IMAGING OF THORACOLUMBAR TRAUMA

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Thoracolumbar Trauma

- Anatomy
- Stability / instability
- Basic trauma vectors
- Fracture patterns
- Post-operative evaluation

Anatomy

- ***Three biomechanical regions***

T1-T8: relatively rigid (ribcage)

L3-sacrum: mobile

T9-L2: transition: immobile - mobile, most injuries occur here

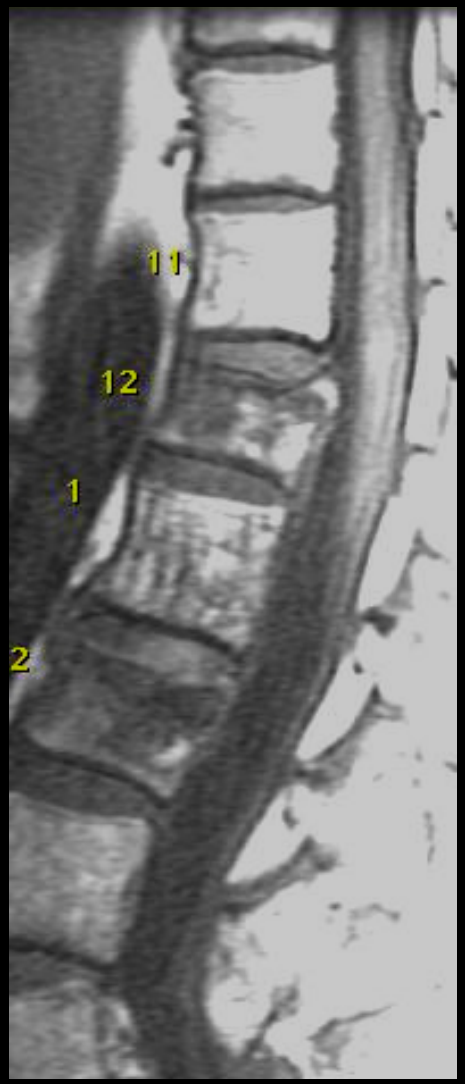
Anatomy

- L-spine: center of gravity - shifted relatively posteriorly
  - posterior elements - approx 30% weight-bearing
  - motion: flexion/extension/rotation
  - lordosis - flexion mechanism straightens L-spine, results in axial load type injury

Anatomy

- **Ligaments**
  - Allow motion, confer stability
  - ALL, PLL, ligamentum flavum, interspinous ligament

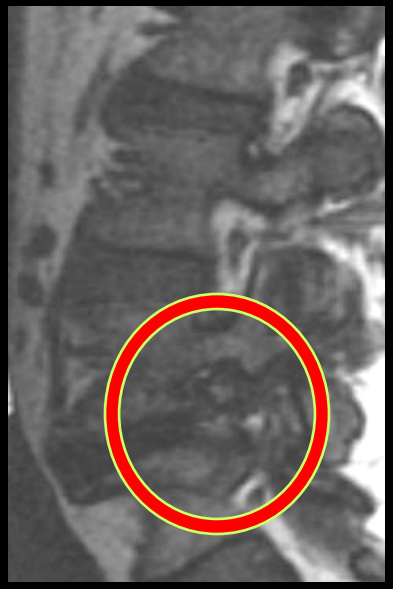
Anatomy

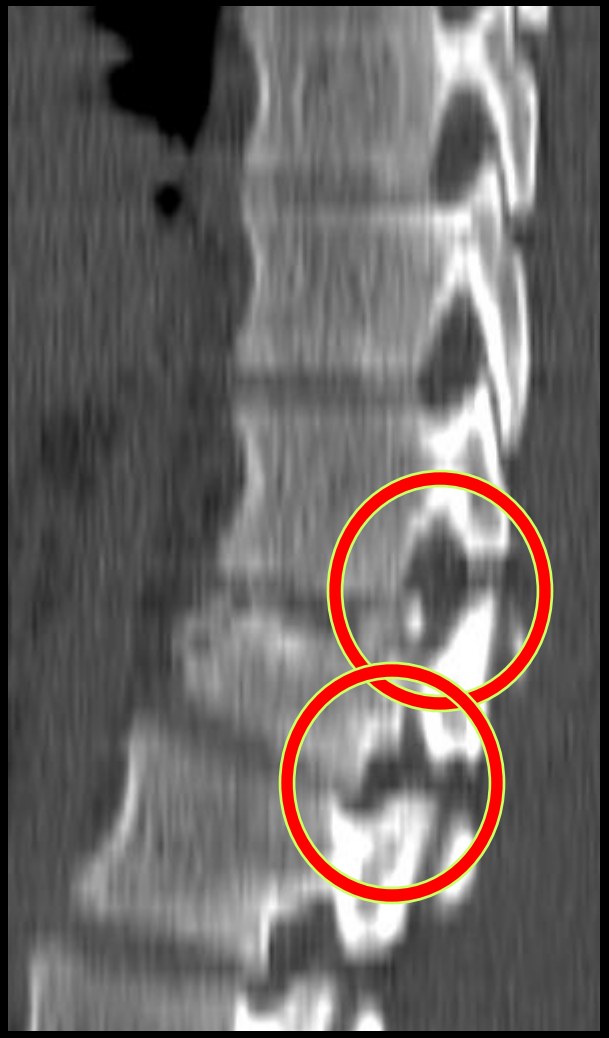


- Spinal canal
  - T-spine: 16 x 16 mm avg.
  - L-spine: 26 x 17 mm avg.
  - cord terminates L1
- Relatively minor injuries to T-spine can result in significant neuro injury
- Canal encroachment in L-spine may not cause neurologic impairment

Anatomy

- **Neural foramina**
  - Nerve roots susceptible to injury by:
    - facet, pedicle, laminar or transverse process fx
    - retropulsion of vertebral body fragments
    - traumatic spondylolisthesis

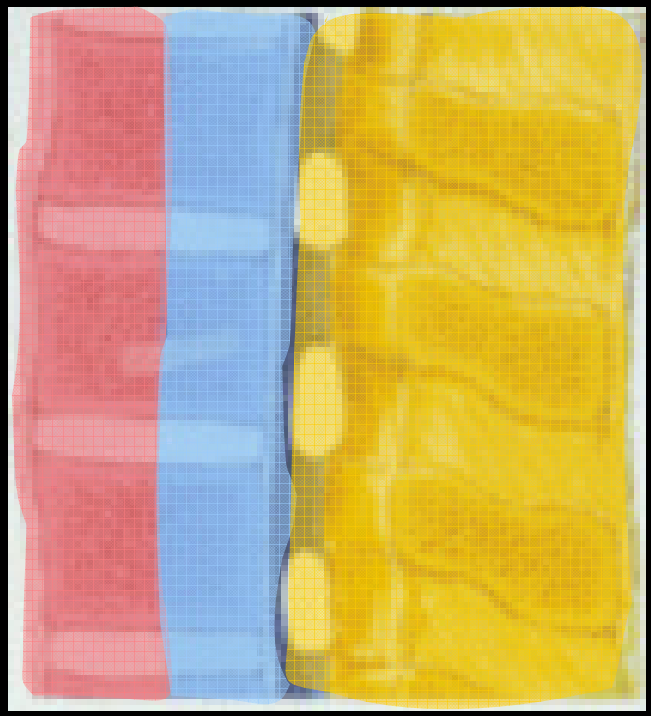




Spine Injury and Instability

Three Column Theory

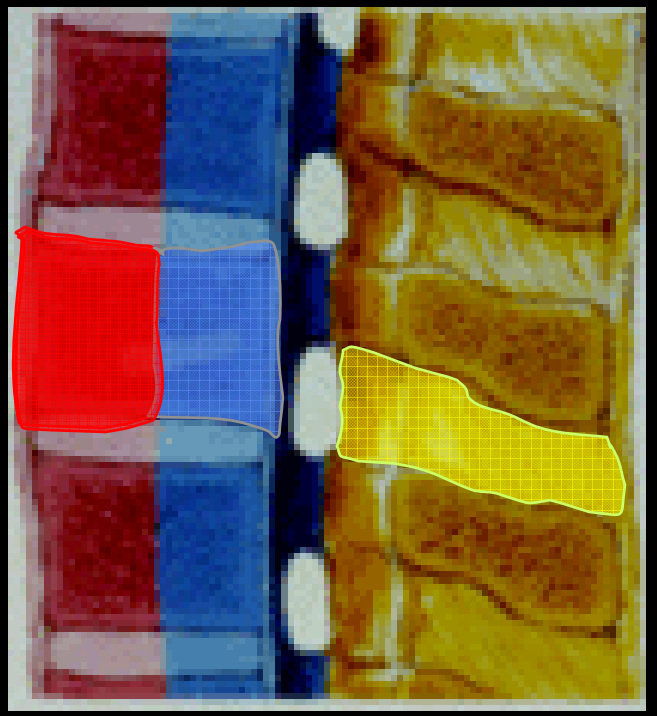
- Anterior column
  - ALL, anterior annulus
  - anterior vertebral body
- Middle column
  - posterior vertebral body
  - posterior annulus, PLL
- Posterior column
  - posterior elements (pedicles, facets, lamina, spinous processes)
  - posterior ligaments



