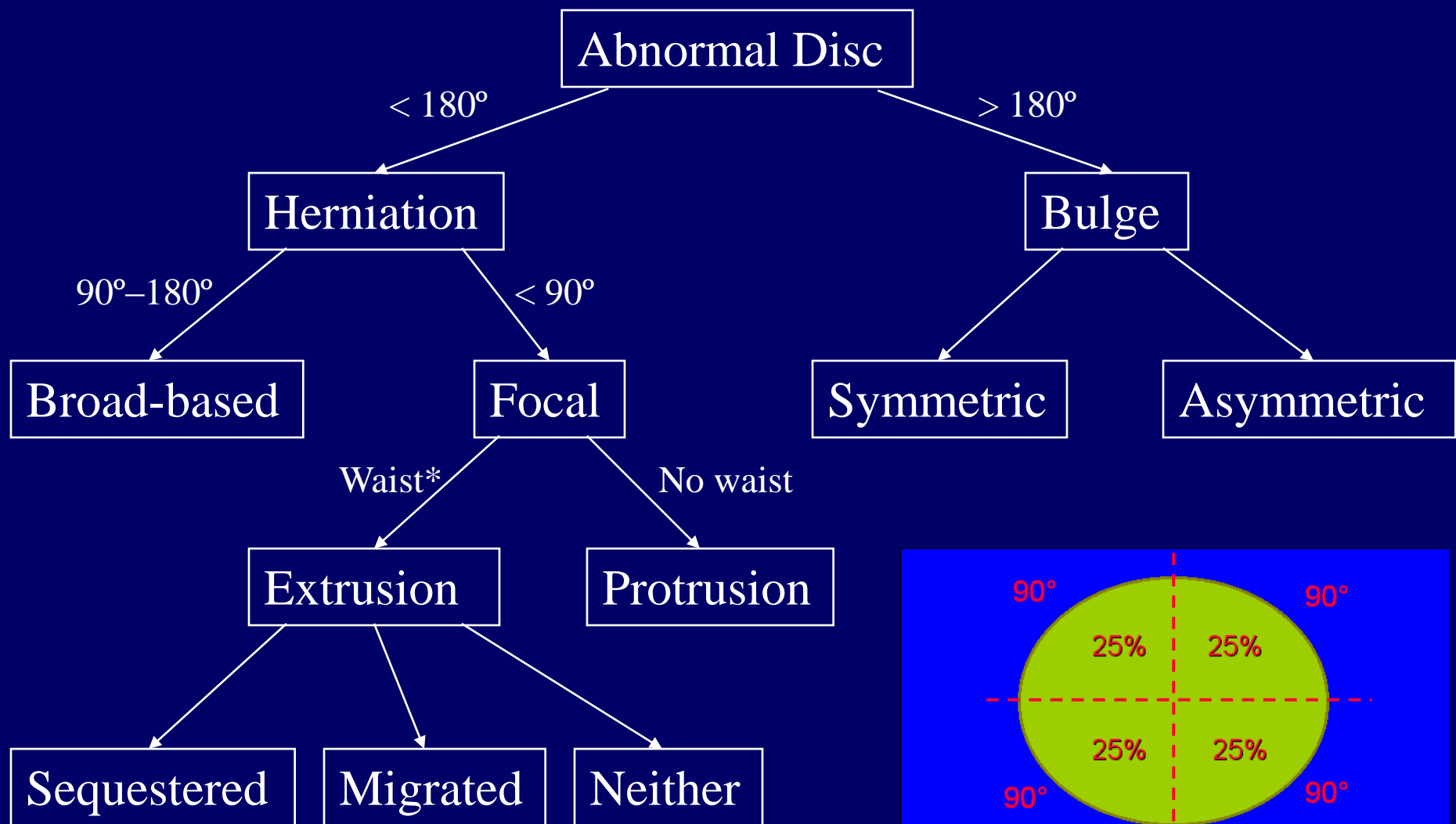
Protrusion



**Protrusion w/
migration**

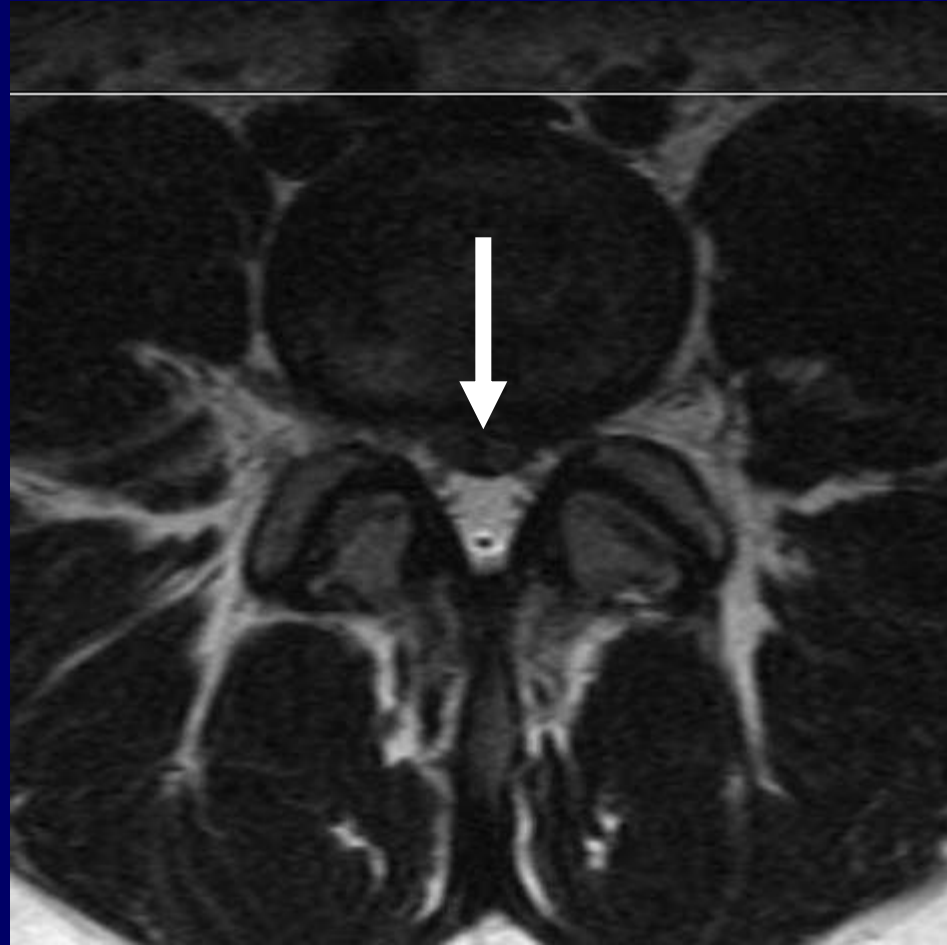
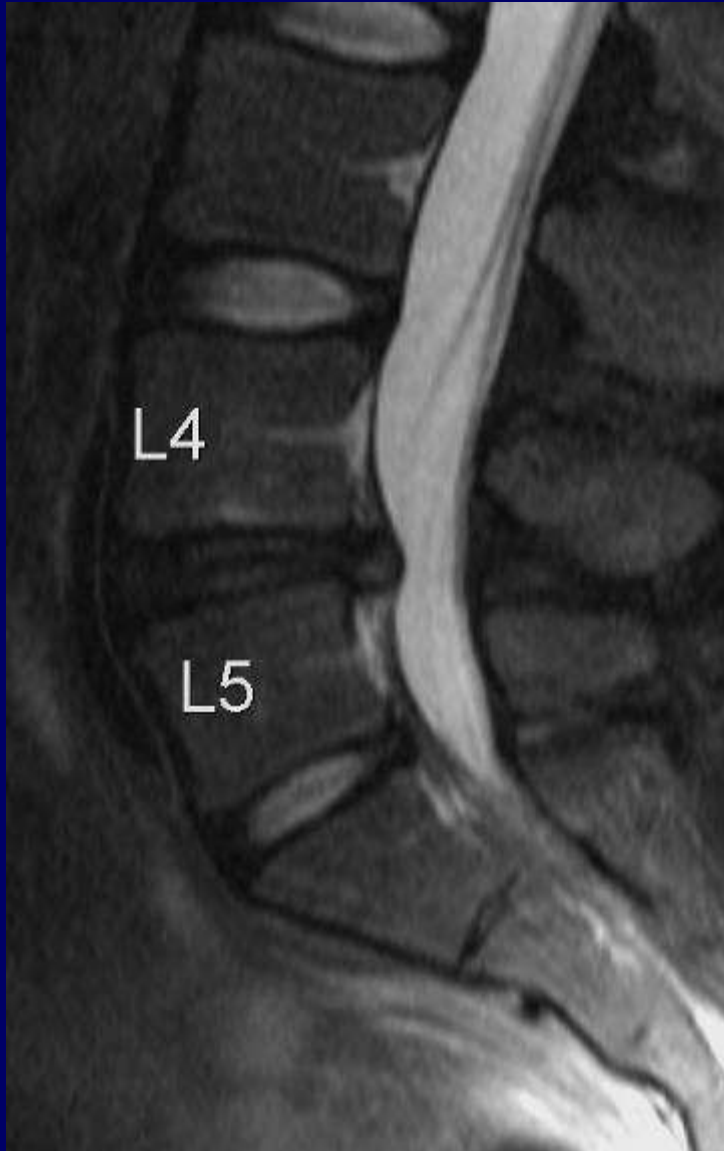


