



# **Low Back Pain**

## ***How Imaging Can Add Value***

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# Disclosures

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- No relevant disclosures

# Message

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- *In the setting of low back pain, “value” can be added by imaging the pathophysiology of pain, not by demonstrating age-related “degeneration”*

# Outline

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- Challenges of imaging low back pain
- Sources of Low Back Pain
- Lumbar Disc Nomenclature
- Imaging pathophysiology of low back pain
- Special Considerations:
  - Retrodural Space of Okada
  - Segmental Instability

# Low Back Pain Paradox

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- Second most common reason for physician office visits in US
- Health care costs > \$100 billion annually
- Ever-increasing use of imaging
- Increasing surgical & other interventions
- ***Back pain remains the single greatest cause of work disability in the US***

# Role of Imaging

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- Primarily role of imaging is detection of underlying systemic disease
- Systemic disease is uncommon
- Presentation with back/leg pain:
  - 0.7% metastatic cancer
  - 0.01% spine infection
  - 4.0% osteoporotic compression fx
  - 0.3% ankylosing spondylitis

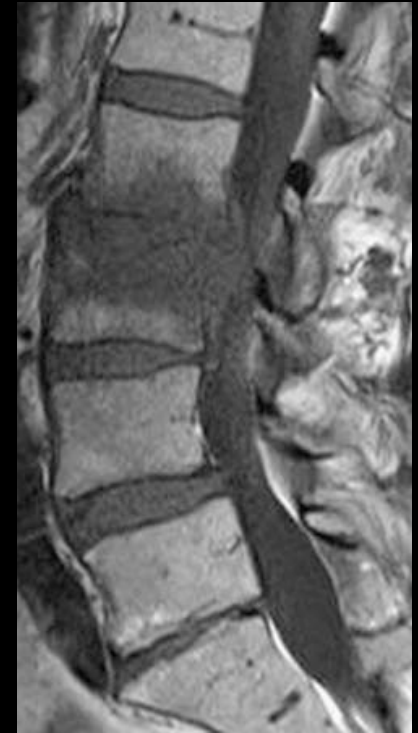
Jarvik. Ann Intern Med 2002



# When to Image: ACR

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- Low back pain +
  - ?underlying systemic disorder or infection
  - Cauda equina sx
  - Persistent pain > 6 weeks, failed conservative Rx
  - Prominent radicular component
  - Progressive neurologic deficits
  - Risk factors for compression fx
  - Candidate for intervention



# Challenges of Imaging

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- Low prevalence of systemic disease implies most findings seen will be “degenerative”
- Specificity Challenge:
  - “Degenerative” findings in asymptomatic subjects
- Sensitivity Challenge:
  - Dynamic lesions
- Usefulness/Validity Challenge:
  - Can imaging predict clinical presentation or course?
  - Can imaging predict response to therapy?



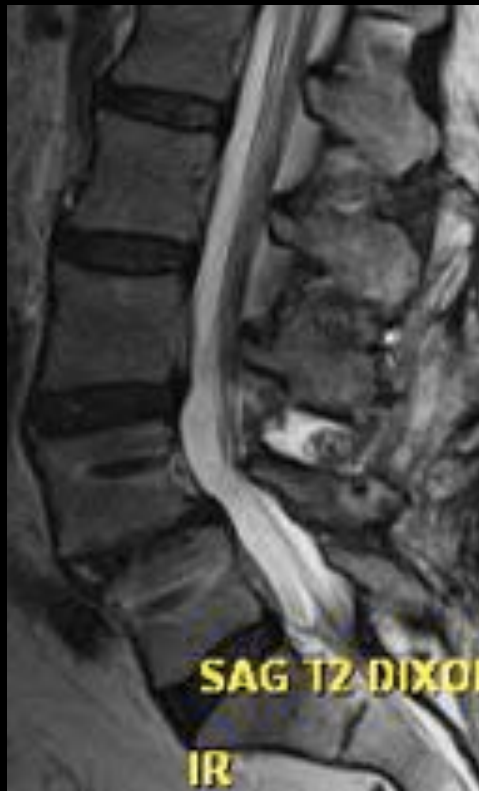
# Specificity Challenge

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Segment	Kanayama <i>J Neurosurg Spine</i> 2009			
	Disc Herniation	Nuclear T2 Signal Loss	Modic Change	HIZ
L1	0.5%	7%	1%	0%
L2	3.5%	12%	3%	4%
L3	16.5%	15.5%	4%	5%
L4	25.0%	49.5%	11%	23.5%
L5	35.0%	53%	10%	24%

# Spine Imaging: Sensitivity

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Recumbent



Standing  
Cone-beam CT

Courtesy: Tim Maus

# Challenges of Imaging

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- *Imaging does not visualize pain*
- Morphologic evaluation of spine not useful
- Age-related “degeneration”  $\neq$  Pain
- Inflammation = Pain
- Need to image physiology of pain
  - Identify source of pain
  - Assist in selection of therapies

# Sources of Low Back Pain

DePalma et al.

**Table 1** Prevalence and mean age by source of LBP

Source of LBP (N = 170)	Count	Prevalence (%)	95% CI prevalence (%)	Mean age (SD)	95% CI age
Intervertebral disc	71	41.8	(34.6, 49.3)	43.7 (10.3)	(41.3, 46.1)
Lumbar facet joint(s)	52	30.6	(24.2, 37.9)	59.6 (13.1)	(56.0, 63.3)
Sacroiliac joint(s)	31	18.2	(13.2, 24.7)	61.4 (17.7)	(54.9, 67.9)
Vertebral insufficiency fracture	5	2.9	(1.3, 6.7)	79.0 (11.8)	(64.3, 93.7)
Pelvic insufficiency fracture	3	1.8	(0.6, 5.1)	71.3 (11.7)	(42.2, 100.4)
Baastrup's disease	3	1.8	(0.6, 5.1)	75.3 (4.7)	(63.6, 87.1)
Fusion hardware	5	2.9	(1.3, 6.7)	59.6 (19.4)	(35.4, 83.8)

LBP = low back pain; CI = confidence interval; SD = standard deviation.

# Clinical Pain Syndromes

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- Axial low back pain
- Axial low back pain + Radicular pain
- Radicular pain

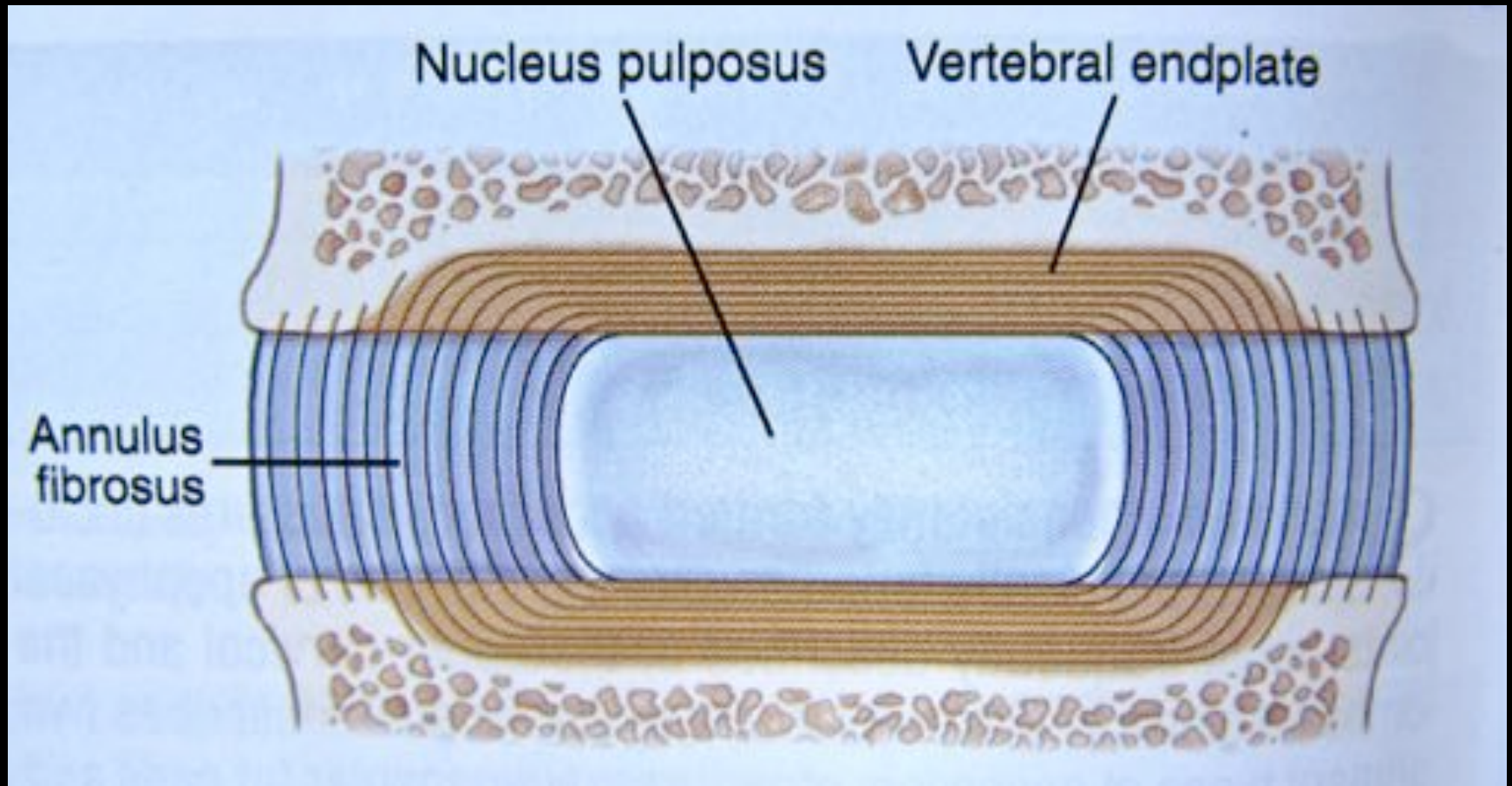
# Axial Low Back Pain

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- Anterior column as source
  - Younger patients
  - IDD (discogenic pain, most common cause)
    - Fissures
    - End-plate inflammation
  - Discography, MR
- Posterior column as source
  - Older patients
  - Facet joints
  - Relief of index pain from anesthetically controlled blocks of joint innervation
  - MRI with physiologic imaging