Denis F. Spine 1983; 8:817-831

Mechanical Instability
Two 'Columns' Disrupted

- **Burst fracture**
  - anterior and middle columns, +/- posterior column
- **Anterior wedge compression with posterior ligament tear**
  - anterior and posterior columns



Mechanically Stable

- **Only one column disrupted**
  - Anterior wedge compression fracture with intact posterior ligaments
  - Isolated posterior element fracture

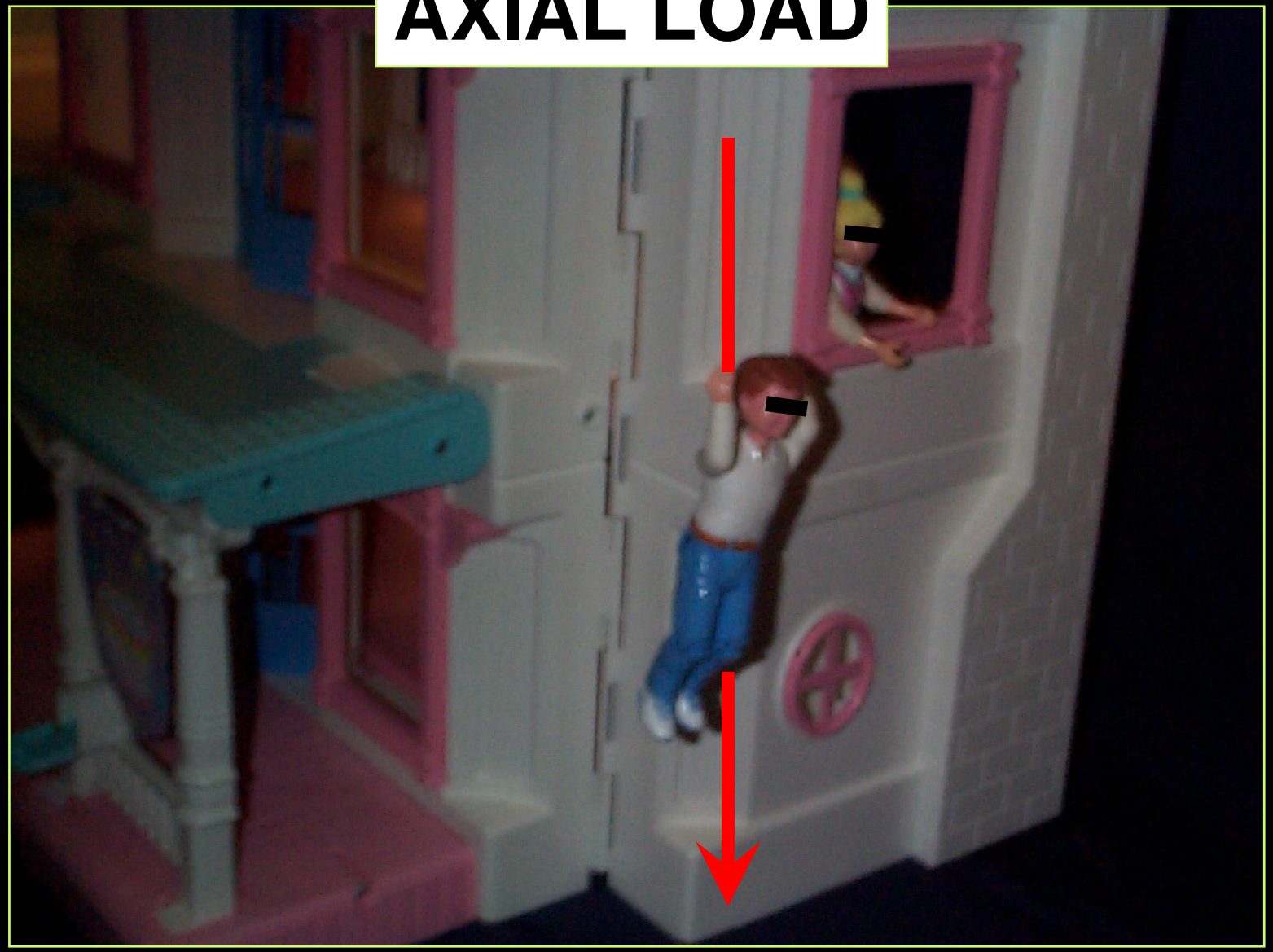
Force Vectors

- Most spine injuries: MVA or fall
- Complex combination of forces
- Force vectors applied to certain areas of the spine result in predictable patterns of fracture
- Understanding of basic vectors aids radiologic interpretation

Basic Spine Trauma Forces

- Axial load
- Flexion / compression
- Flexion / rotation
- Flexion / distraction
- Lateral compression
- Shear
- Extension