**Protrusion w/
migration +
sequestration**

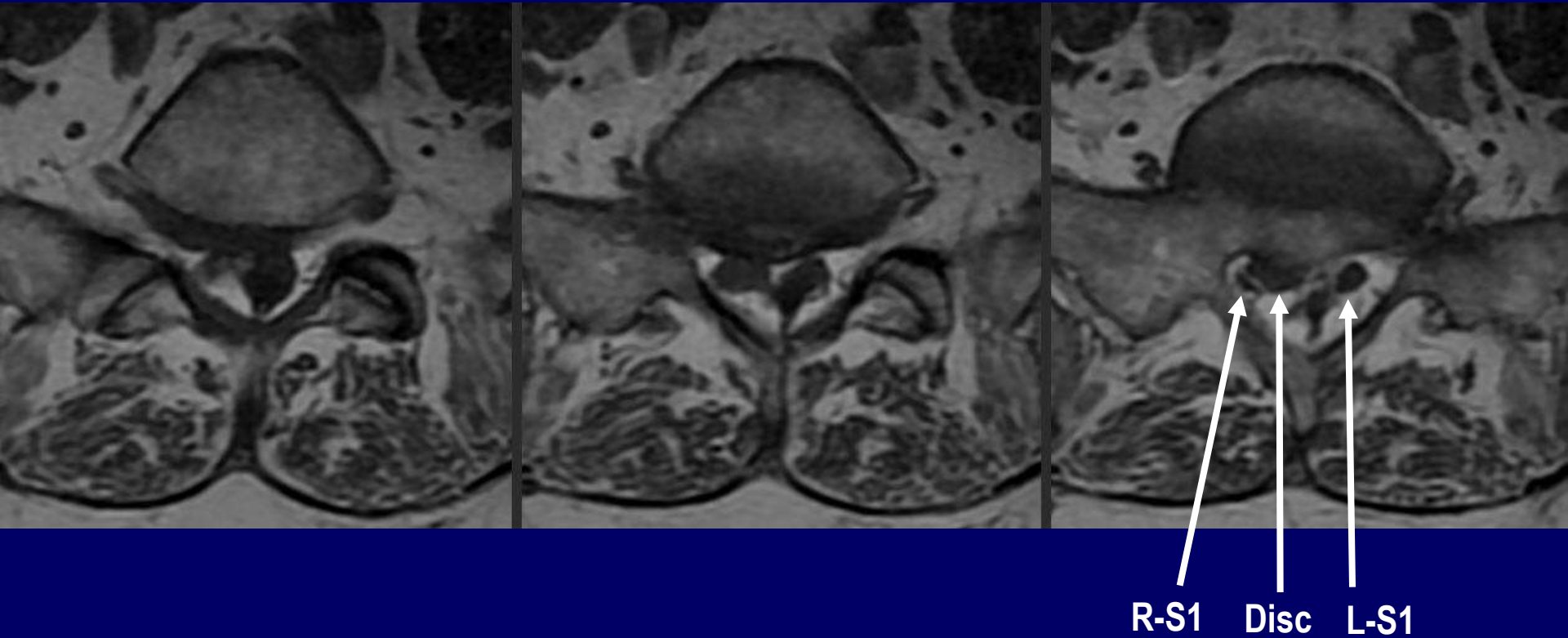


*(In any plane)