# Lumbar Discovertebral Complex

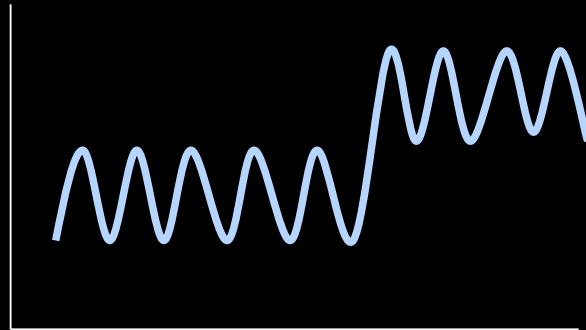
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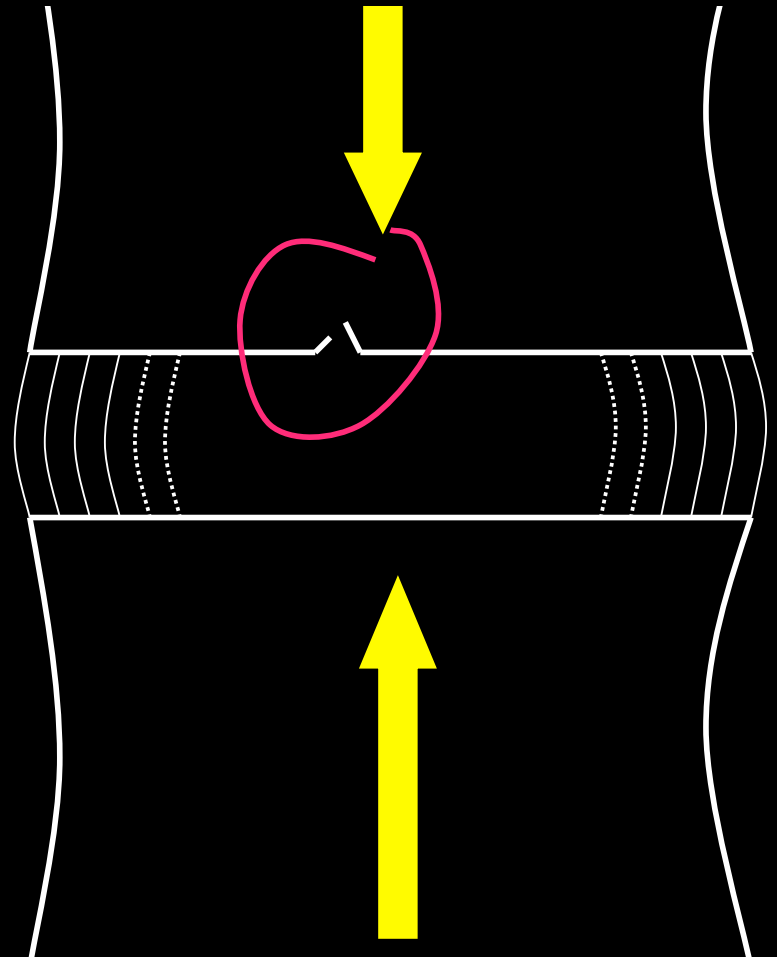
# IDD: Endplate Fatigue Fracture

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Cyclic  
stress  
applied



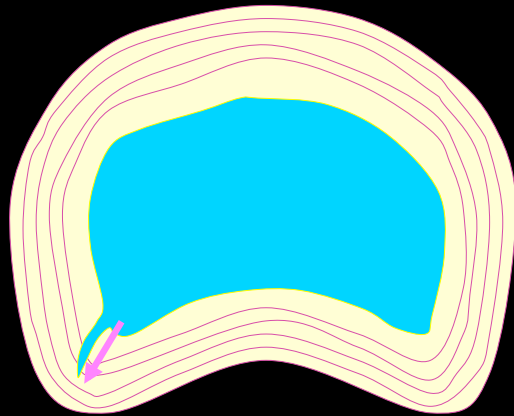
time





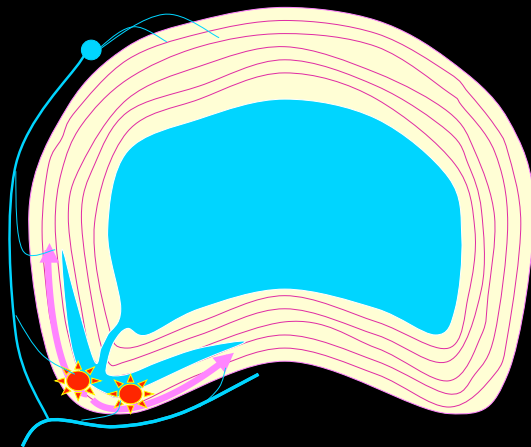
# Internal Disc Disruption

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radial fissure

© N Bogduk 2012



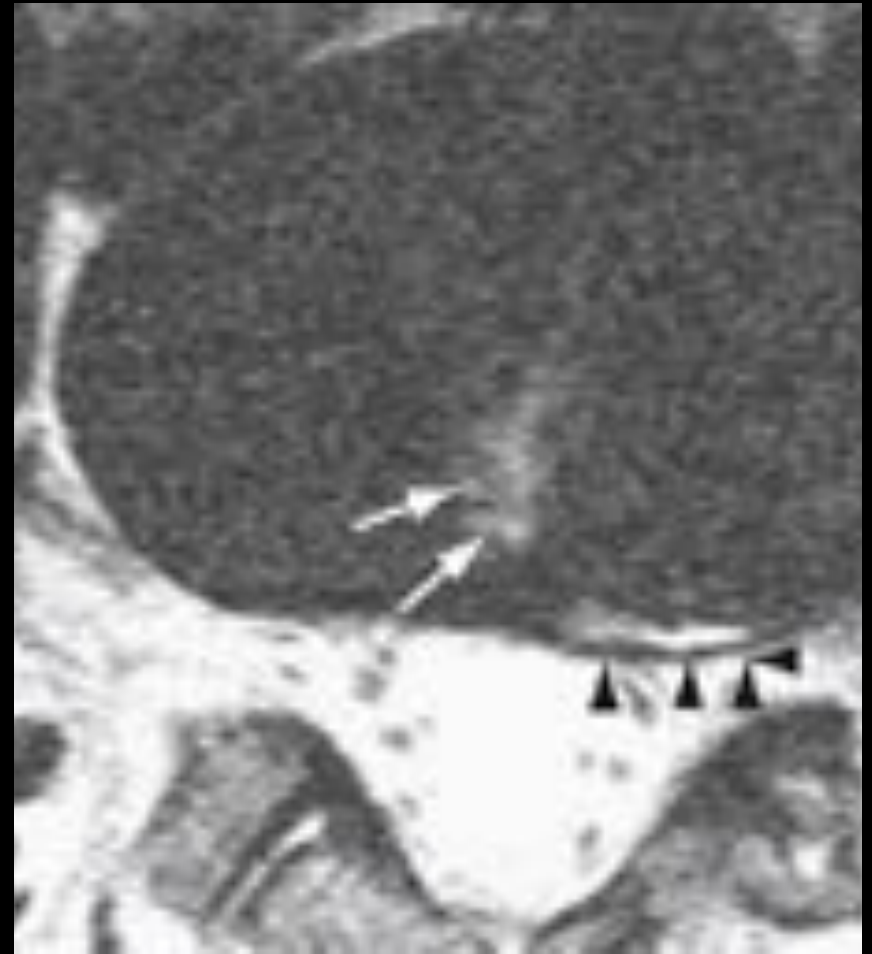
circumferential fissure

© N Bogduk 2012

- Distinct entity
- Not age related change
- Correlates with axial low back pain
- Presence of fissure differentiates an affected disc from a normal or “degenerated” disc

# Radial Fissure

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# IDD: The Evidence

≠ degeneration

≠ age-changes

Pain Reproduction	III	II	I	0
Exact	36	13	5	3
Similar	39	41	25	13
Dissimilar	15	20	5	7
None	10	26	65	77

Vanharanta , et al The relationship of pain provocation to lumbar disc deterioration as seen by CT/discography. *Spine* 1987; 12 (3): 295-8.