AXIAL LOAD



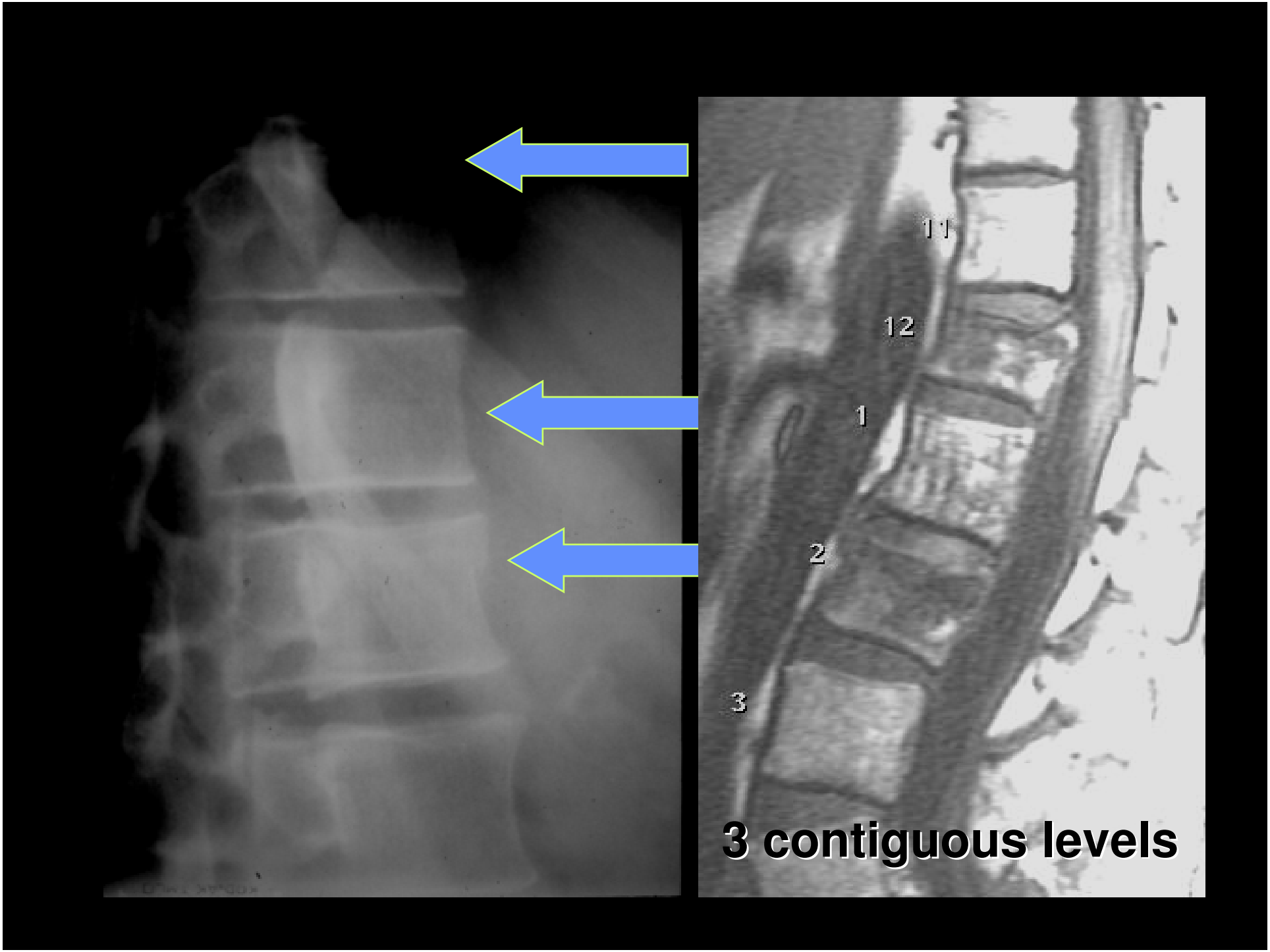
Fall from height

Axial Load

- T-L junction - most common site of injury
- T-spine - may result in flexion force, anterior wedge compression or burst
- 43% fx at another level
- 10% non-contiguous: need to survey whole spine

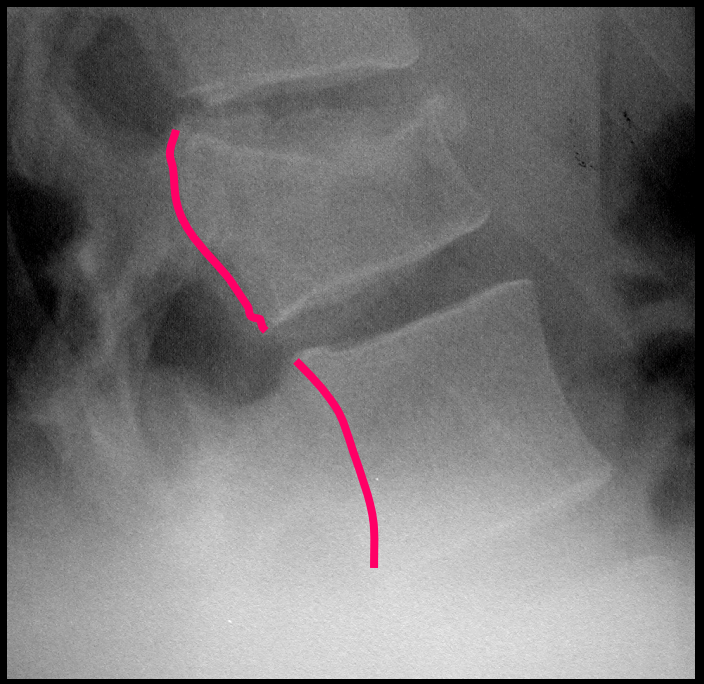
Atlas SW, et al. AJR 1986; 147:575-582

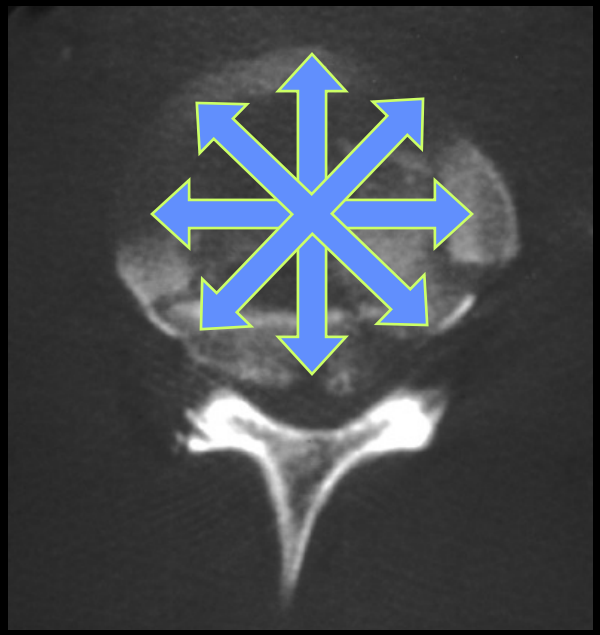
Vaccaro et al. J Spinal Disord 1992; 5:320-329


11
12
1
2
3
3 contiguous levels

Burst Fracture

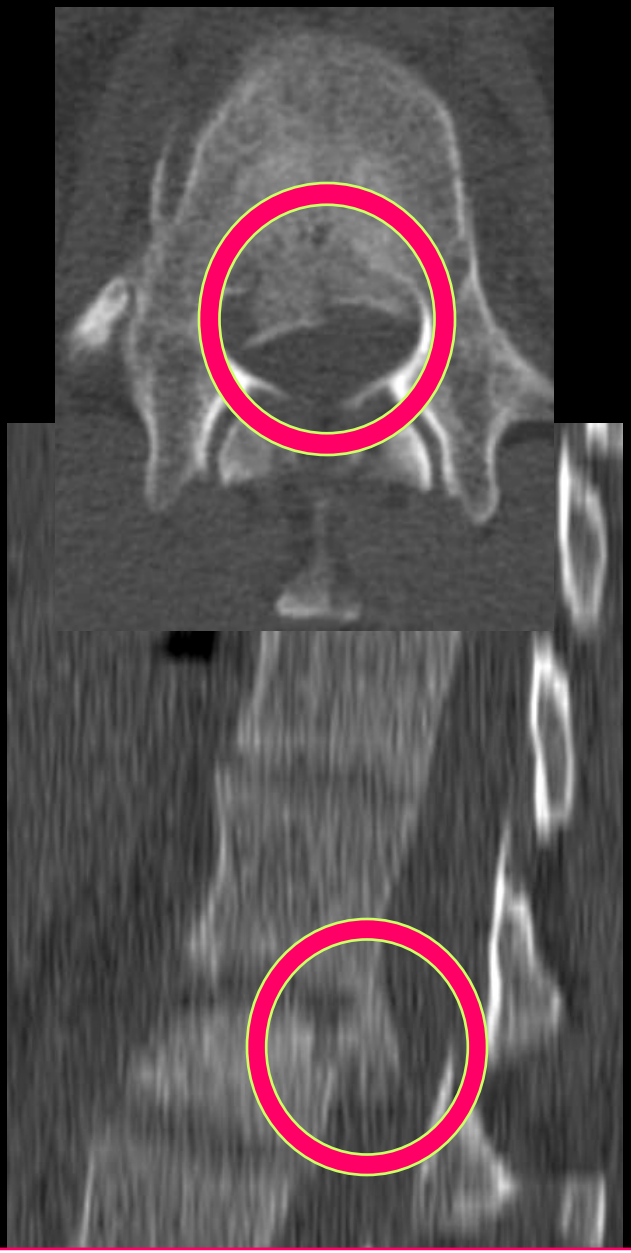
- **Anterior and middle column disrupted**
  - posterior bowing of vertebral body - *anything other than concavity*
  - retropulsion of fragments into spinal canal