Central Disc Protrusion



L5-S1 Disc Extrusion Into Lateral Recess with Impingement of R S1 Nerve Root



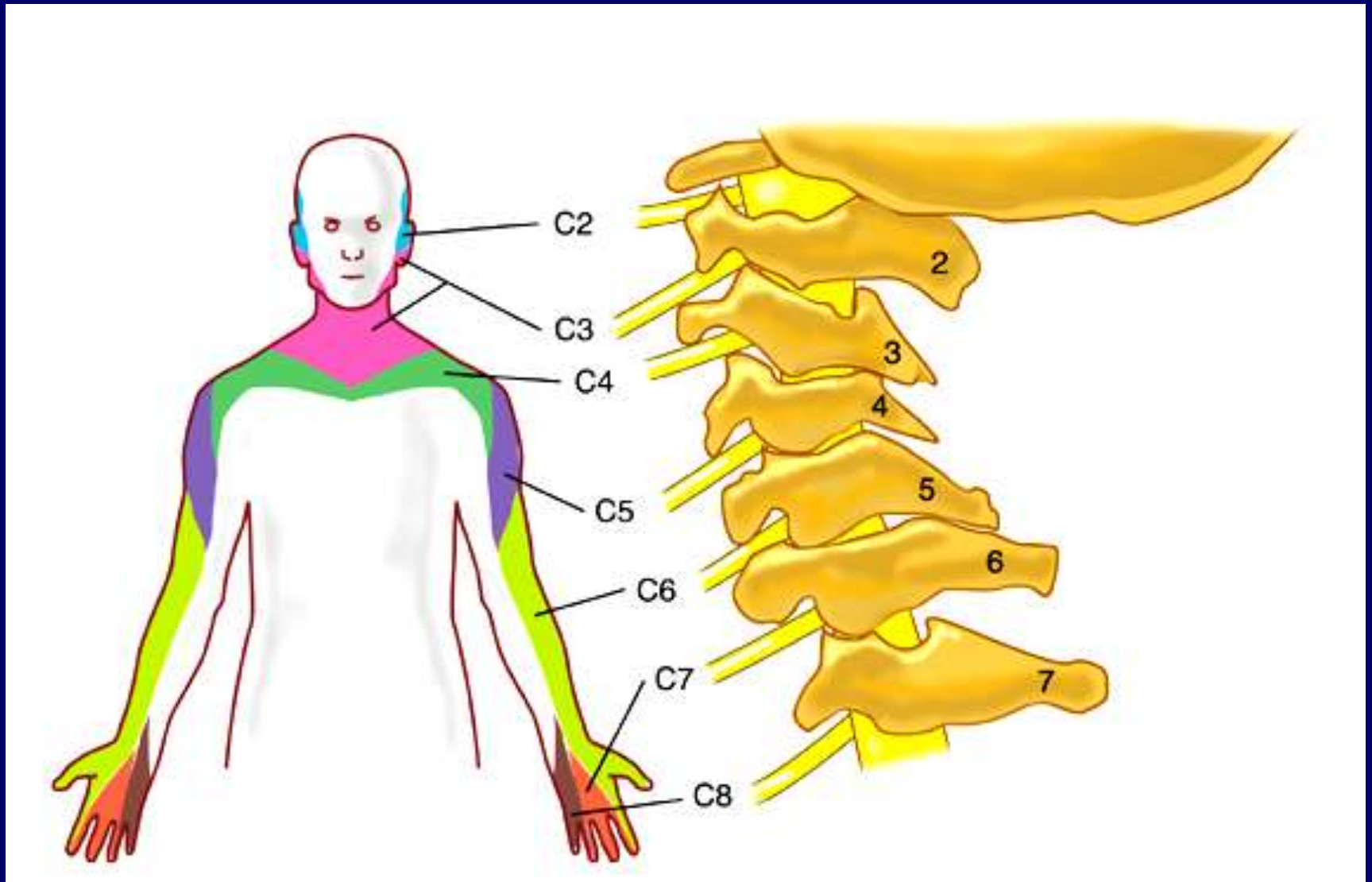
Schmorl's Nodes

Intervertebral disc space

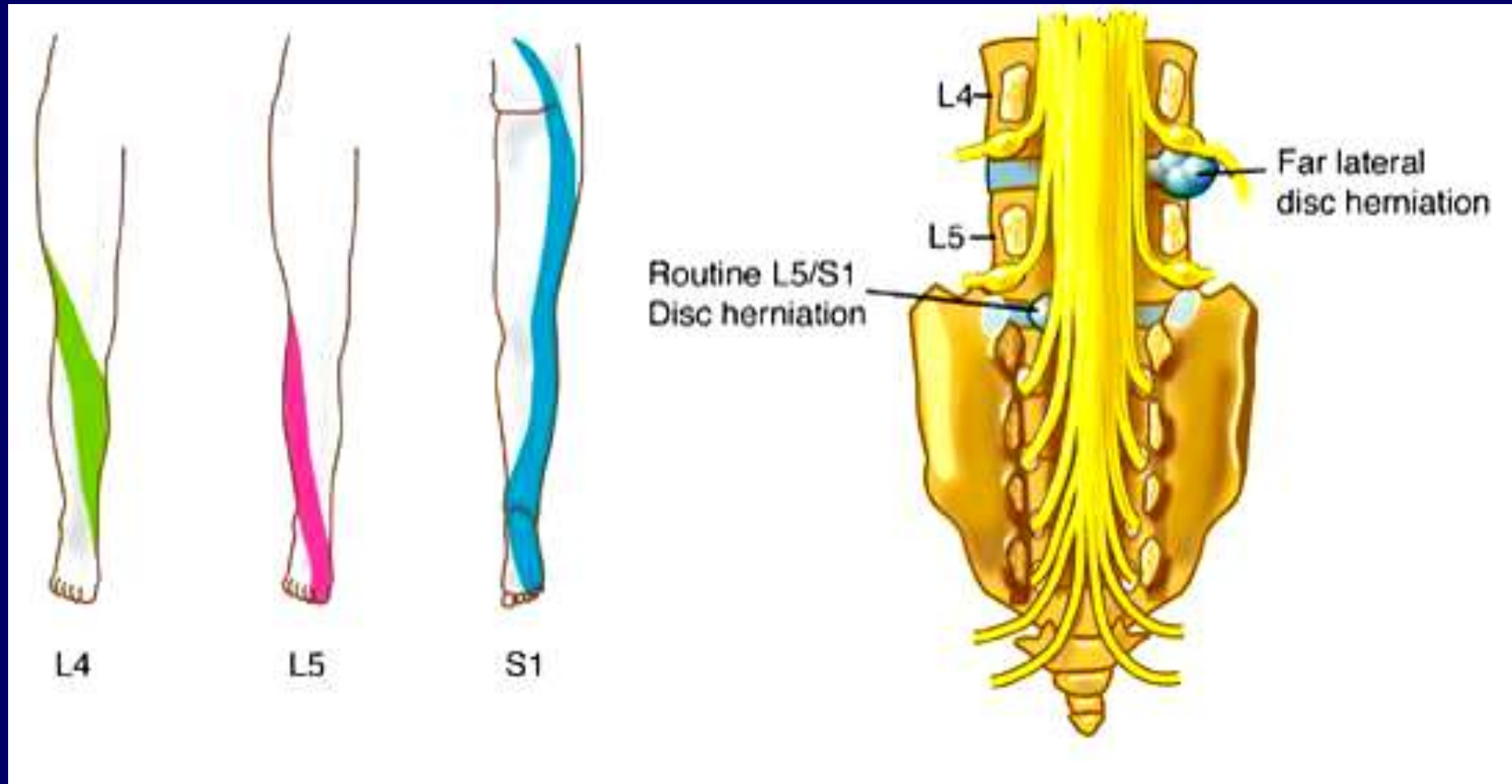
Intravertebral Herniations



Cervical Radiculopathy



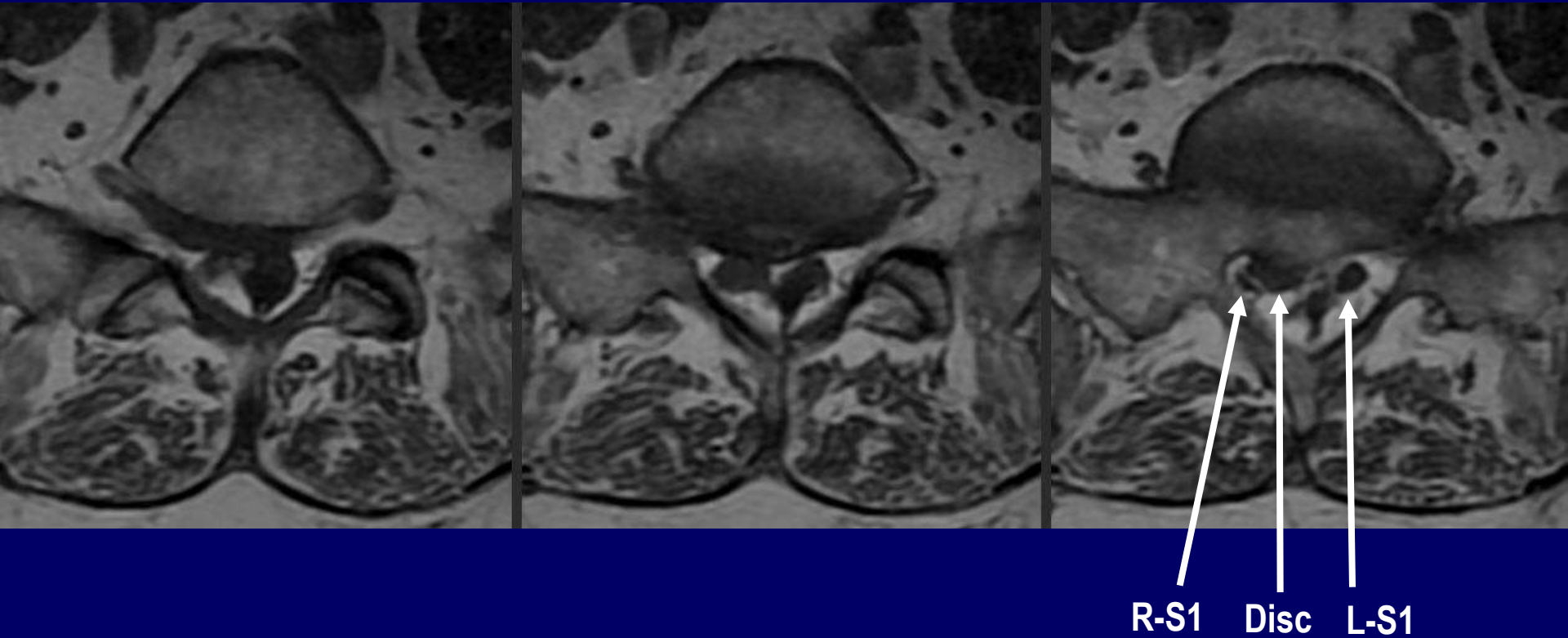
Lumbosacral Radiculopathy (Sciatica)



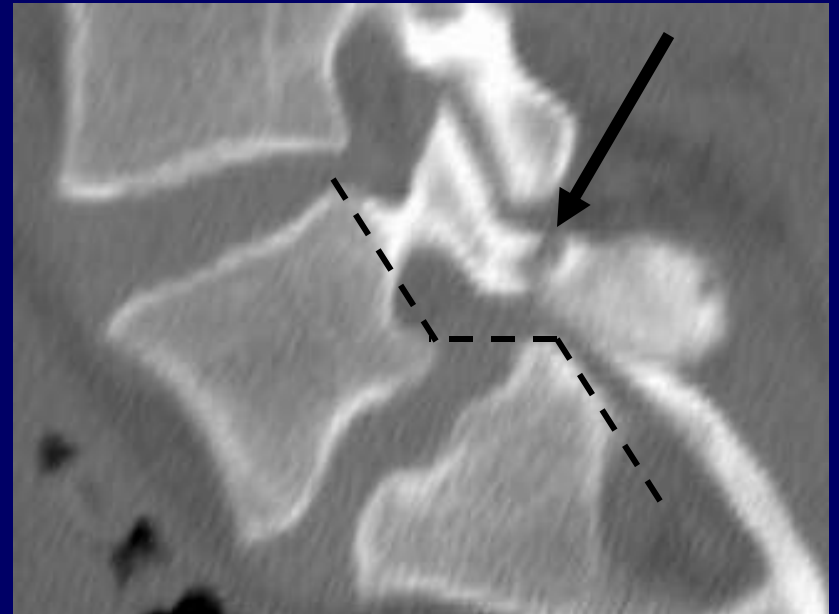
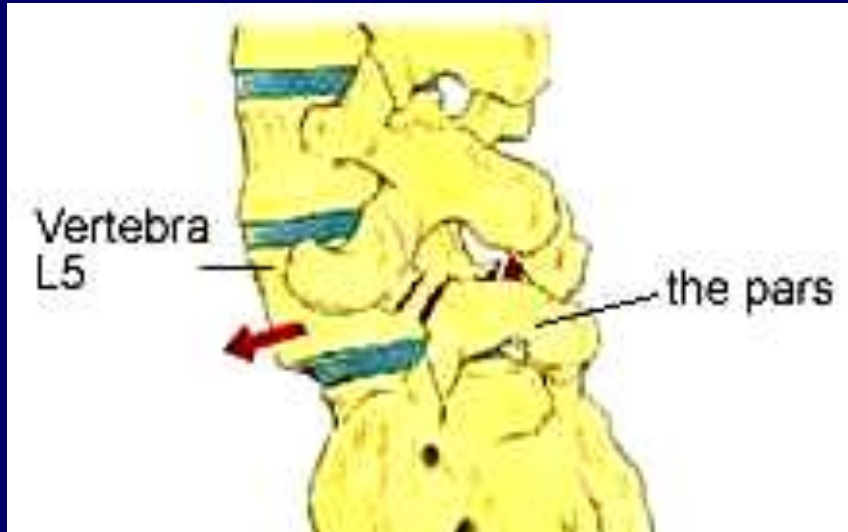
Important:

A herniated disc at (e.g.) L4-5 may impinge either the L4 or L5 nerve roots!

L5-S1 Disc Extrusion Into Lateral Recess with Impingement of R S1 Nerve Root



Spondylolysis / Spondylolisthesis



Confusing “Spondy-” Terminology

- Spondylosis = “spondylosis deformans” = degenerative spine
- Spondylitis = inflamed spine (e.g. ankylosing, pyogenic, etc.)
- Spondylolysis = chronic fracture of pars interarticularis with nonunion (“pars defect”)
- Spondylolisthesis = anterior slippage of vertebra typically resulting from bilateral pars defects
- Pseudospondylolisthesis = “degenerative spondylolisthesis” (spondylolisthesis resulting from degenerative disease rather than pars defects)

Tumors and Other Masses

Classification of Spinal Lesions

- **Extradural = outside the thecal sac (including vertebral bone lesions)**
- **Intradural / extramedullary = within thecal sac but outside cord**
- **Intramedullary = within cord**

Common Extradural Lesions

- **Herniated disc**
- **Vertebral hemangioma**
- **Vertebral metastasis**
- **Epidural abscess or hematoma**
- **Synovial cyst**
- **Nerve sheath tumor (also intradural/extramedullary)**
 - **Neurofibroma**
 - **Schwannoma**