# Diagnosis of IDD: Provocation Discography

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- Contrast injected into nucleus pulposus via percutaneously placed needle
- Two main elements
  - Assessment of patient's response to pain **when fluid is injected into disc**
  - Disc morphology assessed with radiography and CT

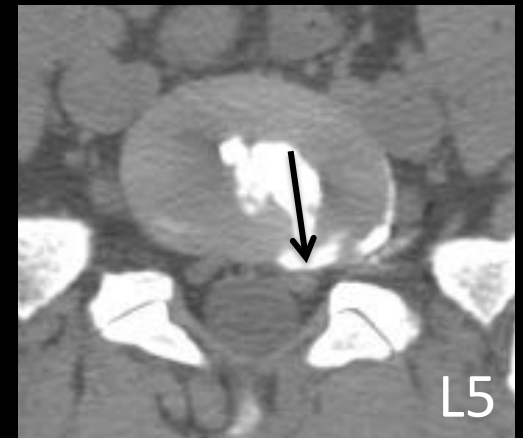
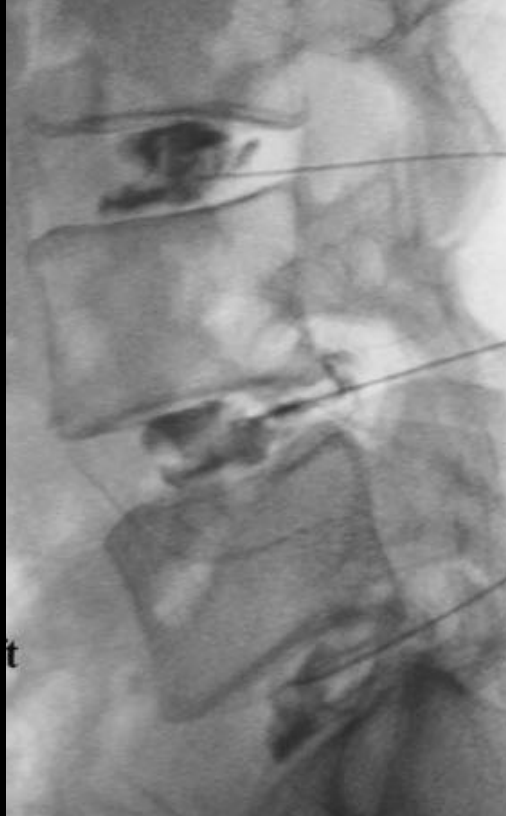


# Discography Indications

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- Not the initial study to evaluate for possible disc herniation or low back pain
- **COMPLEMENTARY STUDY FOR TREATMENT PLANNING**
  - Identify IDD as source of chronic LBP
- **Controversial: Can discography cause accelerated disc degeneration?**

# Internal Disc Disruption Disc Stimulation



Adult athlete, 4 months axial back pain  
Note all Grade IV discs, despite modest  
MRI findings

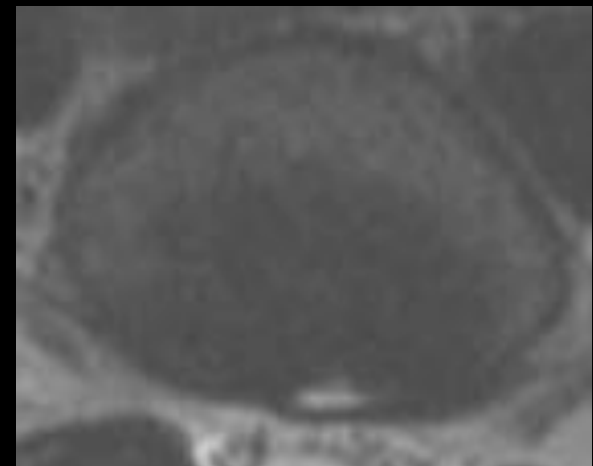
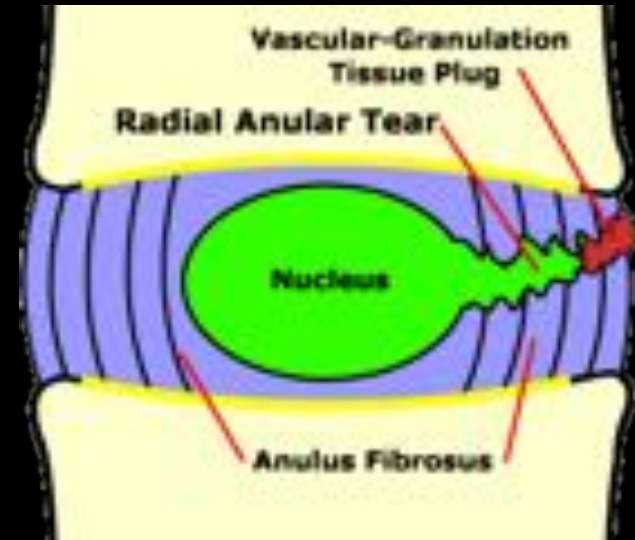
# MR Signs of IDD

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- Inflammatory end plate changes (Modic)
  - Physiologic response to altered load bearing as nuclear matrix degrades
  - Elevated TNF $\alpha$  in cartilaginous end plates
- High intensity zones (HIZ)
  - Inflammatory lesion
  - Predicts a painful disc with high specificity, PPV, +LR

# High Intensity Zone (HIZ)

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# 65y LBP, End plate edema

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# Radicular Pain

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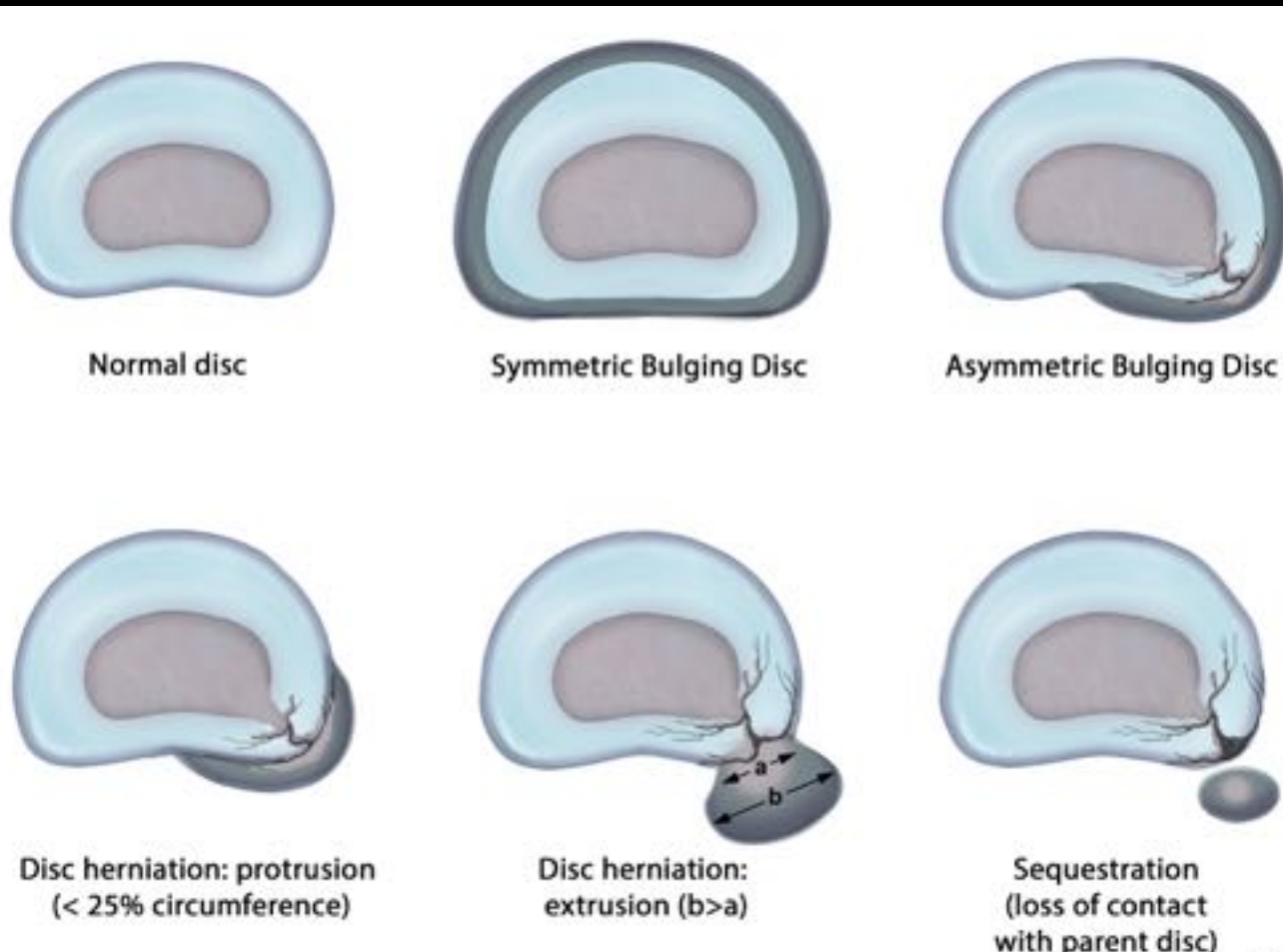
- Young patients, think disc herniation
- Older patients, fixed, stenotic lesions more common
- Fissure weakens posterior annulus
- Allows herniation of nuclear material into outer annulus as contained protrusion or breach the annulus and pass into epidural space as an extrusion