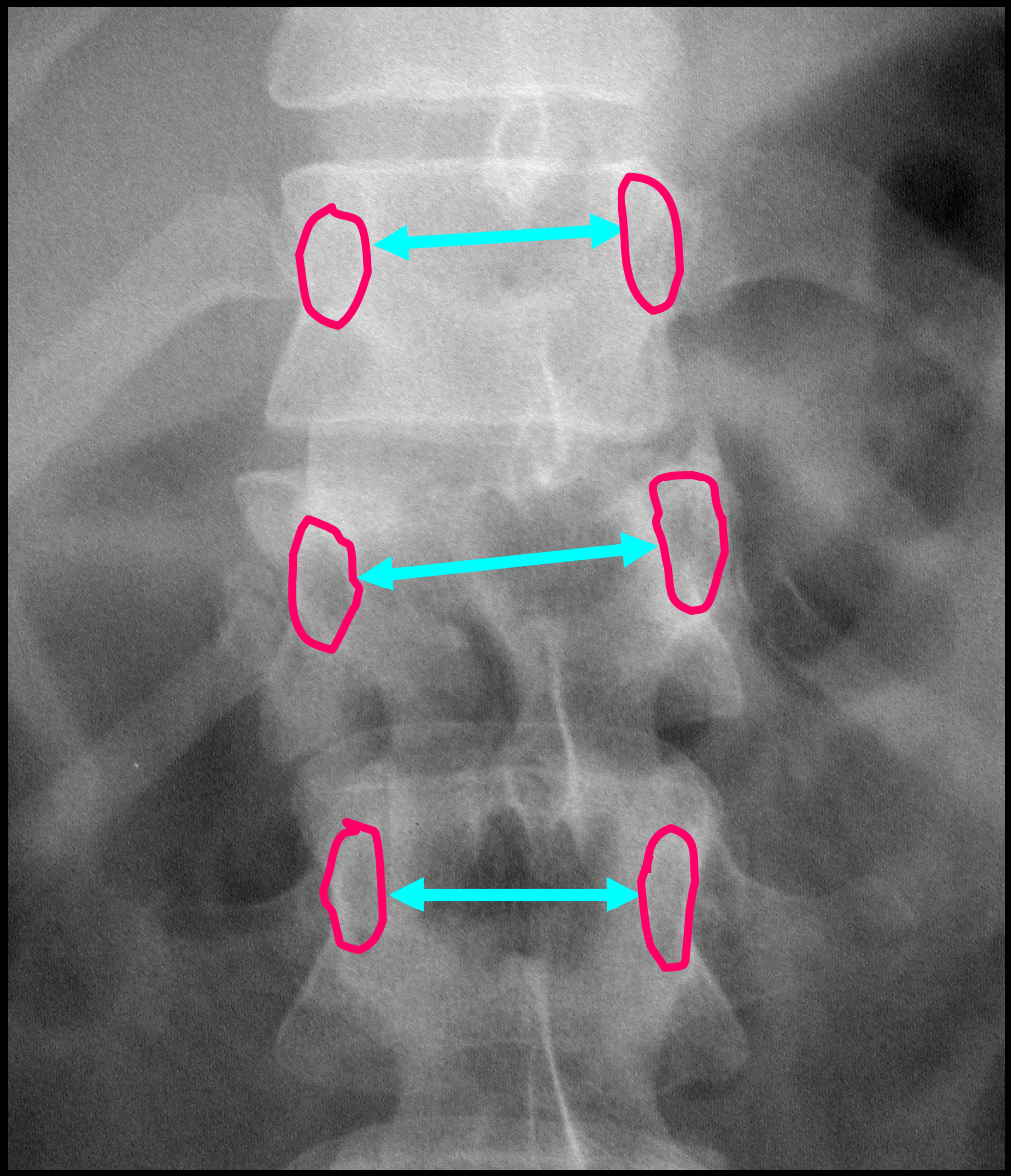


Burst Fracture

- Retropulsed fragment from superior endplate – may rotate, migrate
- Attached to anulus, PLL - *distraction helps reduce*



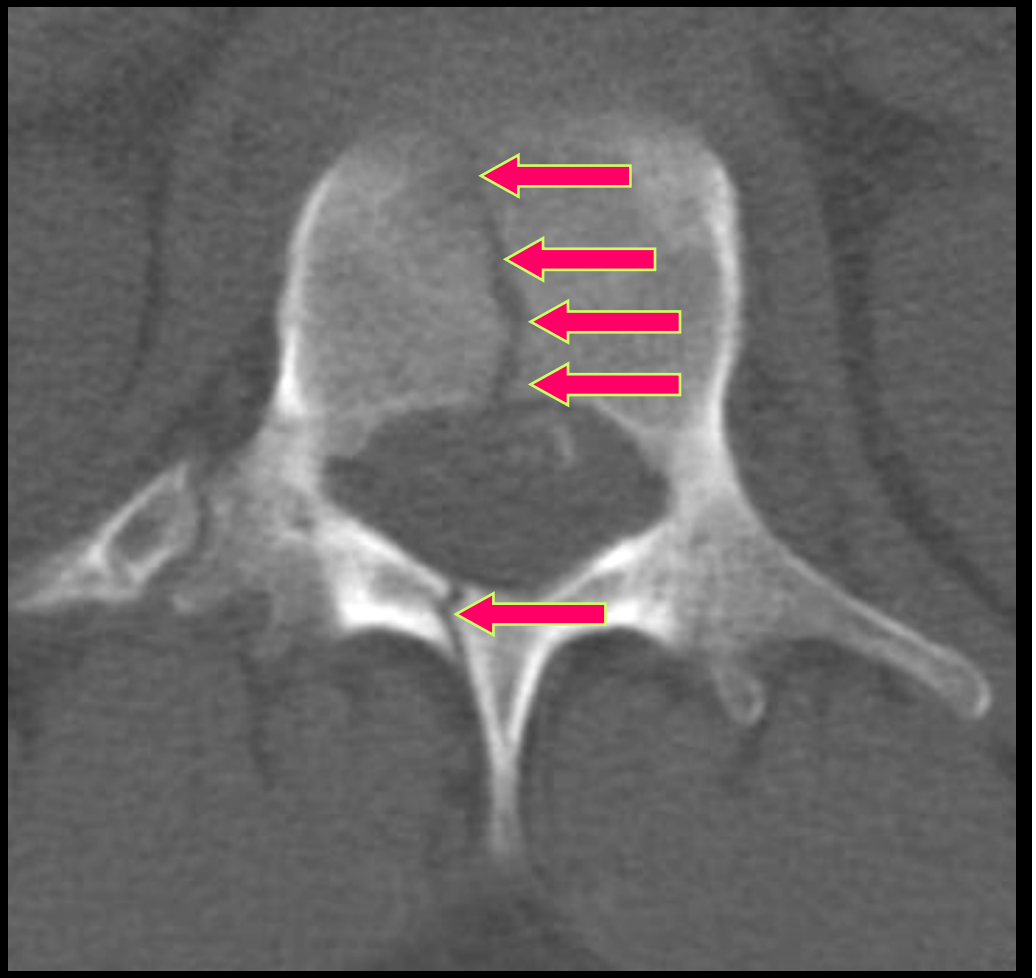
Guerra J, et al. Radiology 1984; 153:769-772
Harrington RM, et al. Spine 1993; 18:692-699



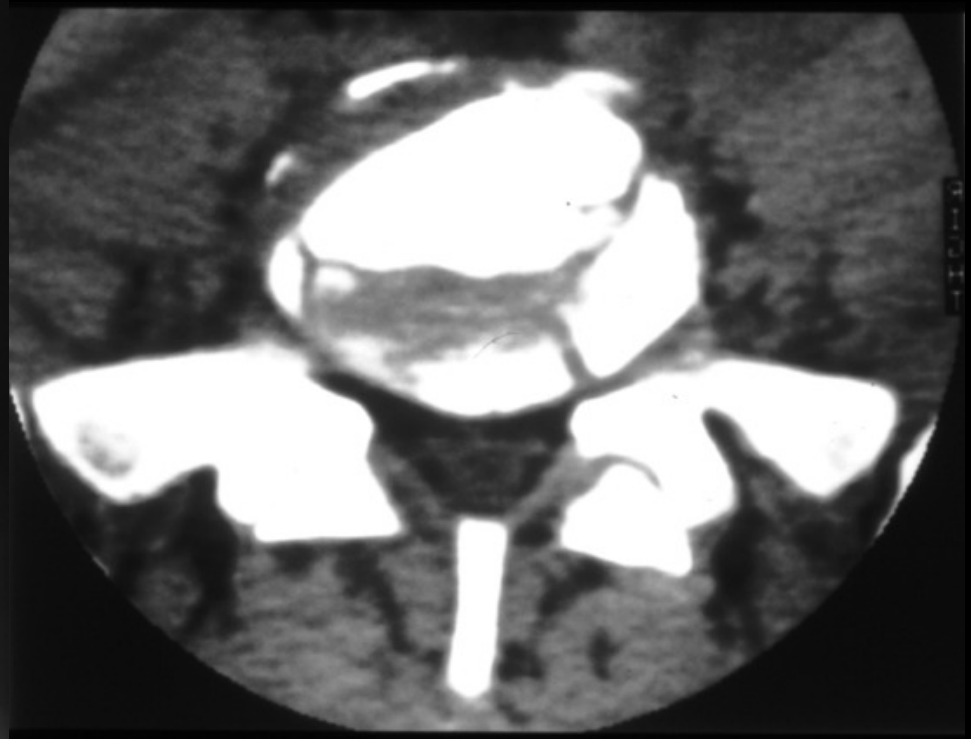
widening of distance between pedicles on AP view