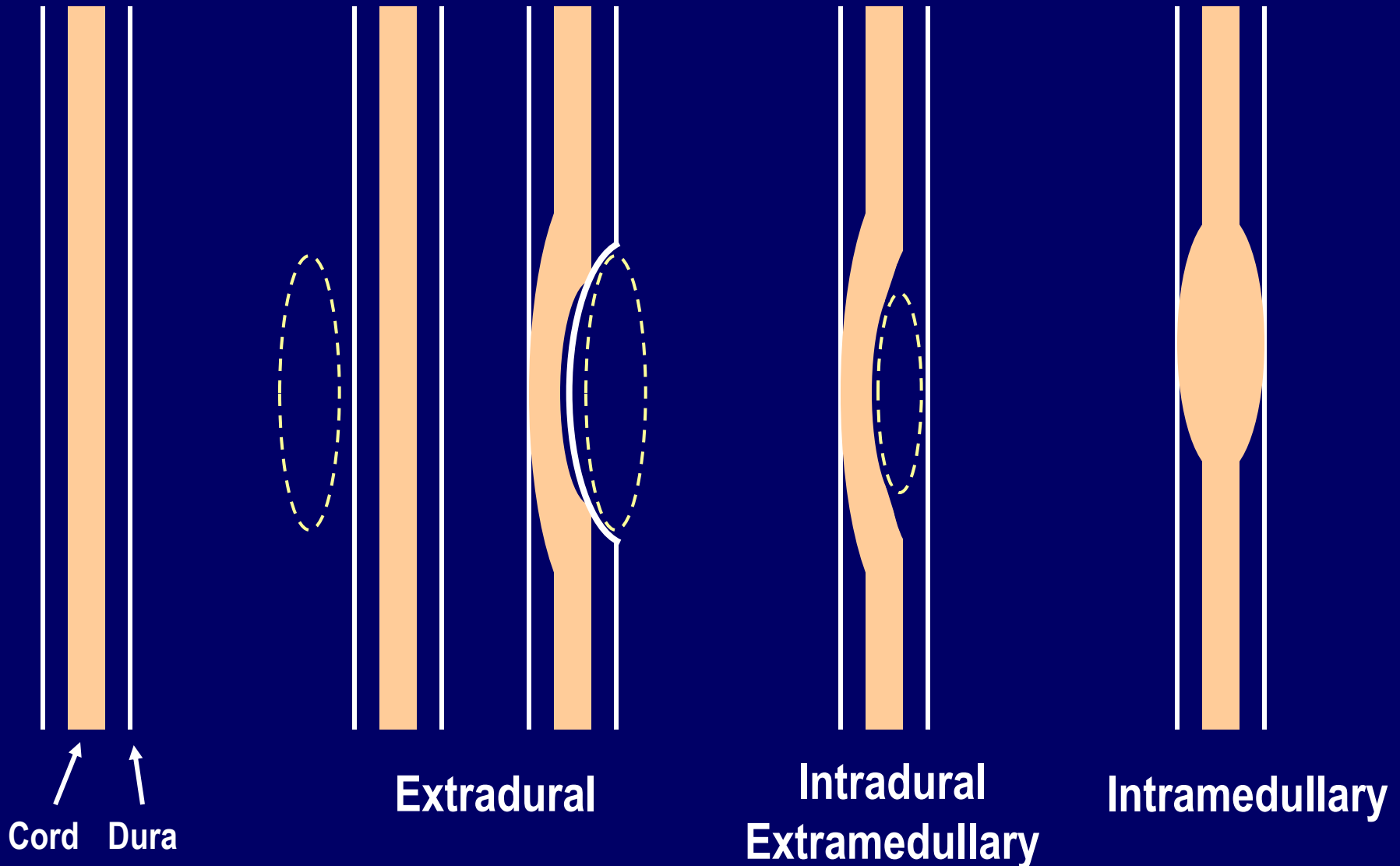
Common Intradural Extramedullary Lesions

- **Nerve sheath tumor (also extradural)**
 - Neurofibroma
 - Schwannoma
- **Meningioma**
- **Drop Metastasis**

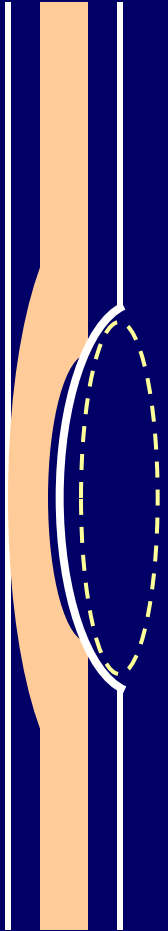
Common Intramedullary Lesions

- Astrocytoma
- Ependymoma
- Hemangioblastoma
- Cavernoma
- Syring
- Demyelinating lesion (MS)
- Myelitis

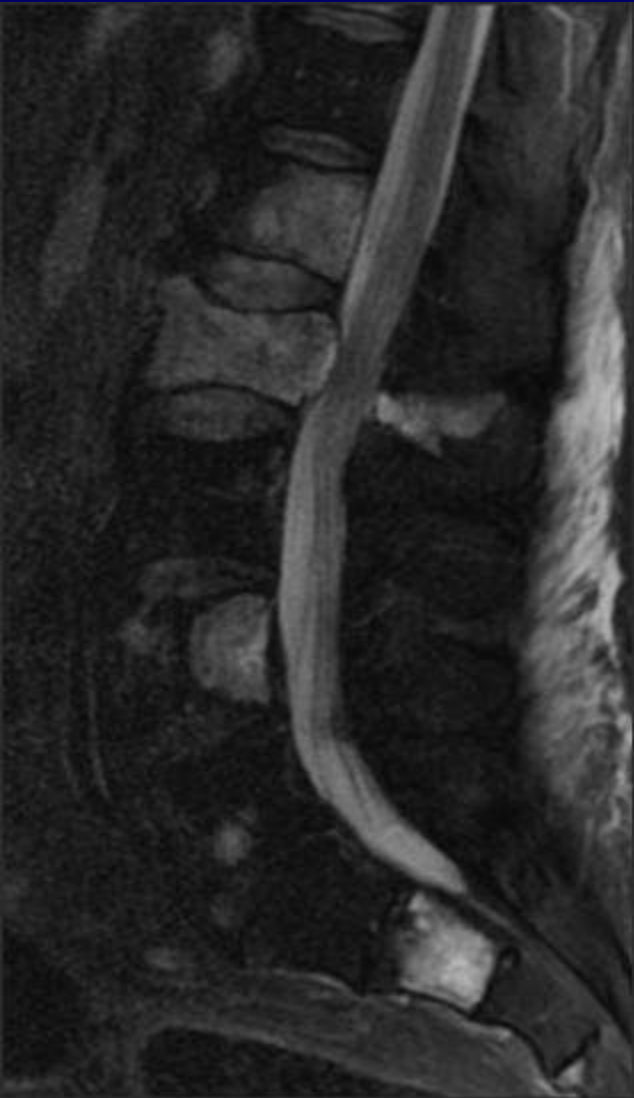
Classification of Spinal Lesions



Extradural: Vertebral Body Tumor



Extradural: Vertebral Metastases



T2 (Fat Suppressed)

T1

T1+C (fat suppressed)

Extradural: Vertebral Metastases



T2 (Fat Suppressed)



T1



T1+C (fat suppressed)

Vertebral Metastases vs. Hemangiomas

Hemangiomas (Benign, usually asymptomatic, commonly incidental):

Bright on T1 and T2 (but dark with fat suppression)
Enhancement variable

Metastases:

Dark on T1, Bright on T2 (even with fat suppression)
Enhancement

Vertebral Hemangiomas



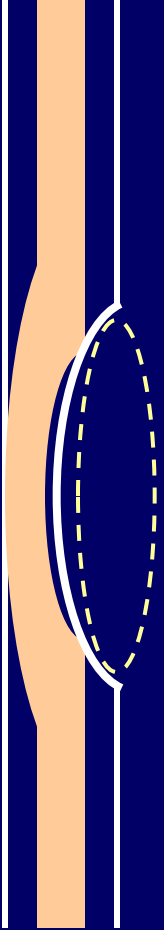
Extradural: Vertebral Metastases

Diffusely T1-hypointense marrow signal may represent widespread vertebral metastases as in this patient with prostate Ca

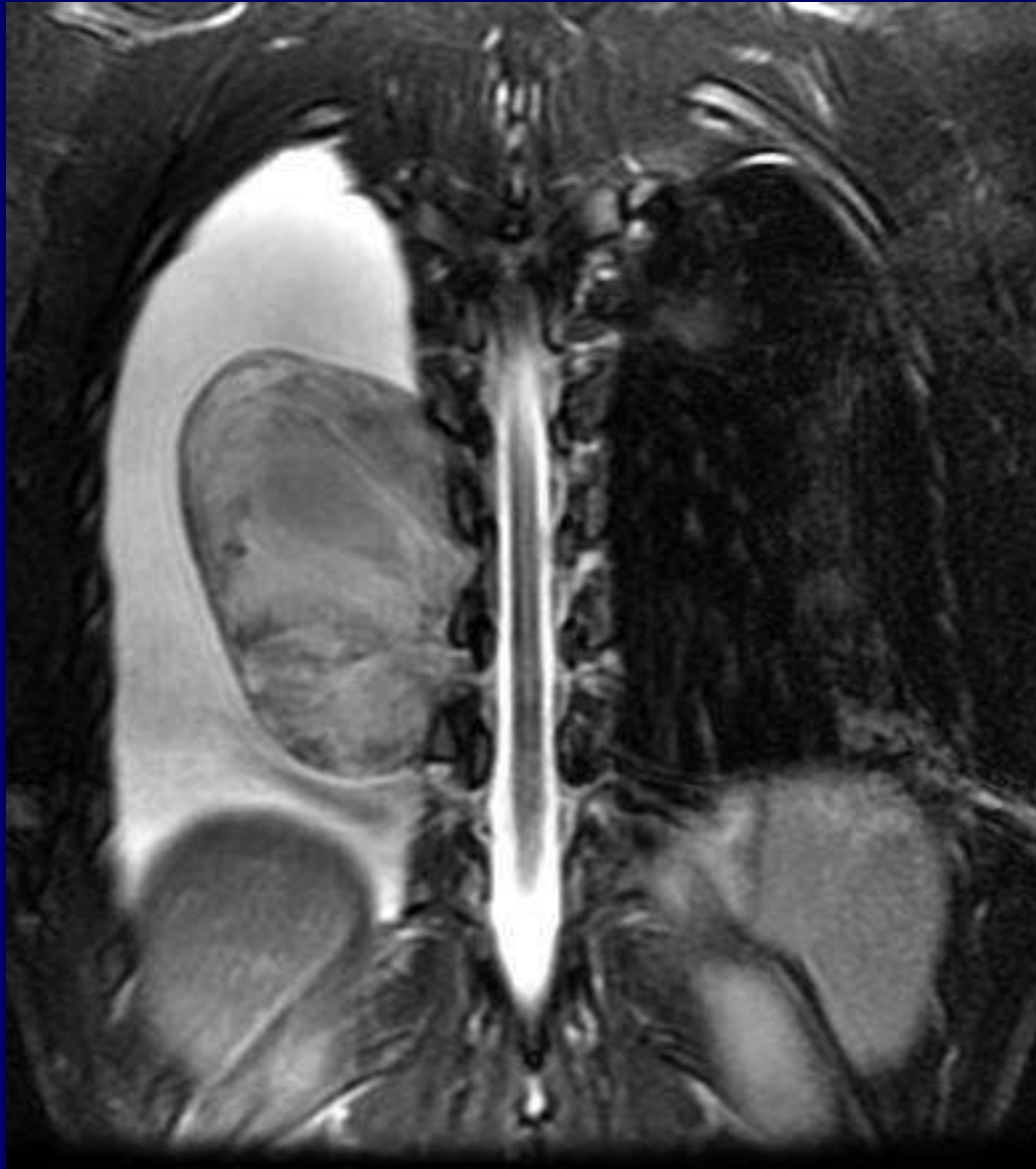
This can also be seen in the setting of anemia, myeloproliferative disease, and various other chronic disease states