# Lumbar Disc Nomenclature

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- “Nomenclature & Classification of Lumbar Disc Pathology,” – collaboration of task forces of NASS, ASNR, ASSR
- **Version 2.0: The Spine Journal 14 (2014): 2525-2545**
- Goal: universal standardization of language
- Definitions based on anatomy & pathology, primarily as visualized on imaging studies

# Disc Herniation Nomenclature



# Disc Herniation Nomenclature

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A. Bulge



B. Protrusion  
 $a > b$



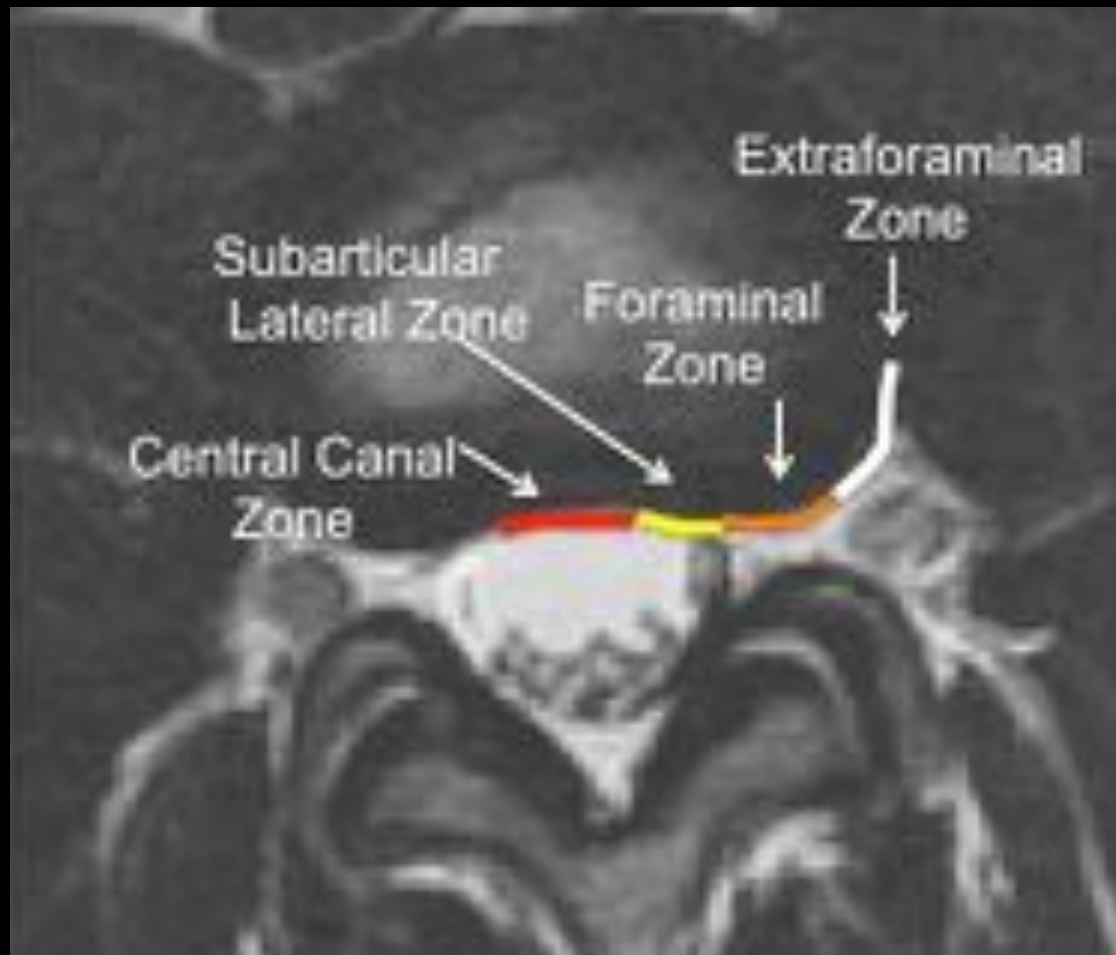
C. Extrusion  
 $b > a$



D. Sequestration

# Lumbar Disc Nomenclature: Zones

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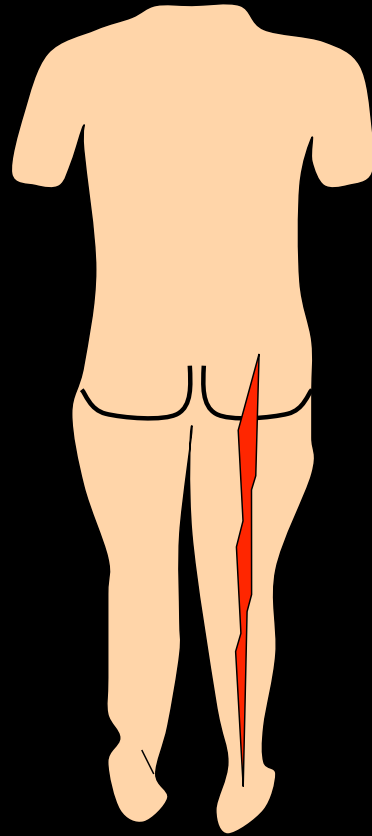
# Acute Foraminal Disc Extrusion

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# Lumbar Radicular Pain

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**PAIN**

**lancinating,  
shooting, or  
“electric”**

**traveling down the limb;  
in a narrow band.**

***Compression of neural tissue***



# Lumbar Radicular Pain

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- Why might epidural corticosteroids be therapeutic in a condition whose primary anatomic basis is neural compression?
- ***Neural compression & an inflammatory reaction***

# Pathogenesis of Radicular Pain

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## Evidence of an inflammatory component:

1. Surgical relief of neural compression is not uniformly clinically successful
2. Severity of symptoms has no relationship with herniation size or shape
3. Conservative therapy including ESI is often effective
4. Introduction of nucleus pulposus into the epidural space, without nerve compression, induces nerve dysfunction & degeneration

Mulleman D, et al. Pathophysiology of disk-related sciatica. I.--Evidence supporting a chemical component. *Joint Bone Spine* 2006; 73 (2): 151-8.

# How to detect inflammation on MRI?

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- Fat-saturated T2 / STIR
- Gadolinium enhanced
  - Demonstrates extent of granulation tissue & associated chemical radiculitis
- If no evidence of a neural compressive lesion on standard imaging consider an enhanced examination