Burst Fracture

- Sagittal split through vertebral body, posterior elements
  - *dural laceration*



Denis F, et al. Spine 1991; 16:433-439



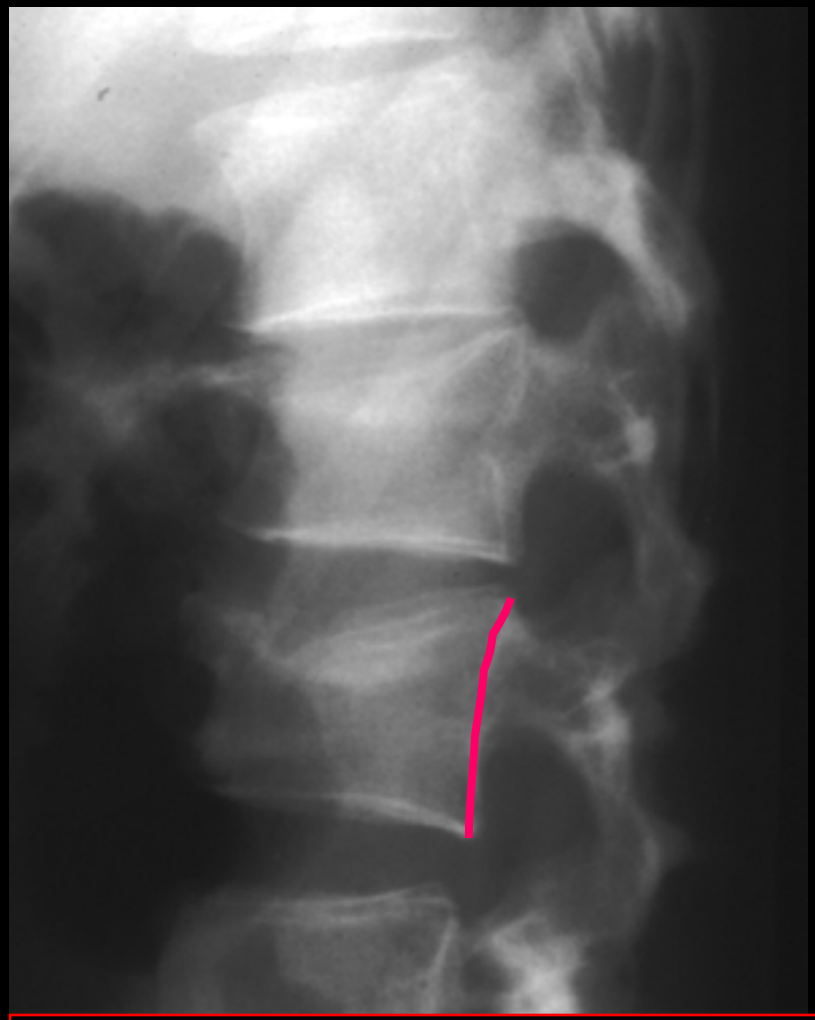
Lower lumbar burst fx
- May not require decompression

Burst vs. Anterior Wedge Fx

- Anterior wedge - anterior column - stable
- Burst - 2-3 columns - unstable
- Important to differentiate
  - Look for posterior vertebral concavity
  - CT for evaluation of posterior vertebral body, fracture of posterior elements
  - As many as 20% of burst fractures may be missed if radiographs alone are used
  - MRI for ligamentous disruption / neuro sx