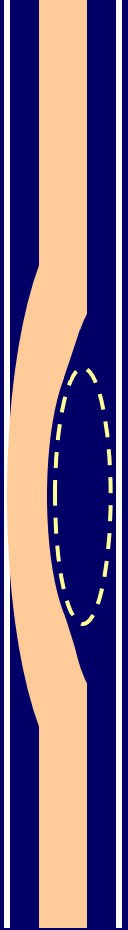
Extradural: Epidural Abscess



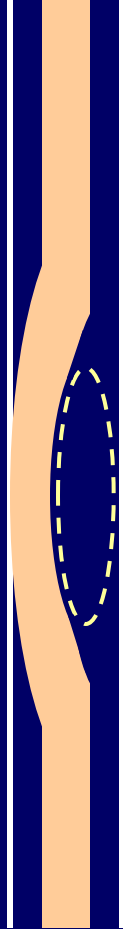
Extradural: Nerve Sheath Tumor (Schwannoma)



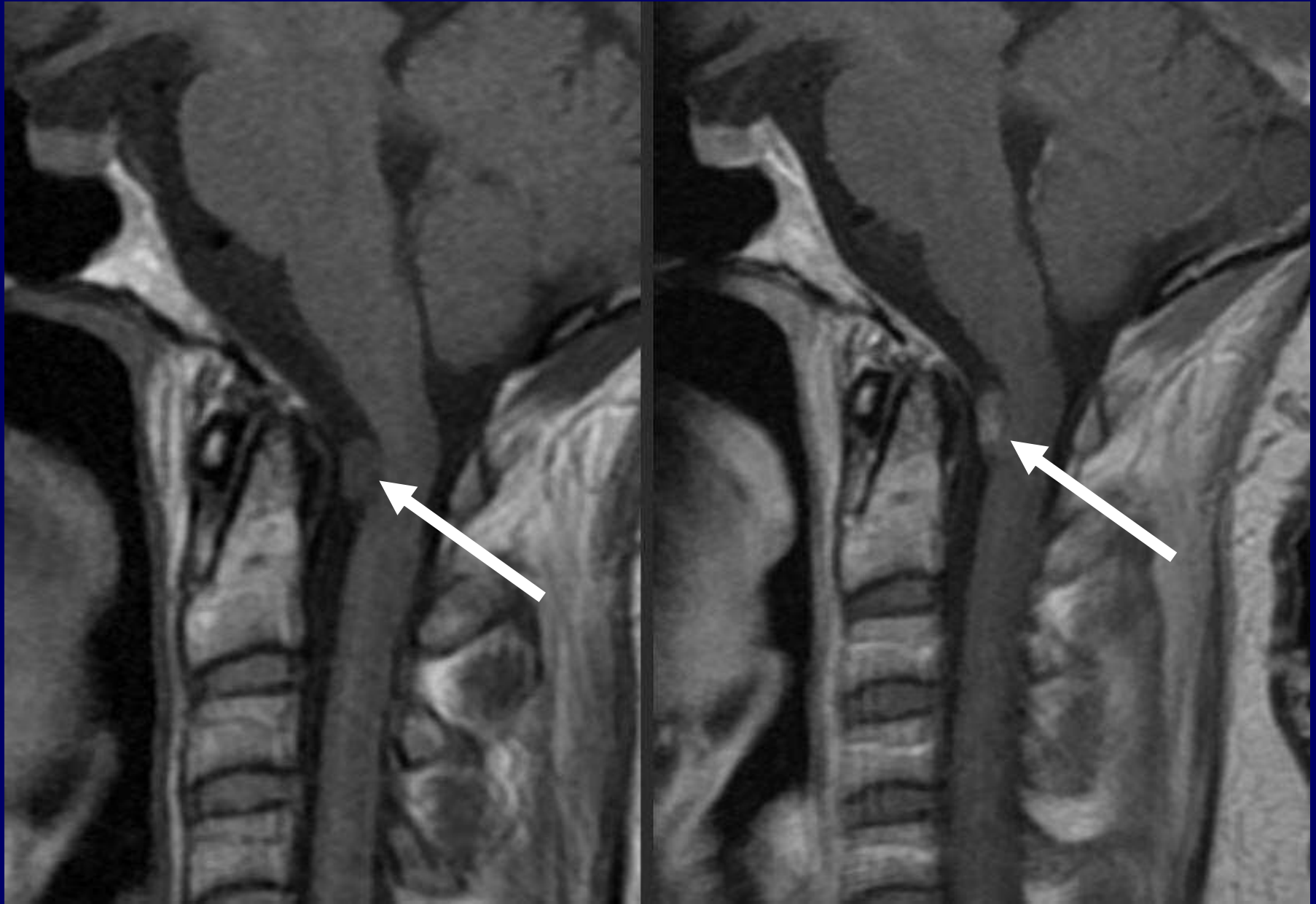
Intradural Extramedullary: Meningioma



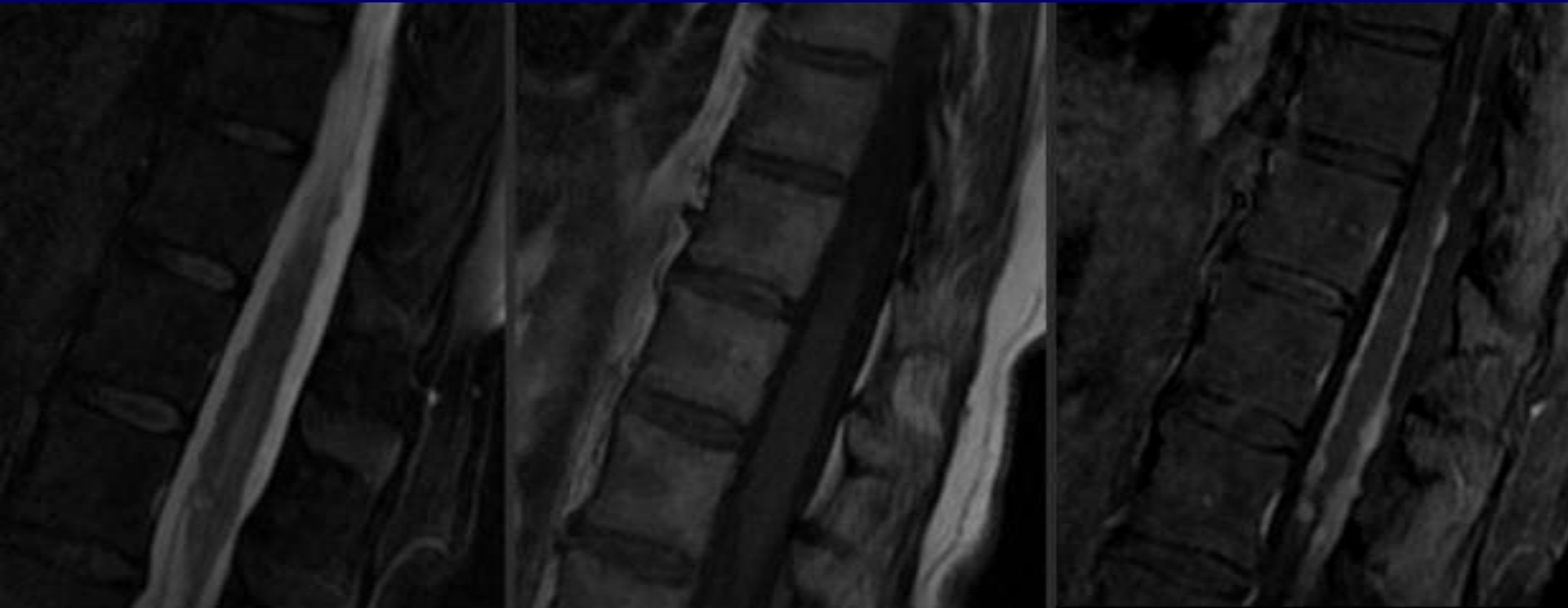
Intradural Extramedullary: Meningioma



Intradural Extramedullary: Nerve Sheath Tumor (Neurofibroma)



Intradural Extramedullary: “Drop Mets”