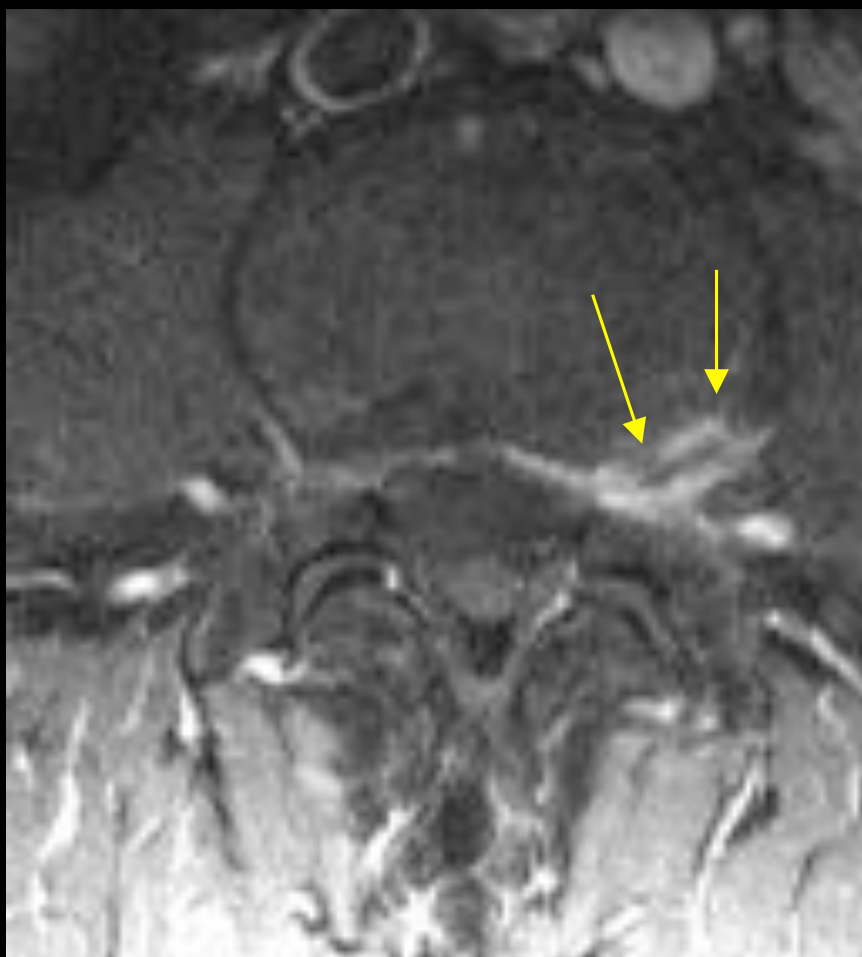
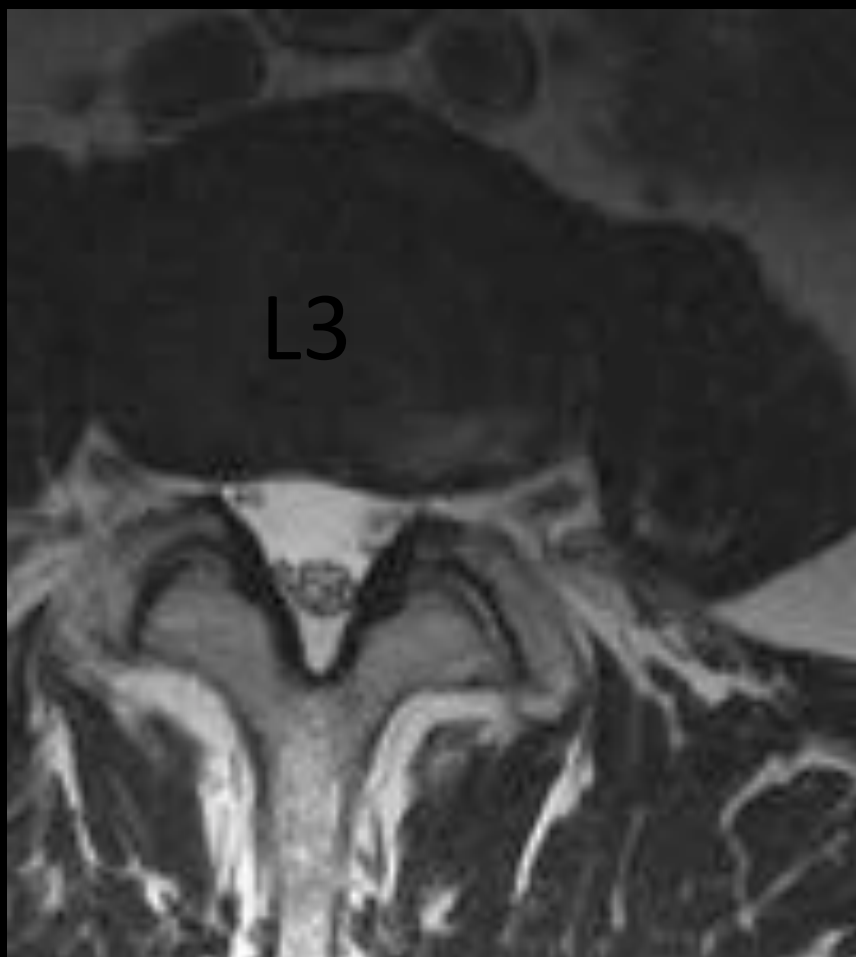
# Sequestration, inflammatory enhancement

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# Chemical Radiculitis

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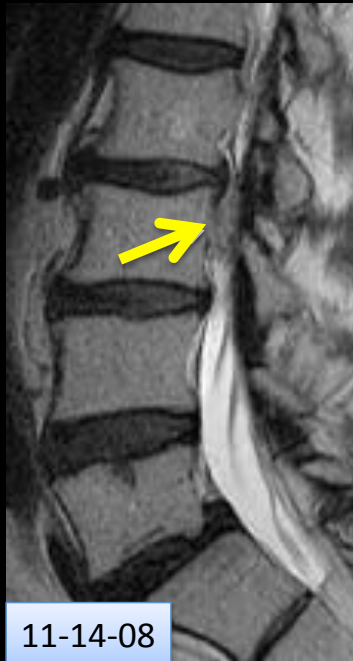
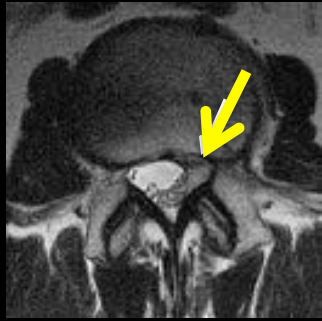
# 75M Left L5 Radicular Pain

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# Disc Extrusion: Resolution

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11-14-08



12-2-09

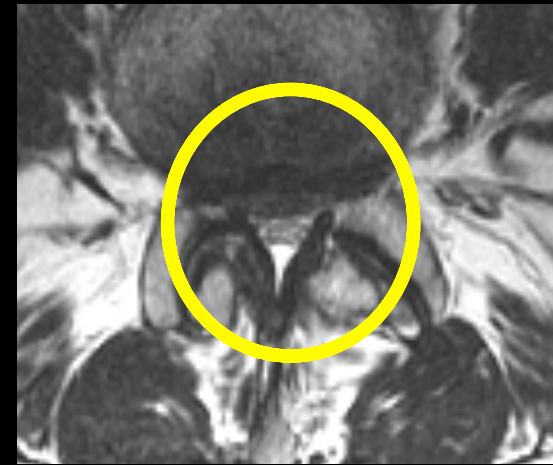


Resolution of left L2  
extrusion over 1 year  
Symptoms resolved as well

# Radicular Pain: Fixed lesions

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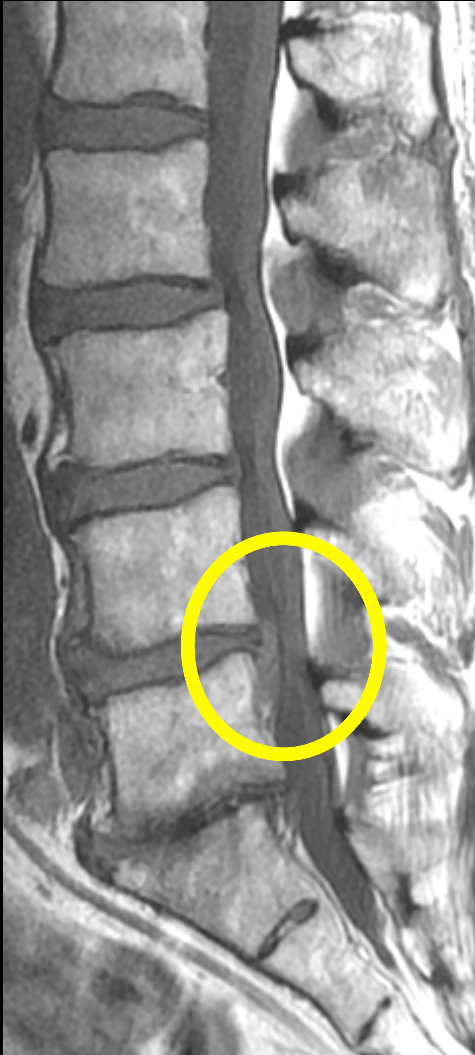
- Inflammatory response in fixed lesions (spinal stenosis) is precipitated by venous hypertension
- Pain syndrome typically consists of gluteal & LE pain worse with walking, relieved with rest, usually with back pain +/- weakness





# Spinal Stenosis

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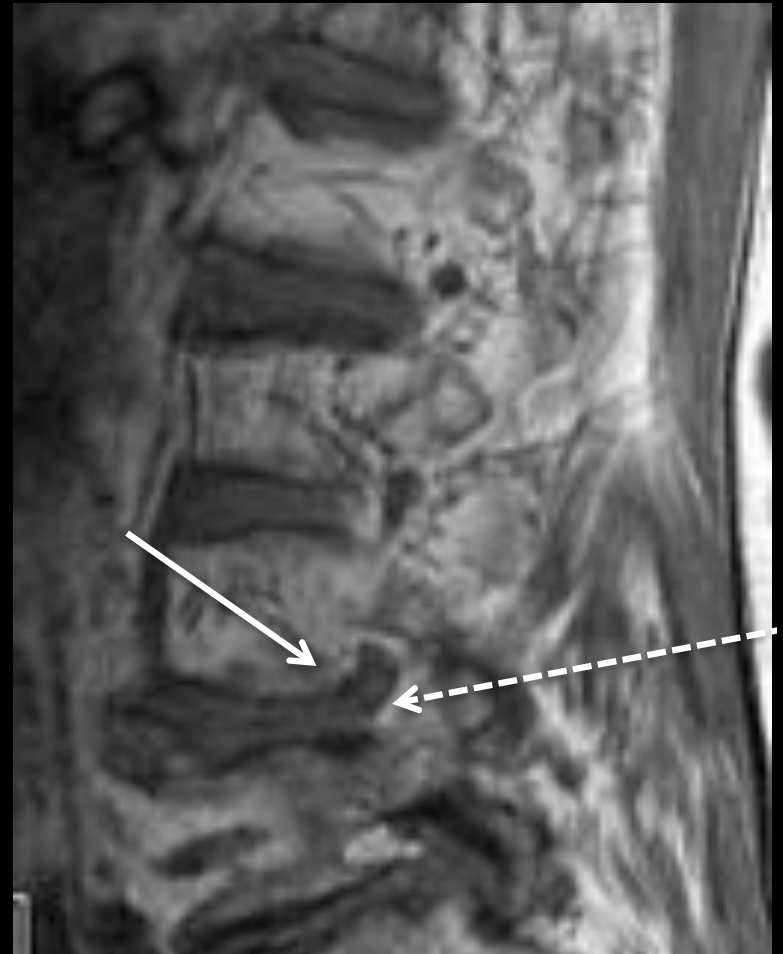
# Image Guided Rx: Epidural Steroids