Ballock RT, et al. J Bone Joint Surg Br 1992; 74:147-150

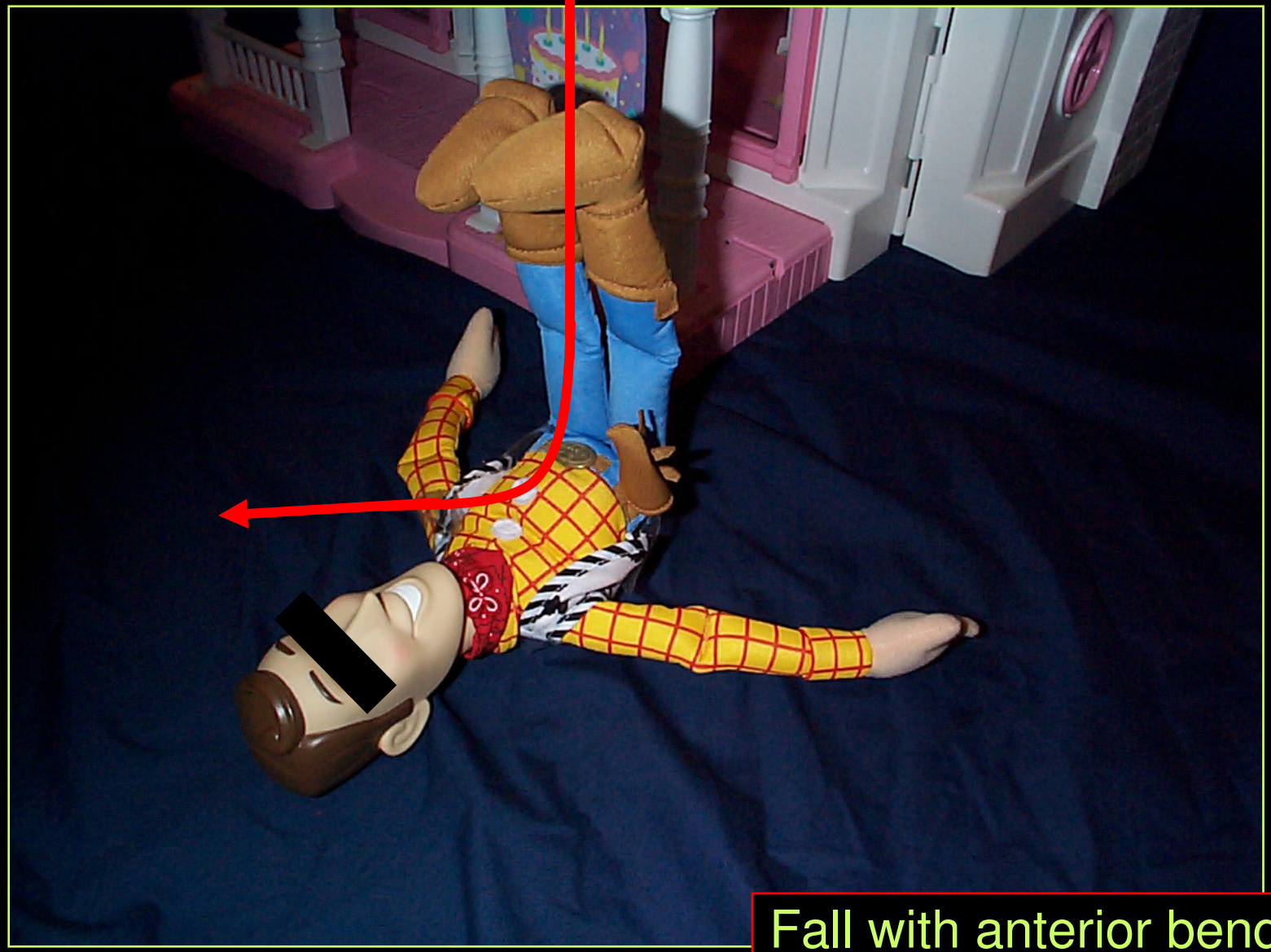
Anterior Wedge Compression Fracture



Importance of posterior vertebral body line:
Anything except concavity = burst

Daffner et al. AJR 1987; 148:93-96

FLEXION COMPRESSION INJURY



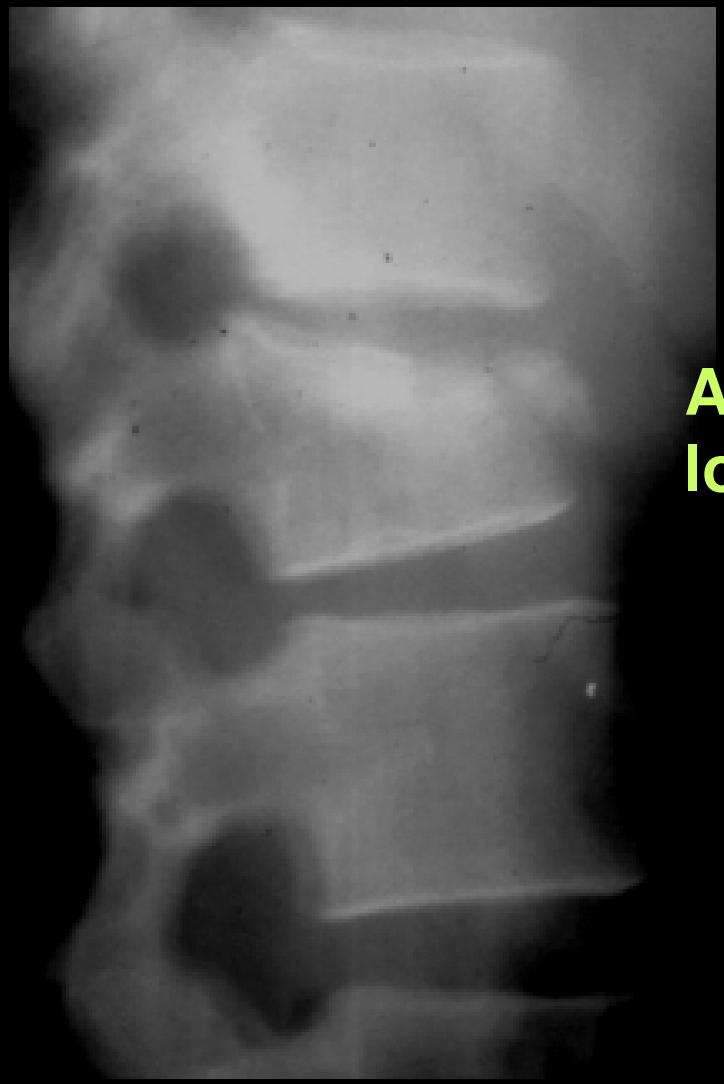
Fall with anterior bending

Flexion / Compression

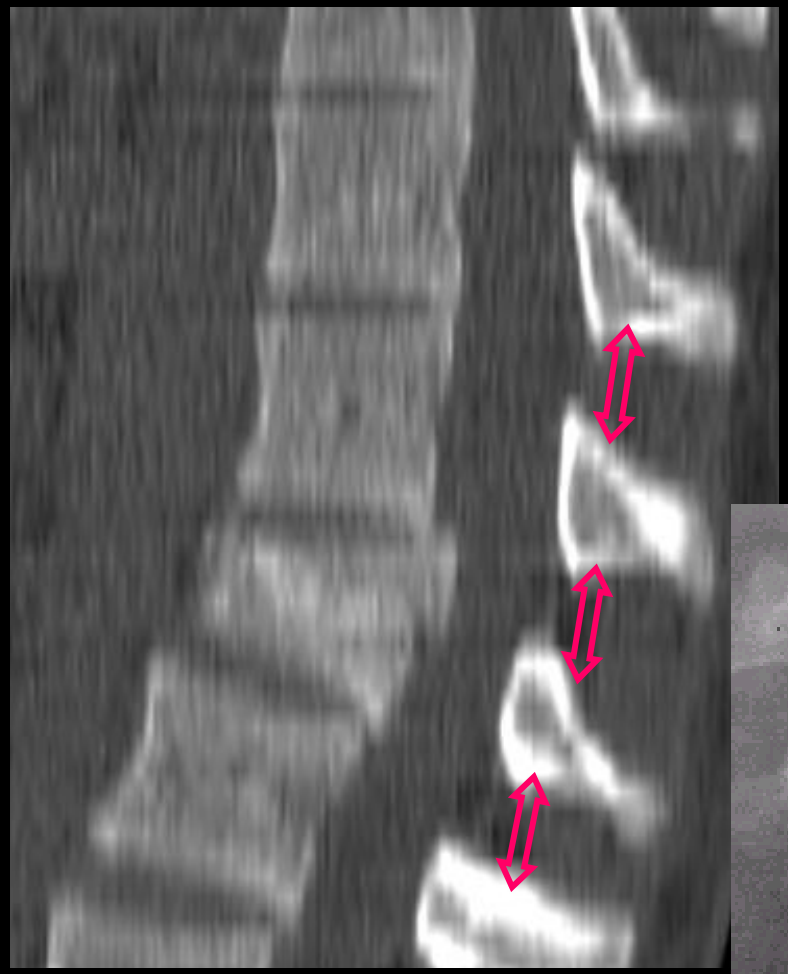
- Anterior wedge compression vs. burst fracture
- Higher risk of posterior ligamentous disruption
- Loss of height anterior > posterior

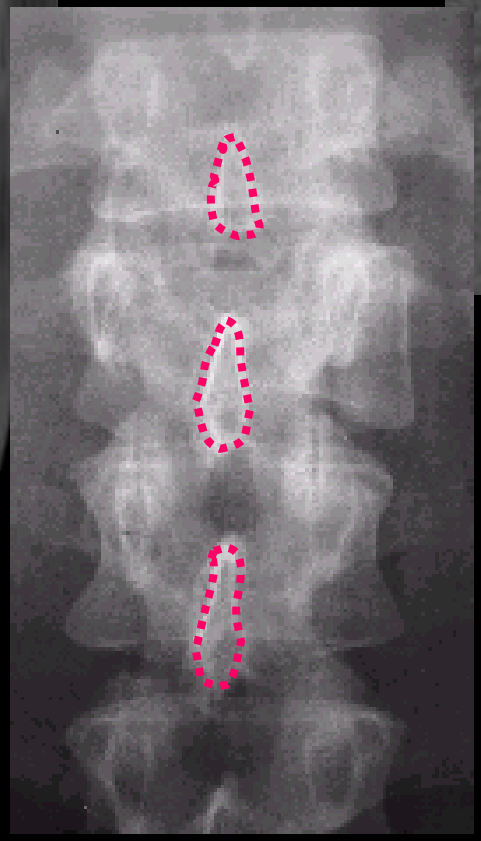
Grenier N, et al. Radiology 1989; 171:197-205
Petersilge CA, et al. Radiology 1995; 194:49-54