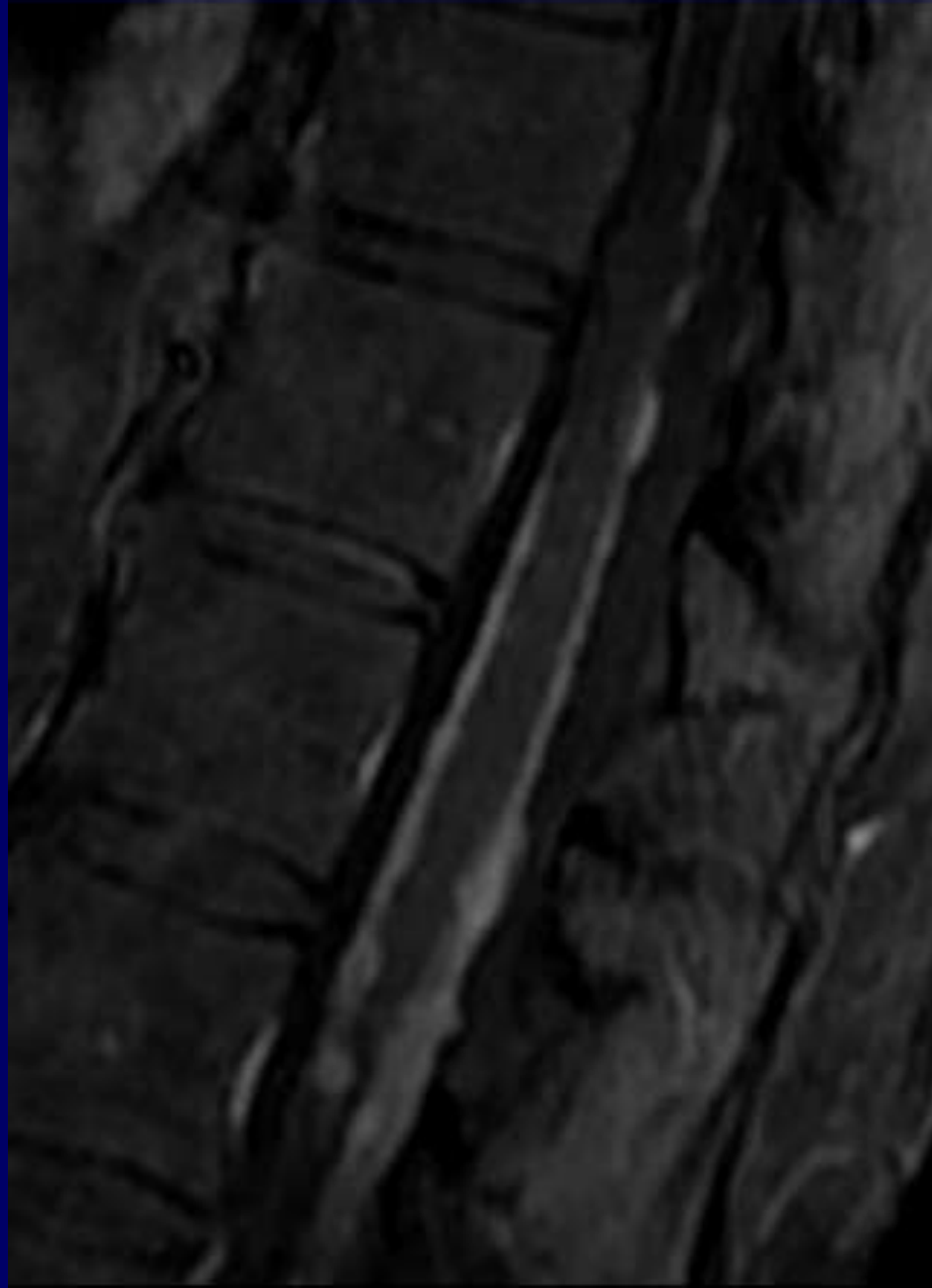


T2

T1

T1+C

Intradural Extramedullary: “Drop Mets”



Intradural Extramedullary: Arachnoid Cyst

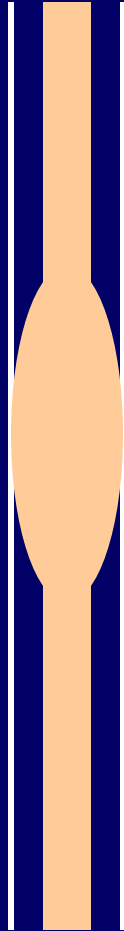


T2

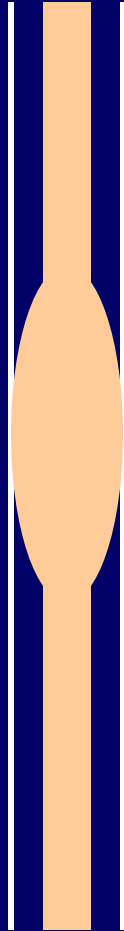


T1

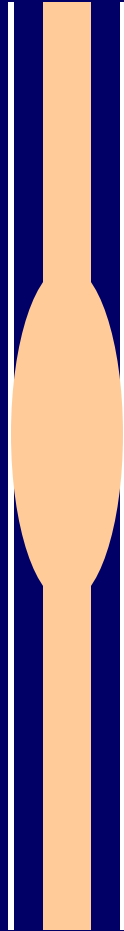
Intramedullary: Astrocytoma



Intramedullary: Astrocytoma



Intramedullary: Cavernoma



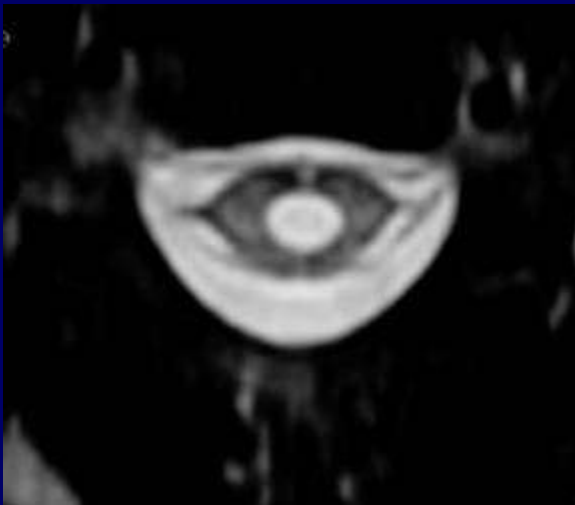
Intramedullary: Ependymoma



Intramedullary: Syringohydromyelia

Seen with:

- congenital lesions
 - Chiari I & II
 - tethered cord
- acquired lesions
 - trauma
 - tumors
 - arachnoiditis
- idiopathic



Intramedullary: Syringohydromyelia

Seen with:

- congenital lesions
 - Chiari I & II
 - tethered cord
- acquired lesions
 - trauma
 - tumors
 - arachnoiditis
- idiopathic



Confusing “Syrinx” Terminology

- Hydromyelia: Fluid accumulation/dilatation *within central canal*, therefore *lined by ependyma*
- Syringomyelia: Cavitory lesion within cord parenchyma, of any cause (there are many). Located *adjacent to central canal*, therefore *not lined by ependyma*
- Syringohydromyelia: Term used for either of the above, since the two may overlap and cannot be discriminated on imaging
- Hydrosyringomyelia: Same as syringohydromyelia
- Syrinx: Common term for the cavity in all of the above

Infection and Inflammation

Infectious Spondylitis / Diskitis

Common chain of events (bacterial spondylitis):

- 1. Hematogenous seeding of subchondral VB**
- 2. Spread to disc and adjacent VB**
- 3. Spread into epidural space → epidural abscess**
- 4. Spread into paraspinal tissues → psoas abscess**
- 5. May lead to cord abscess**