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- Evidence Based Indications:
  - Radicular pain in patients whom:
    - Have failed conservative therapy
    - Pain is likely to have an inflammatory component
    - Lack contraindications to the procedure
- Lumbar TFESI
  - high quality evidence of efficacy in treatment of radicular pain
  - greater clinical effectiveness in acute pain patients (< 3 months)
- Attenuates local inflammatory response, patient remains functional

# Importance of Pre-Procedure Imaging

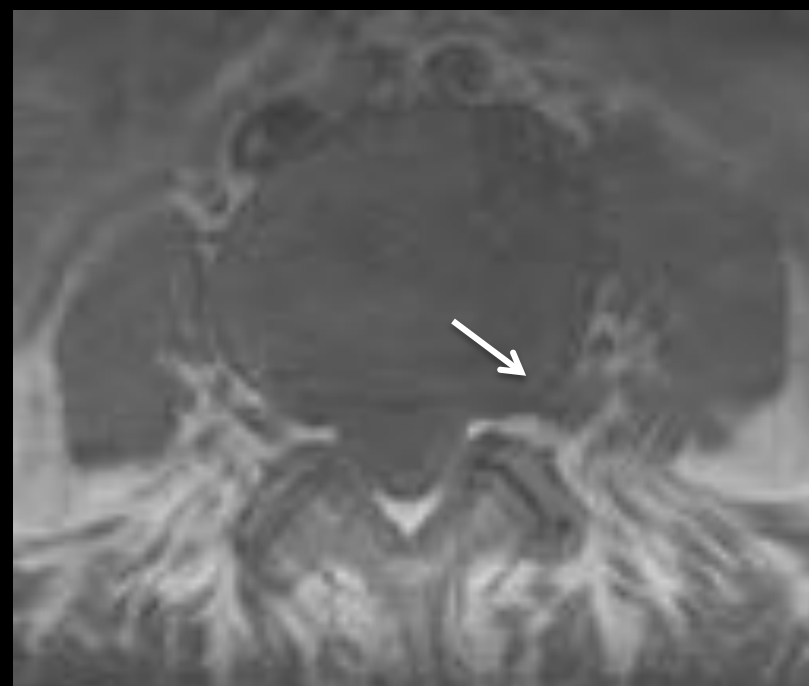
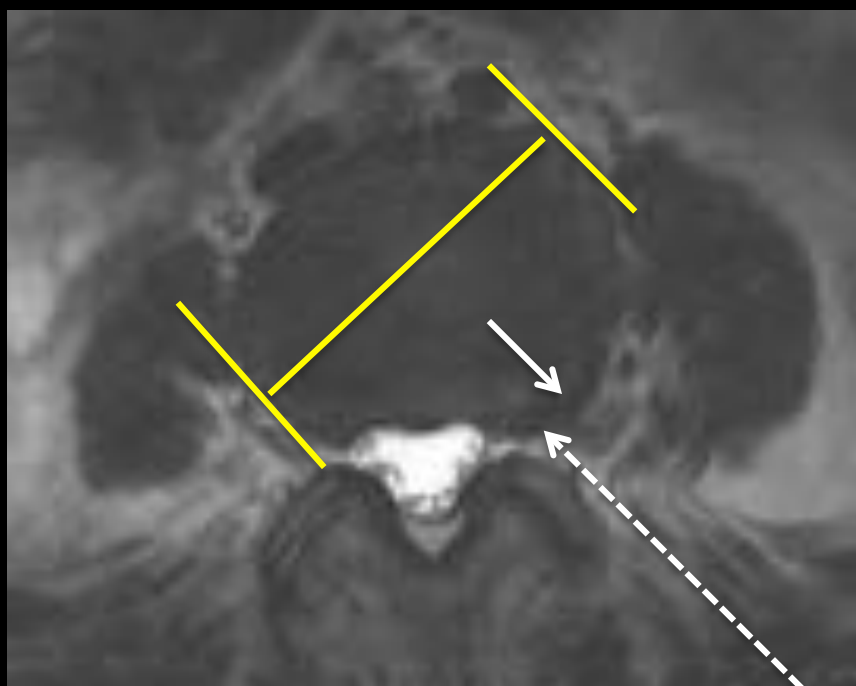
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68F anterior thigh pain

# 68F anterior thigh pain

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# Posterior Element Pain Generators

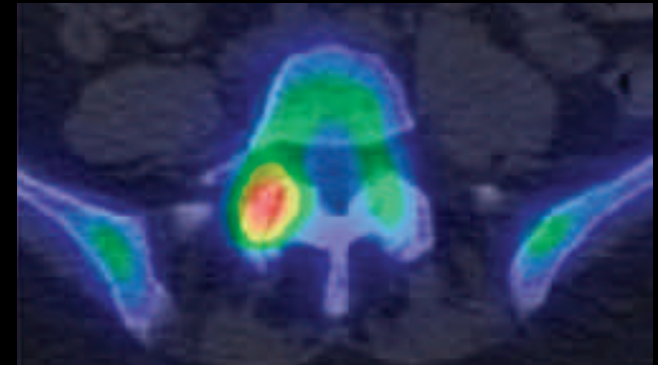
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- Facet synovitis
  - Axial low back pain, can be radicular if mass effect, referred pain syndromes
  - Synovial cysts
- Acute or subacute pars defects
- Interspinous bursitis
- ***Inflammation is common element***

# Facetogenic Pain

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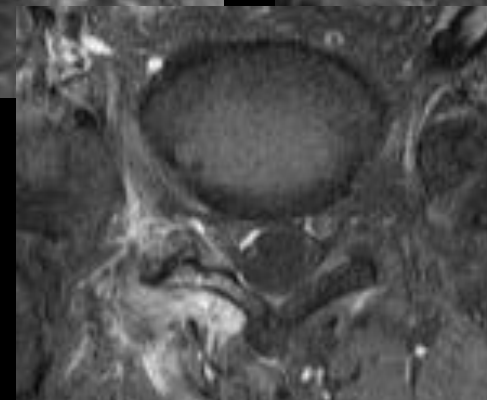
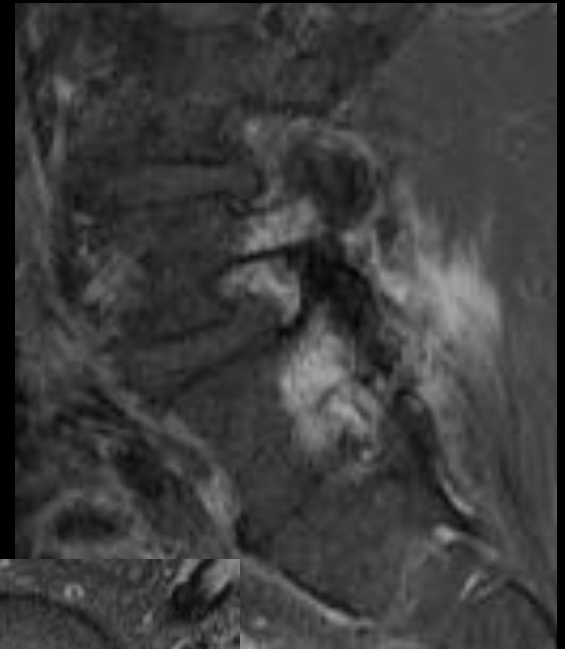
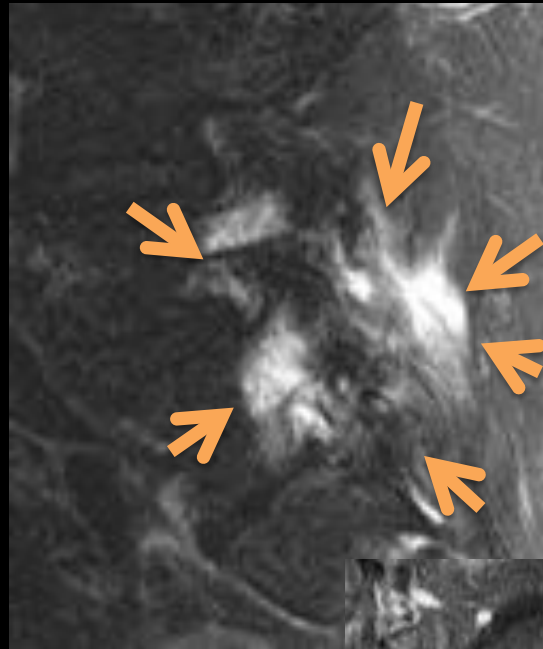
- Nonspecific exam
- Mechanical pain exacerbated with bending, rotation, or extension
- Structural changes of facet arthrosis do not correlate with pain: *age-related change*
- Imaging can provide physiologic information regarding inflammation



60F right lower facet pain syndrome, SPECT/CT

# Facet Joint: Physiologic Imaging

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- T2 Hyperintensity, enhancement
- Perifacet soft tissue, joint, bone