Flexion / Compression Injury



Anterior >> posterior
loss of height



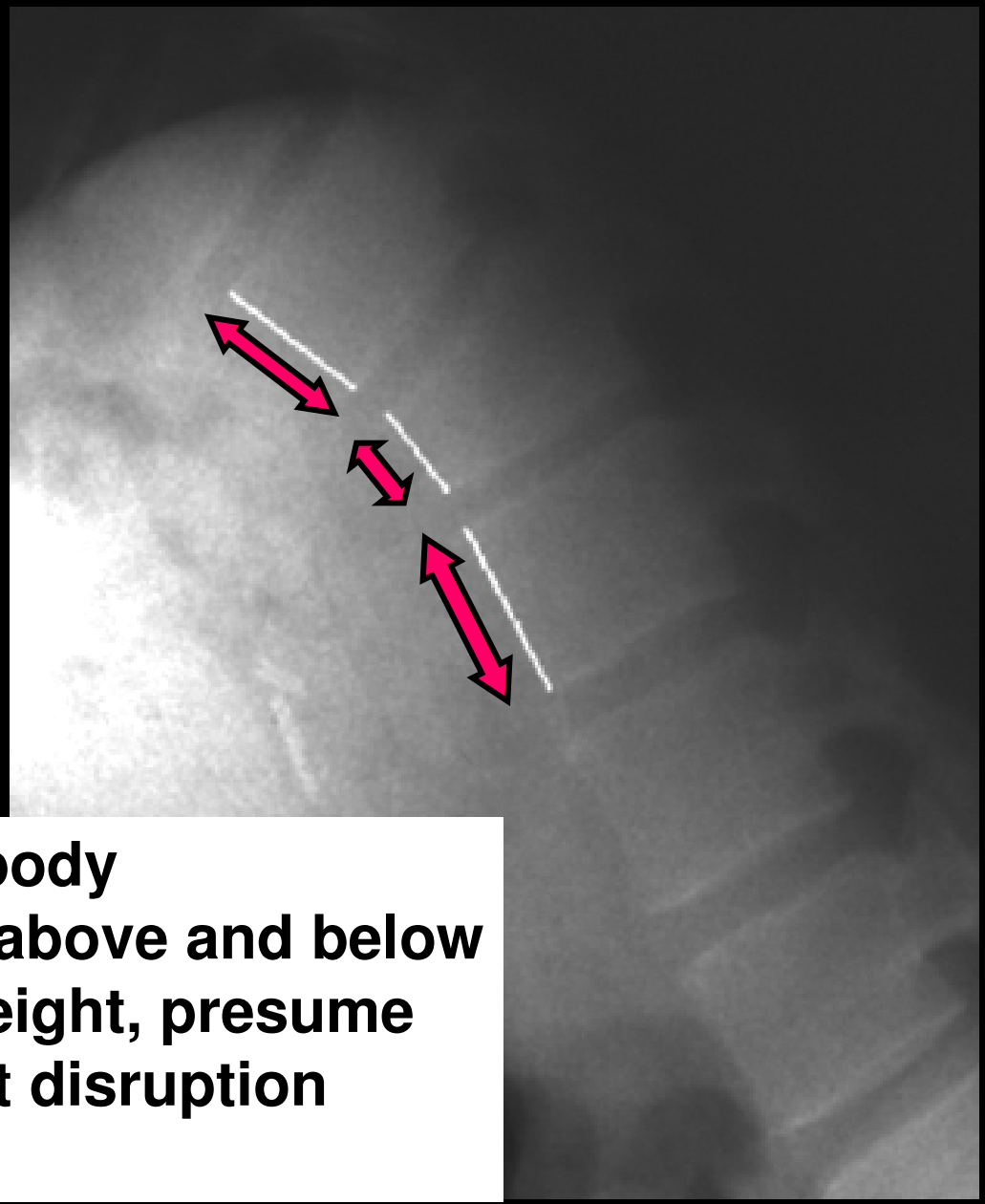


Flexion Compression Injury: Burst Fracture

-No interspinous widening; posterior ligs intact

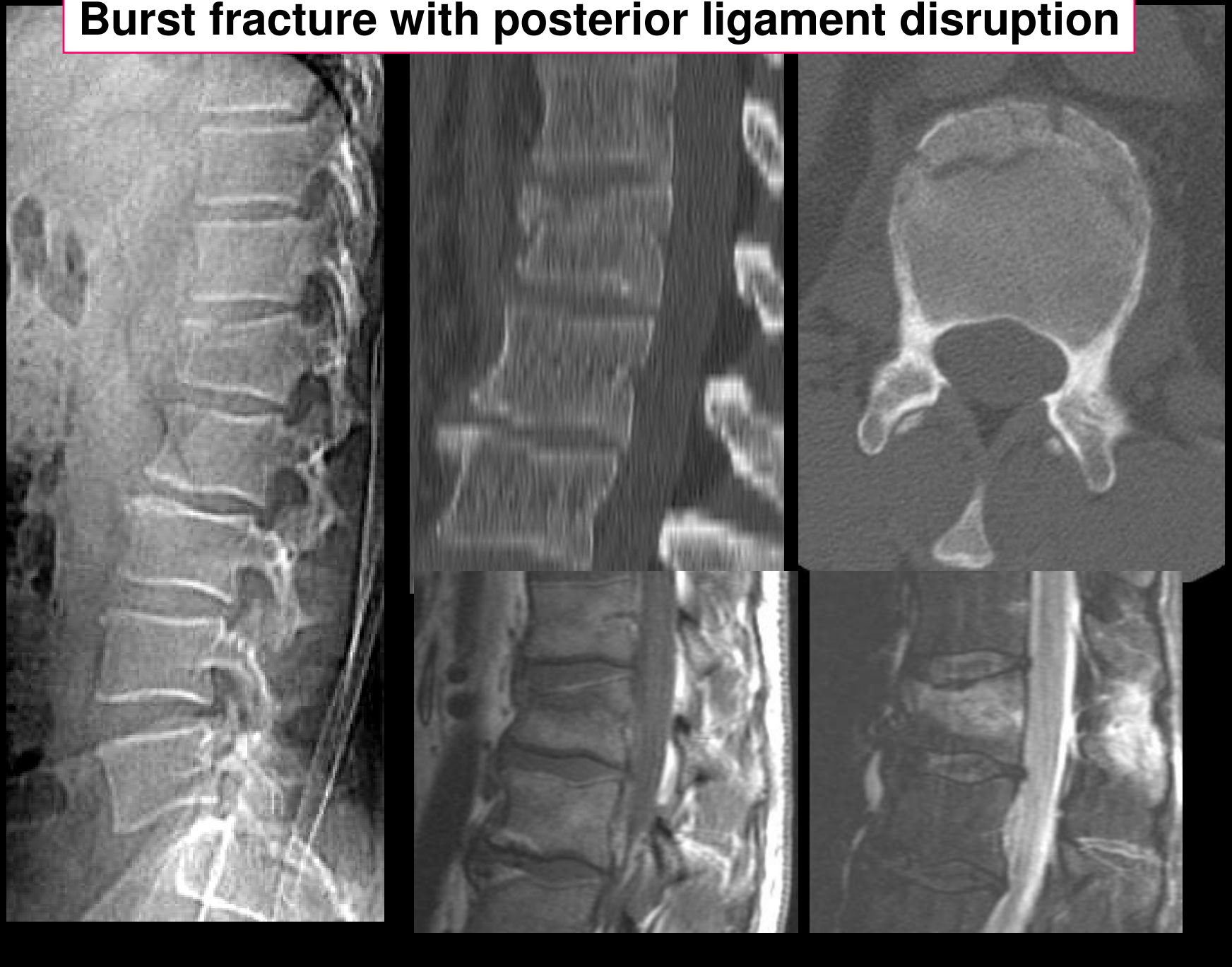
Flexion / Compression

- **Posterior ligamentous disruption may not be apparent radiographically**
  - *CT or MRI*
  - *On Xray: if anterior compression 50% or greater, assume posterior lig disruption and instability*
- **If unrecognized**
  - *progressive anterior collapse, deformity (middle column - fulcrum)*

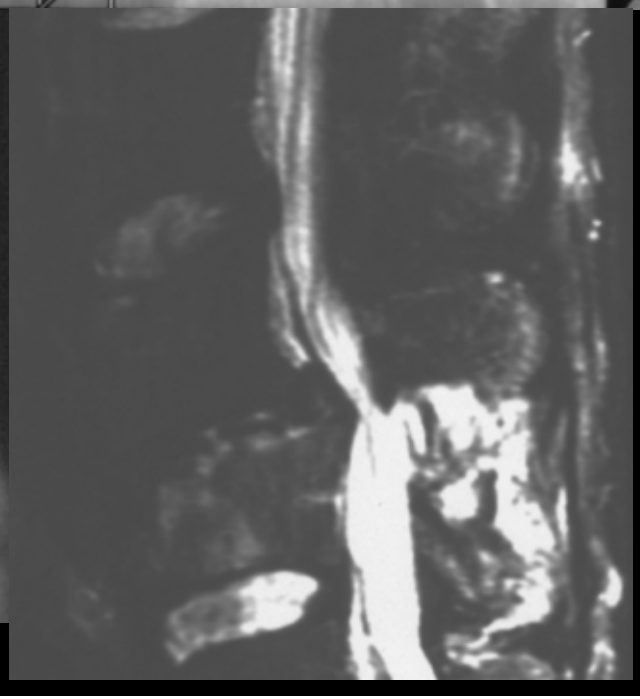


Measure anterior body
-compare to body above and below
-if > 50% loss of height, presume posterior ligament disruption
-MRI to confirm

Burst fracture with posterior ligament disruption



Anterior wedge compression fracture with posterior ligament disruption - delayed instability