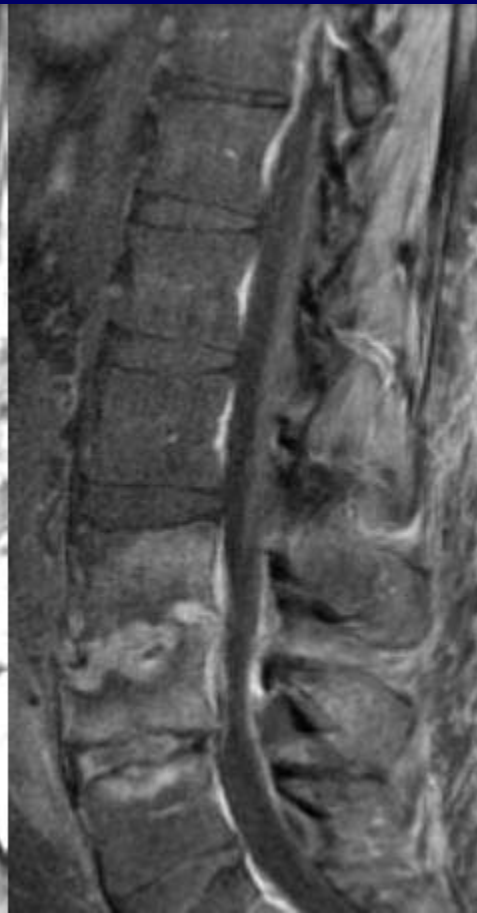
Infectious Spondylitis / Diskitis



T2



T1



T1+C

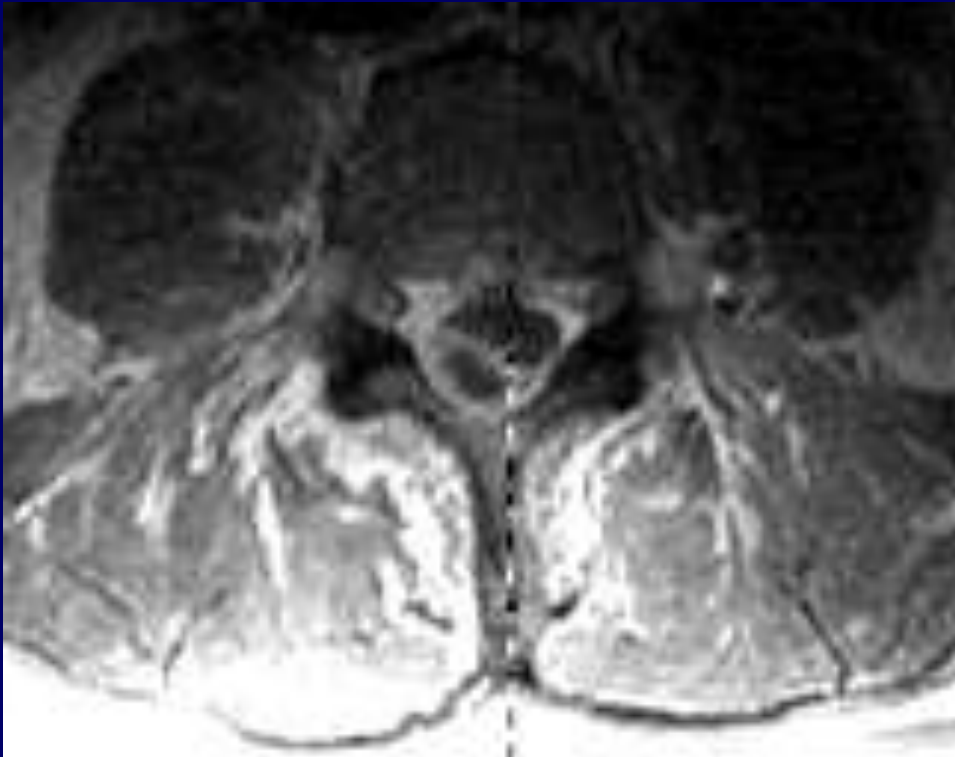


T1+C

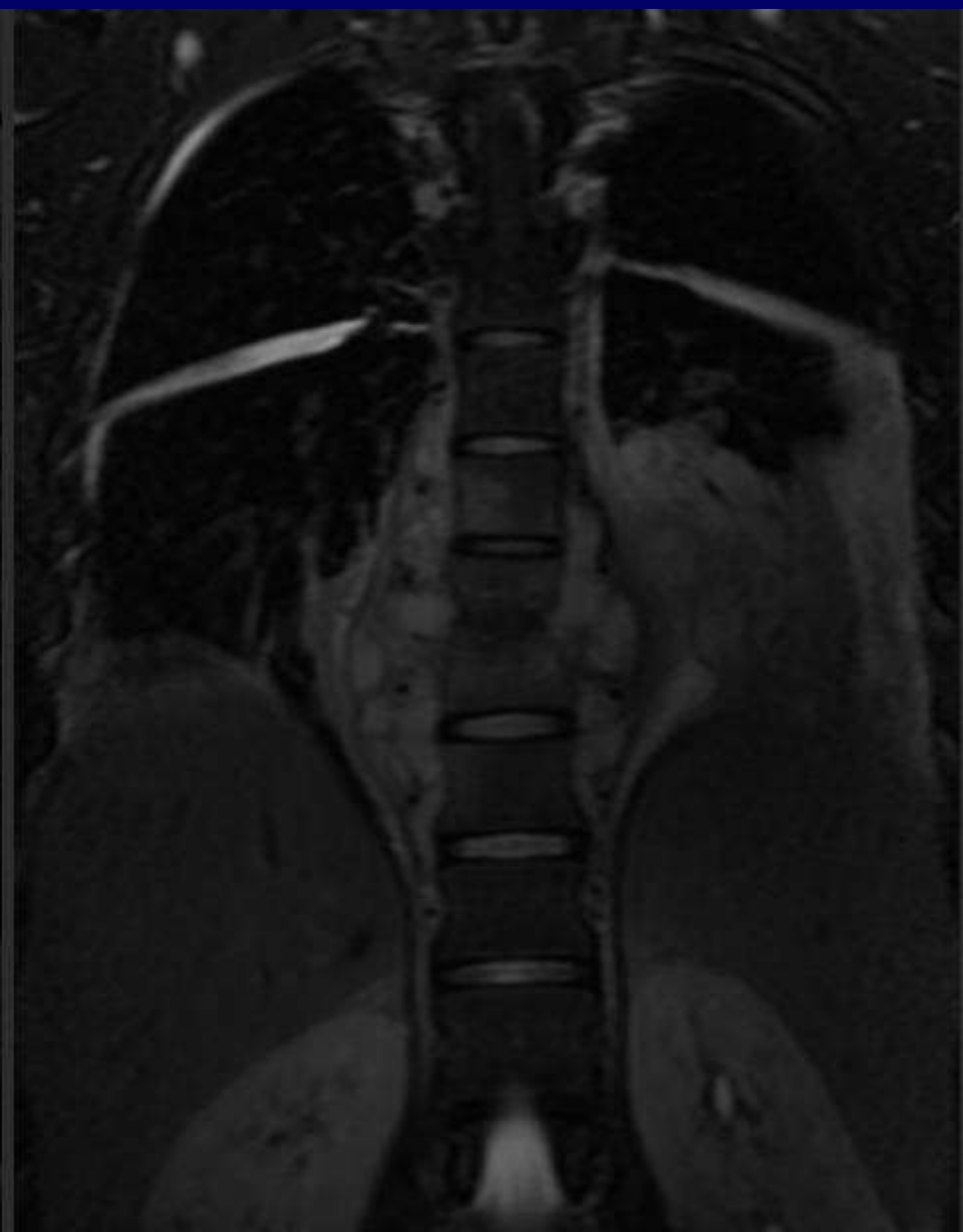
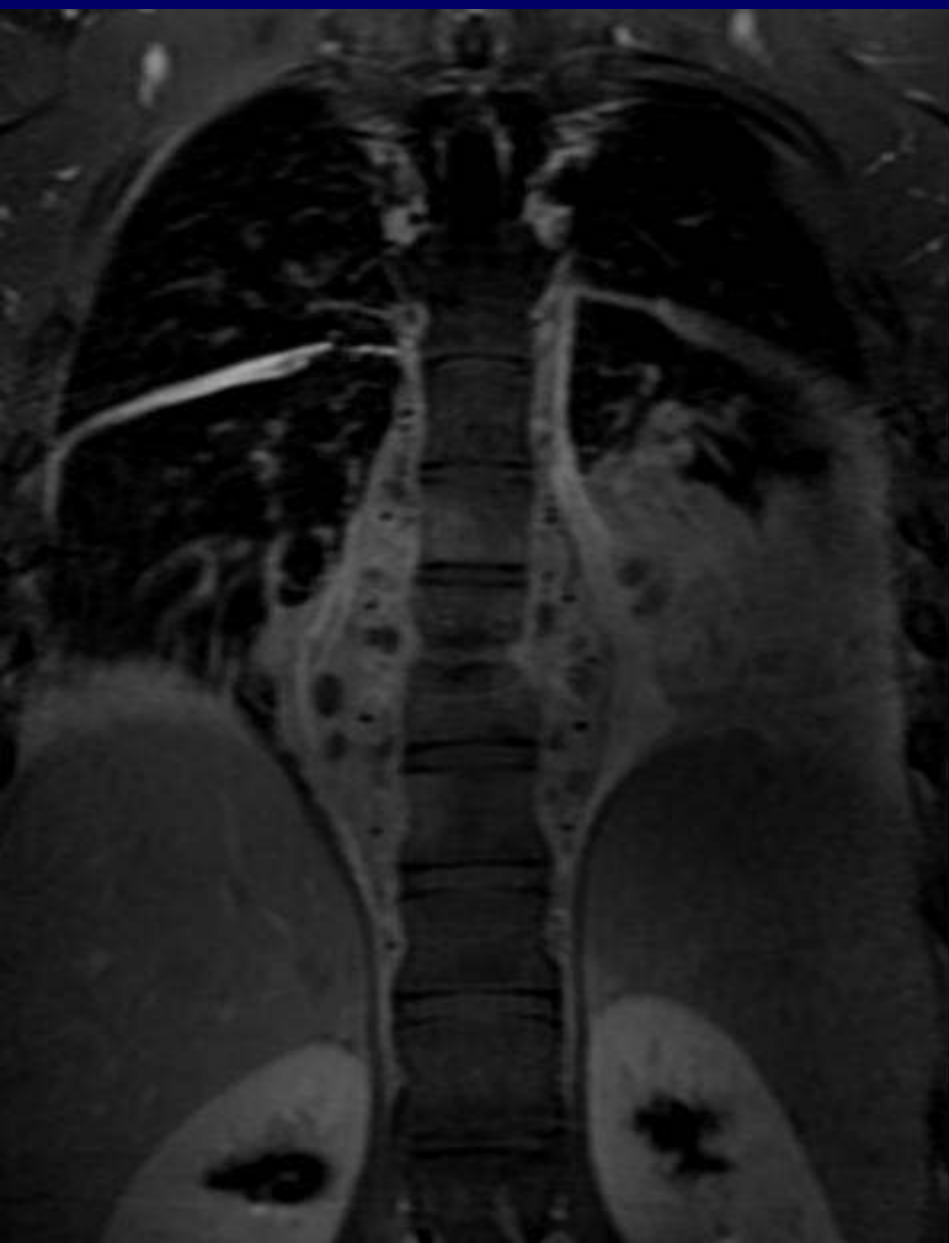
Infectious Spondylitis / Diskitis