# Facet Joint Innervation

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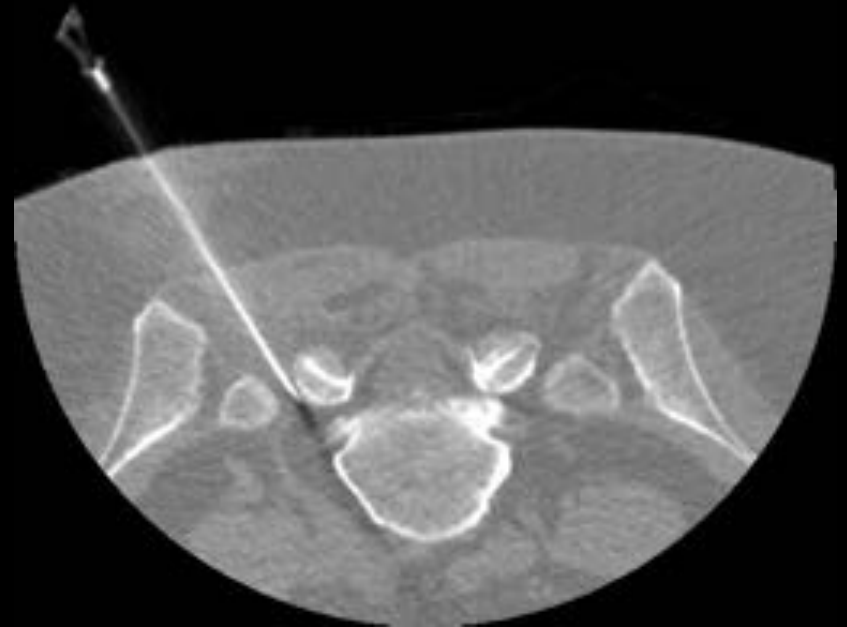
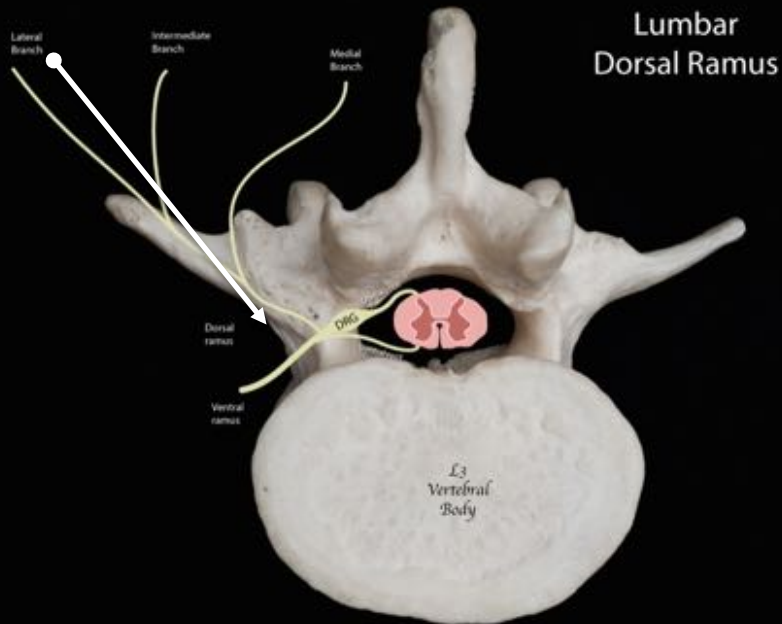


Courtesy: F.H. Willard



# Blocking Facet Joint Innervation

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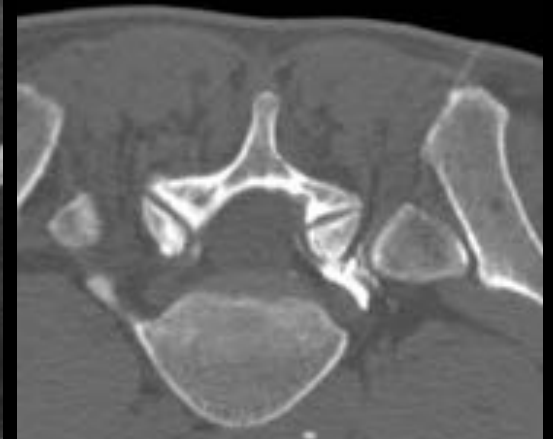
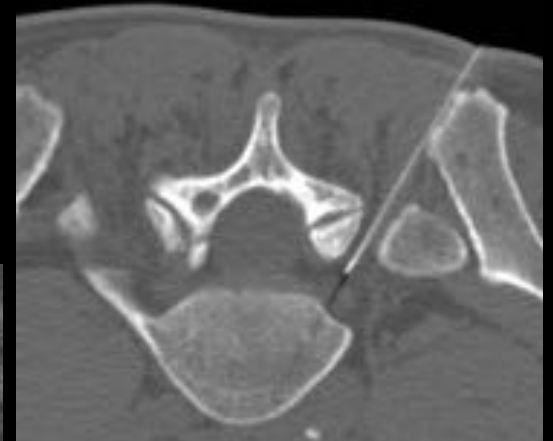


Courtesy: F.H. Willard

# Synovial Cyst

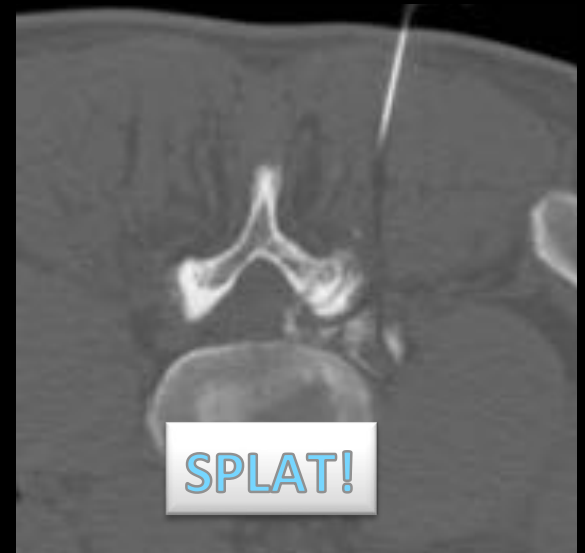
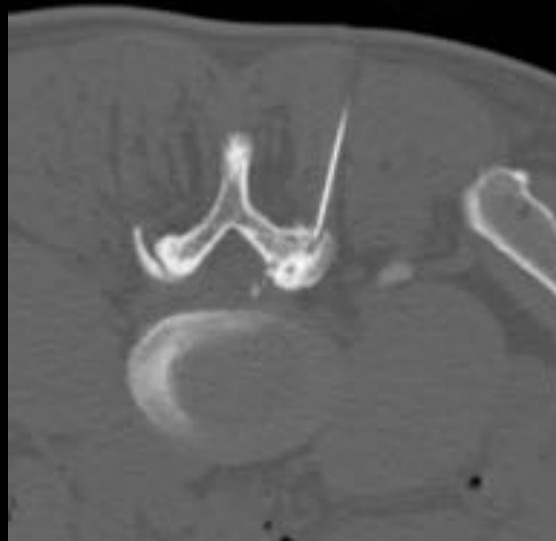
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M, 61 Left L5 radicular pain



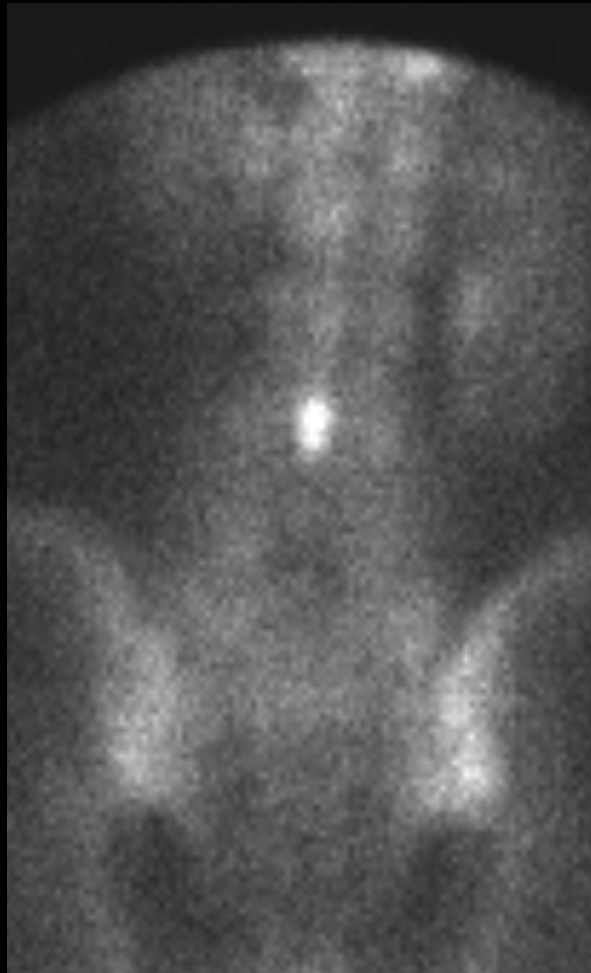
# Synovial Cyst Rupture

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# Posterior Element Pain: Interspinous Bursitis