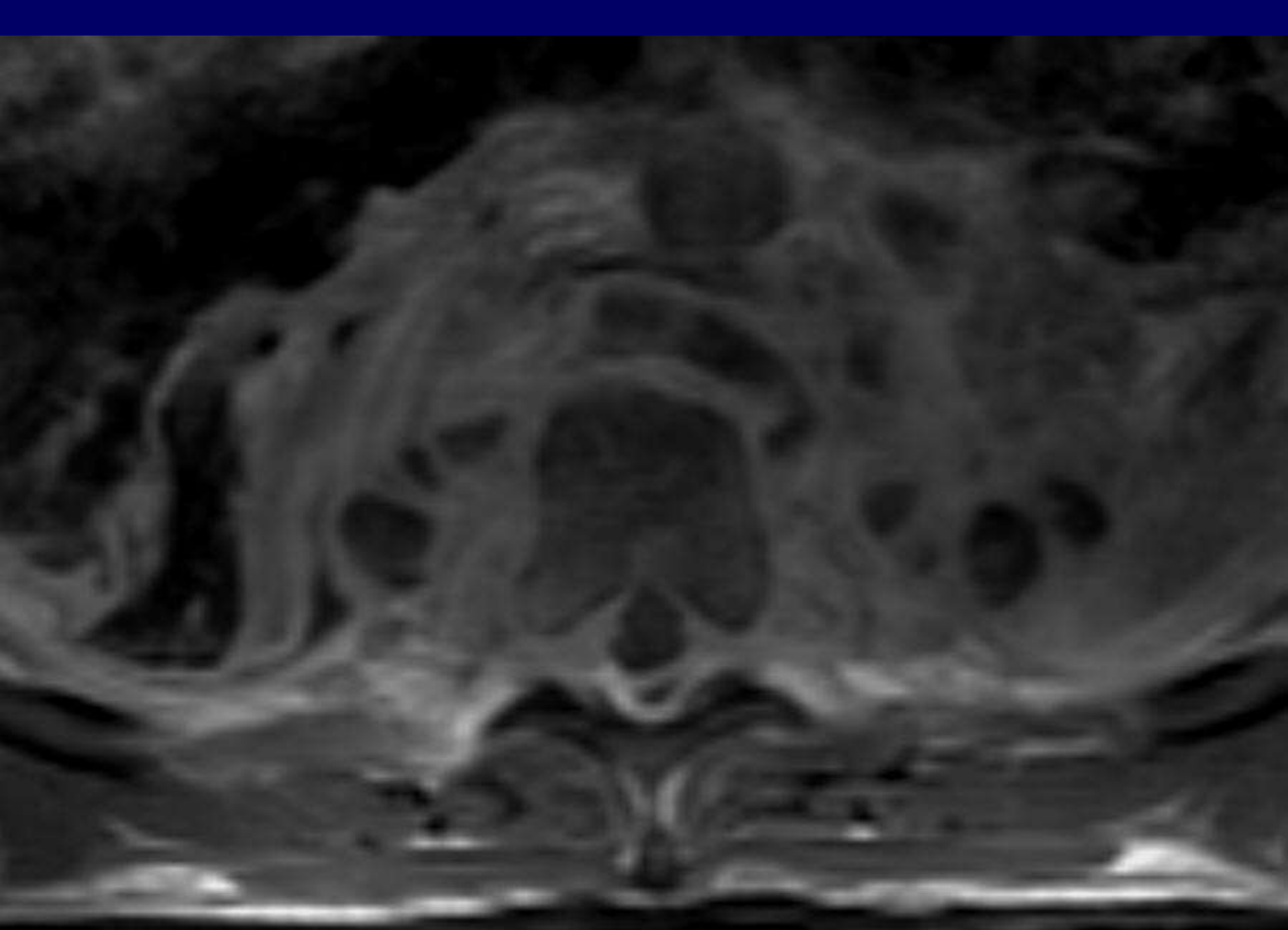


Pyogenic Spondylitis / Diskitis with Epidural Abscess

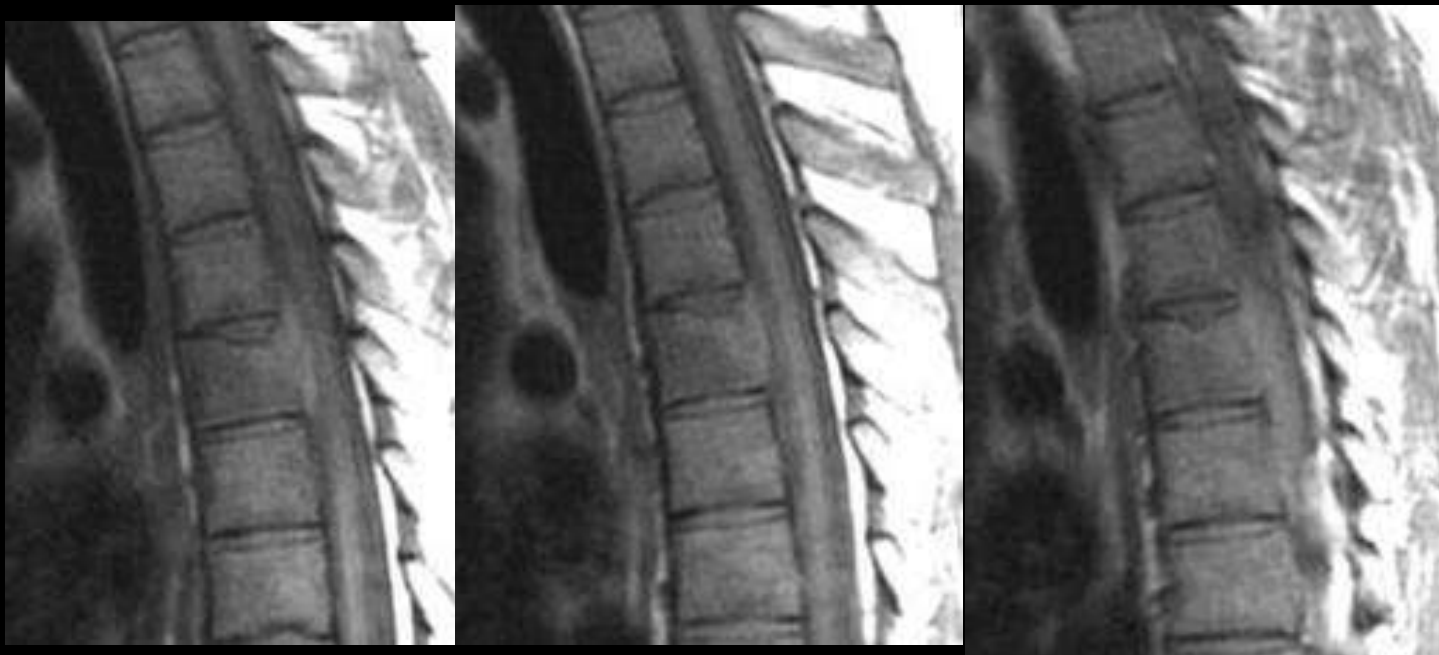








T1



T2



Spinal TB (Pott's Disease)

- Prominent bone destruction
- More indolent onset than pyogenic
- Gibbus deformity
- Involvement of several VB's



T1 + C

Spinal TB (Pott's Disease)

- Prominent bone destruction
- More indolent onset than pyogenic
- Gibbus deformity
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Transverse Myelitis

Inflamed cord of uncertain cause

Viral infections

Immune reactions

Idiopathic

Myelopathy progressing over hours to weeks

DDX: MS, glioma, infarction

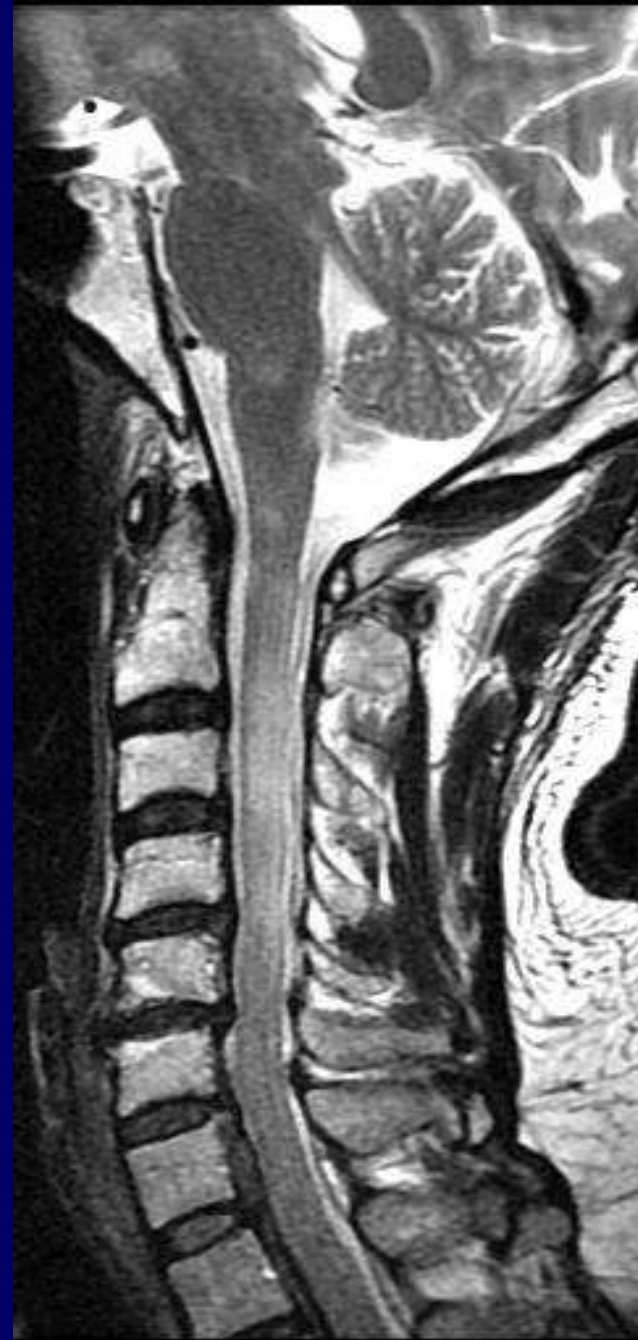


Multiple Sclerosis

Inflammatory demyelination eventually leading to gliosis and axonal loss

T2-hyperintense lesion(s) in cord parenchyma

Typically no cord expansion (vs. tumor); chronic lesion may show atrophy



Multiple Sclerosis

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T2-hyperintense lesion(s) in cord parenchyma

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Cord Edema

As in the brain, may be secondary to ischemia (e.g. embolus to spinal artery)

or

venous hypertension (e.g. AV fistula)



Spine Imaging Guidelines

1. Uncomplicated LBP usually self-limited, requires no imaging
2. Consider imaging if:
 - Trauma
 - Cancer
 - Immunocompromise / suspected infection
 - Elderly / osteoporosis
 - Significant neurologic signs / symptoms
3. Back pain with signs / symptoms of spinal stenosis or radiculopathy, no trauma:
Start with MRI; use CT if:
 - Question regarding bones or surgical (fusion) hardware
 - Resolve questions / solve problems on MRI (typically use CT myelography)
 - MRI contraindicated

Spine Imaging Guidelines (cont.)

4. Begin with plain films for trauma; CT to solve problems or to detail known fractures; MRI to evaluate soft-tissue injury (ligament disruption, cord contusion)
5. MRI for sx of radiculopathy, cauda equina syn, cord compression, myelopathy
6. Fusion hardware is safe for MRI but may degrade image quality; still worth a try
7. Indications for IV contrast in MRI:
 - Tumor, infection, inflammation (myelitis), any cord lesion
 - Post-op L-spine (discriminate residual/recurrent disk herniation from scar)
8. Emergent or scheduled? Emergent only if immediate surgical or radiation therapy decision needed (e.g. cord compression, cauda equina syndrome)
9. Difficult to image entire spine in detail; target study to likely level of pathology
10. CT chest/abdomen/pelvis includes T-L spine (no need to rescan trauma pts*)
 - * If image data still on scanner (24-48 hours)



Introduction to Neuroimaging SPINE



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