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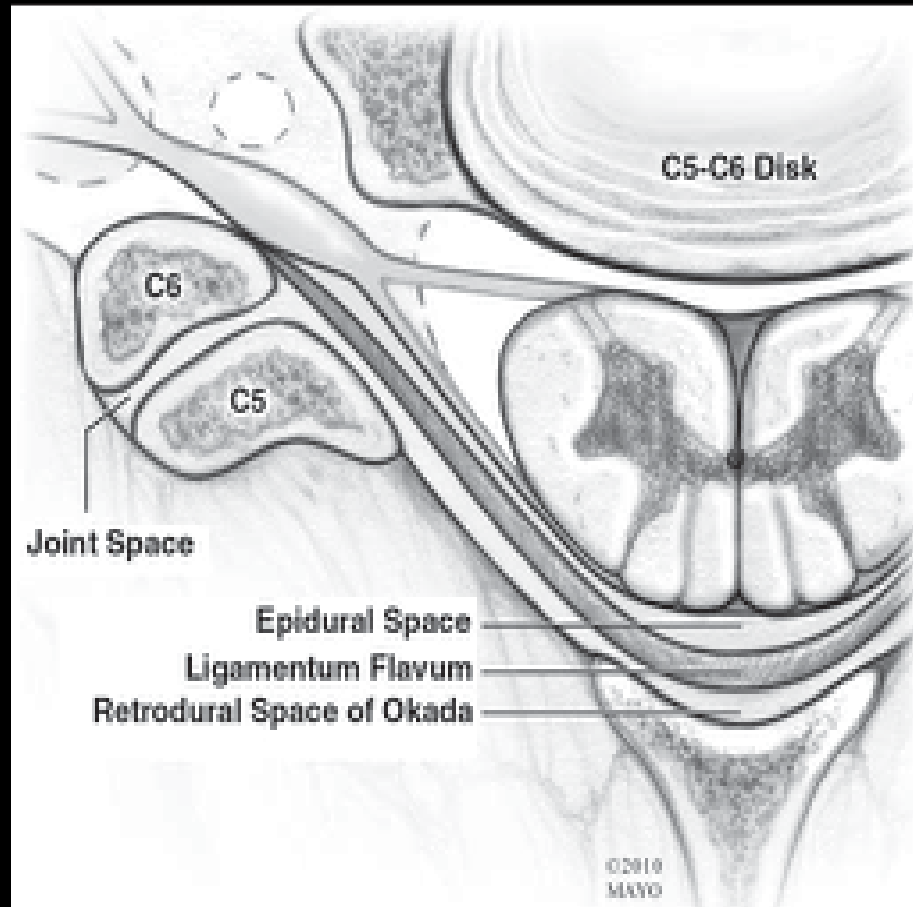
# Attempted ESI: Bilateral Facet Arthrograms

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# Retrodural Space of Okada

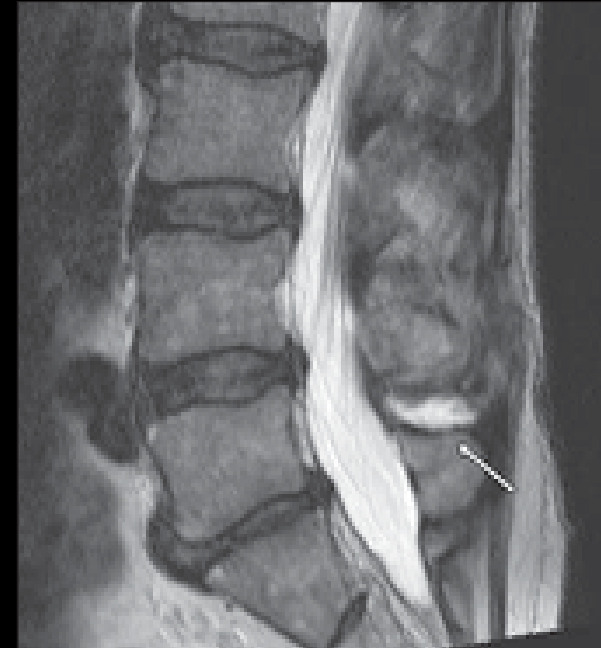
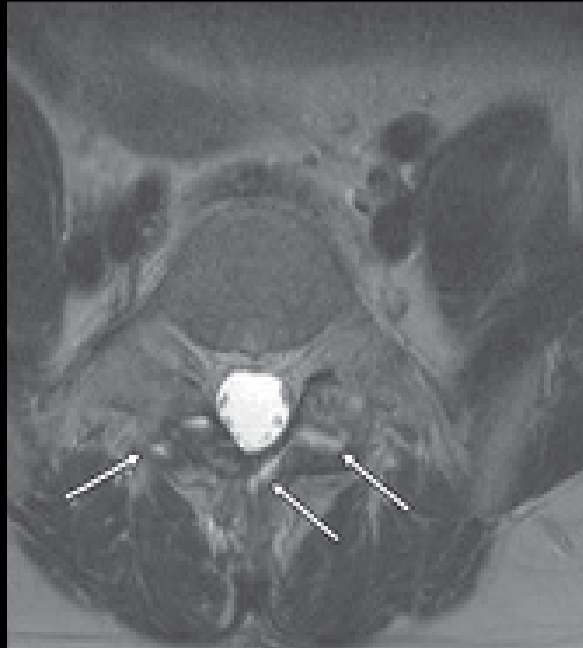
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Murthy, NS et al. The Retrodural Space of Okada. *AJR* 2011; 196:W784-9

# Retrodural Space of Okada

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# Segmental Instability

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- Degenerative, isthmic etiology
- Abnormal motion segment
  - **posterior column** (facet DJD, pars defect)
  - **anterior column** (disk degeneration)
  - translation, rotation, angular curvature
- Unremitting sx, surgical fusion





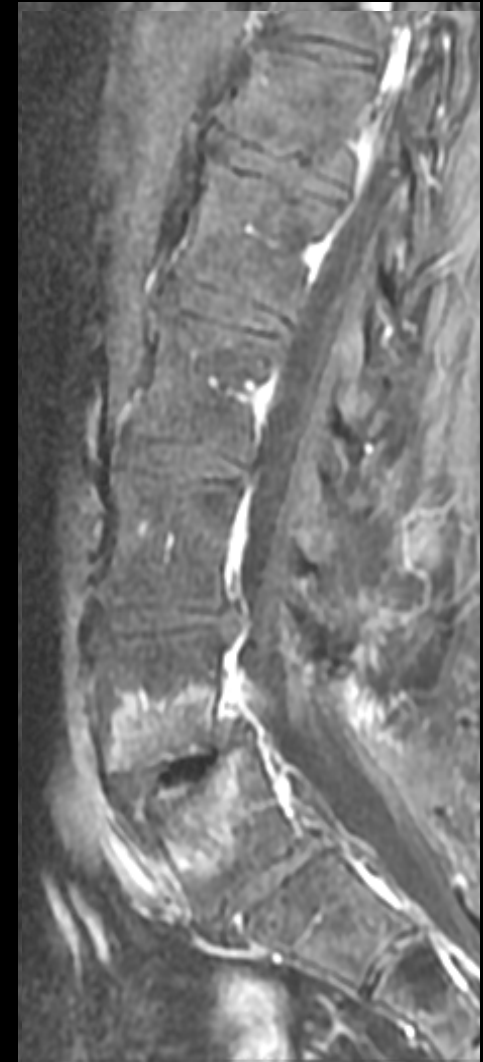
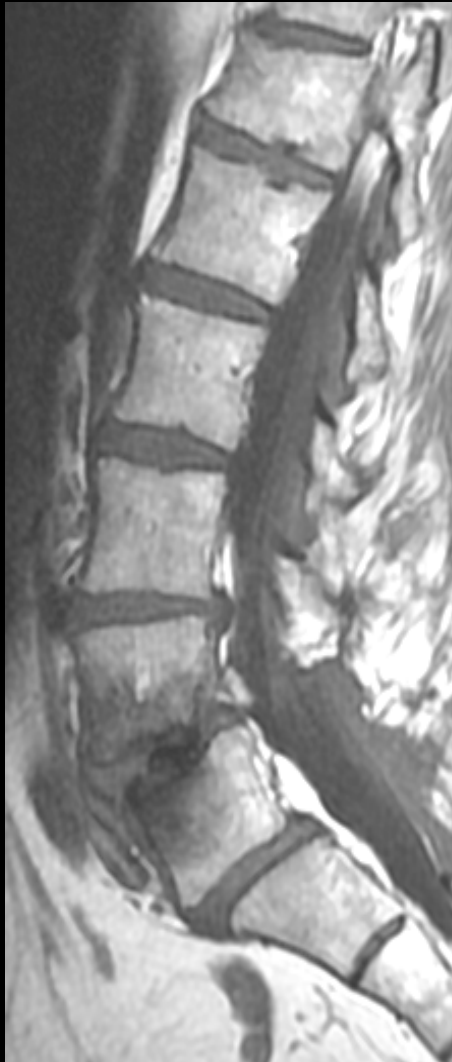
# Segmental Instability

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# Segmental Instability

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# Take Home Points

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- Pathophysiology of spine imaging rooted in biochemistry of inflammation
- Inflammation is basis of low back pain clinical pain syndromes
- IDD is mechanism for discogenic pain
- Facet pain syndromes – older patients
- Physiologic imaging can be valuable in establishing diagnosis & in directing treatment

# Thank You

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- Questions???
- Contact: [Vinil.shah@ucsf.edu](mailto:Vinil.shah@ucsf.edu)