Flexion / Rotation

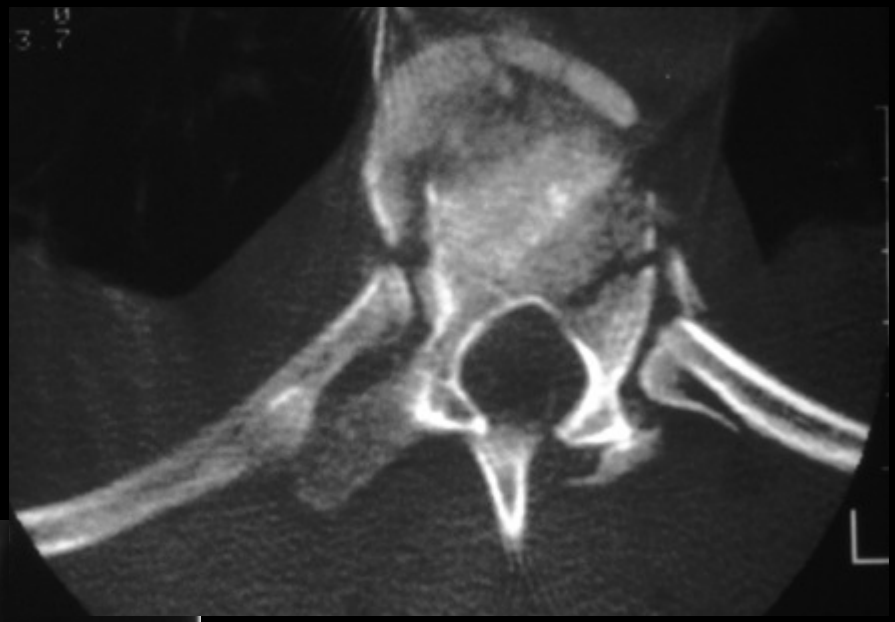
- T/L junction
- Flexion vector: anterior wedge or burst
- Rotation: addition of this vector tends to result in instability
  - *disruption of posterior ligaments*
  - *posterior element fracture*
  - *can lead to dislocation*
- High incidence of neurologic deficit

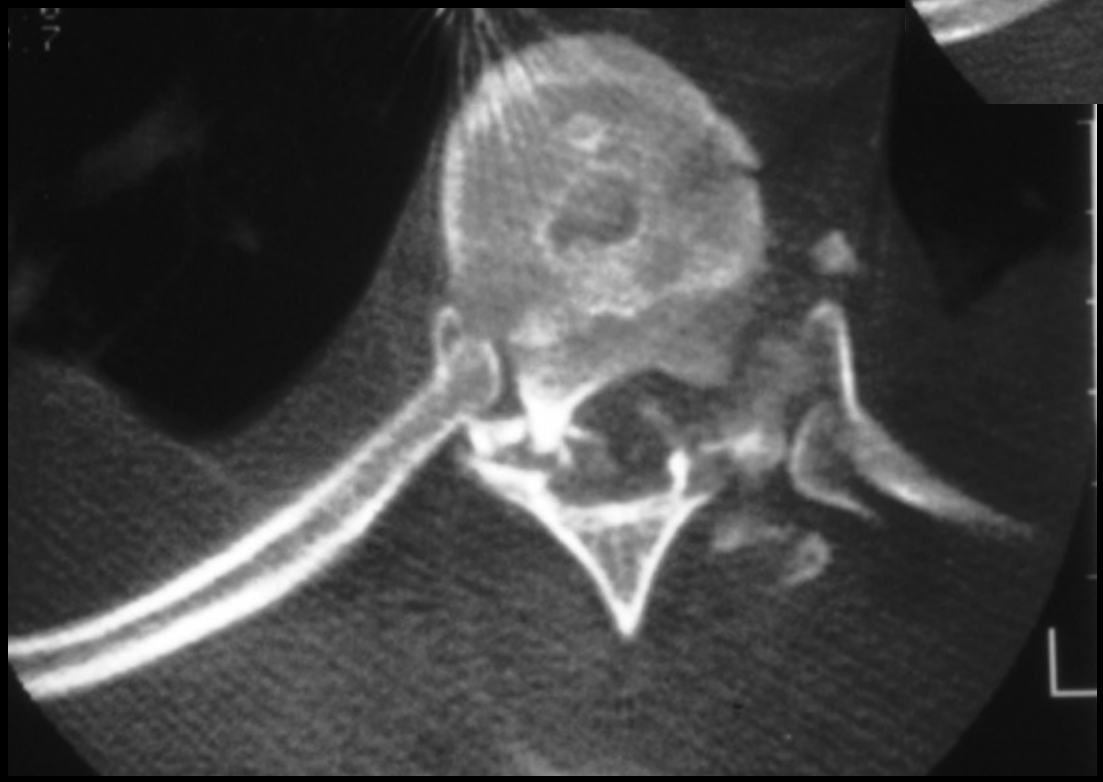
FLEXION-ROTATION INJURY

Anterior bending with twisting at the waist

Rotation of one vertebral body on another

-Burst fracture
-Rib fracture/dislocation
-Visceral injury





-Posterior element fractures
-Severe spinal canal compromise

Flexion / Distraction

- Axis of flexion is moved anteriorly (seatbelt injury)
- Results in distractive force as flexion is applied, posterior > anterior
- Neuro usually preserved (approx. 10% with neuro deficit)
- Chance fracture and variants
  - pure osseous
  - combined osseous and ligamentous
  - pure disc / ligamentous

Lapbelt Injury

FLEXION-DISTRACTION INJURY

Classic Chance Fracture

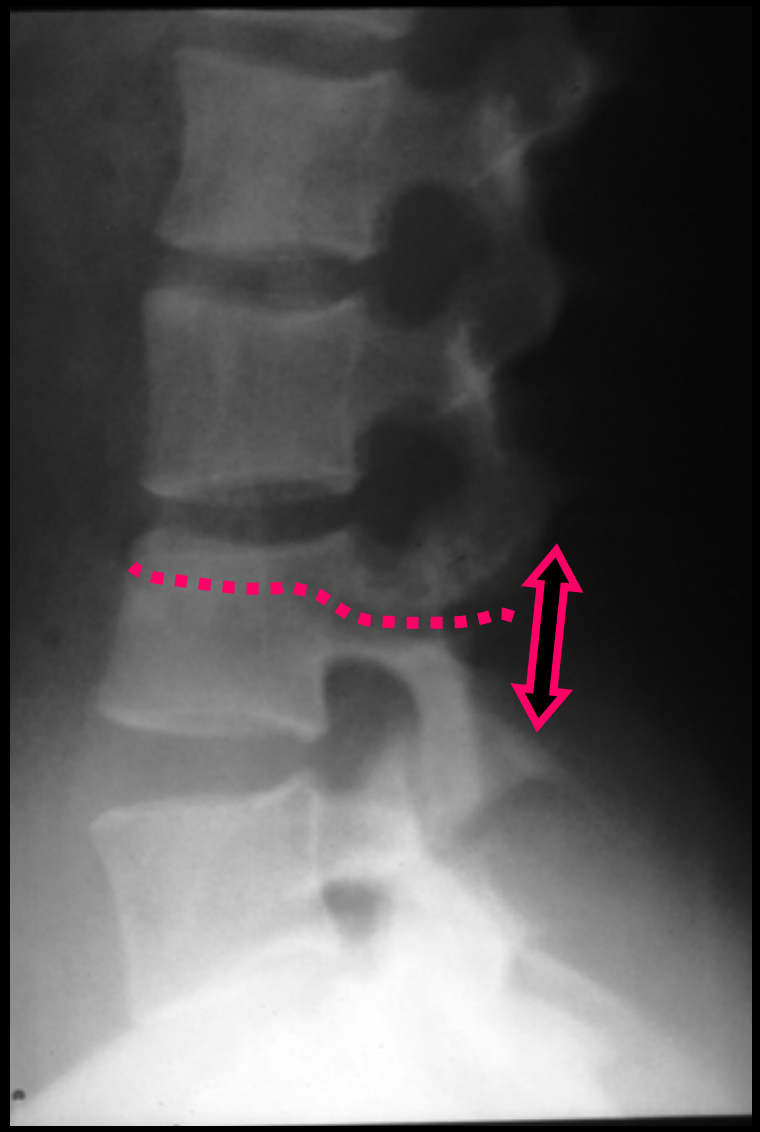
- Pure osseous
  - *Most common (approx. 50%)*
  - *Technically unstable*
  - *But excellent prognosis for healing / long term stability*
- Xray: horizontal split - spinous process, lamina, pedicles, vertebral body with distraction posterior > anterior

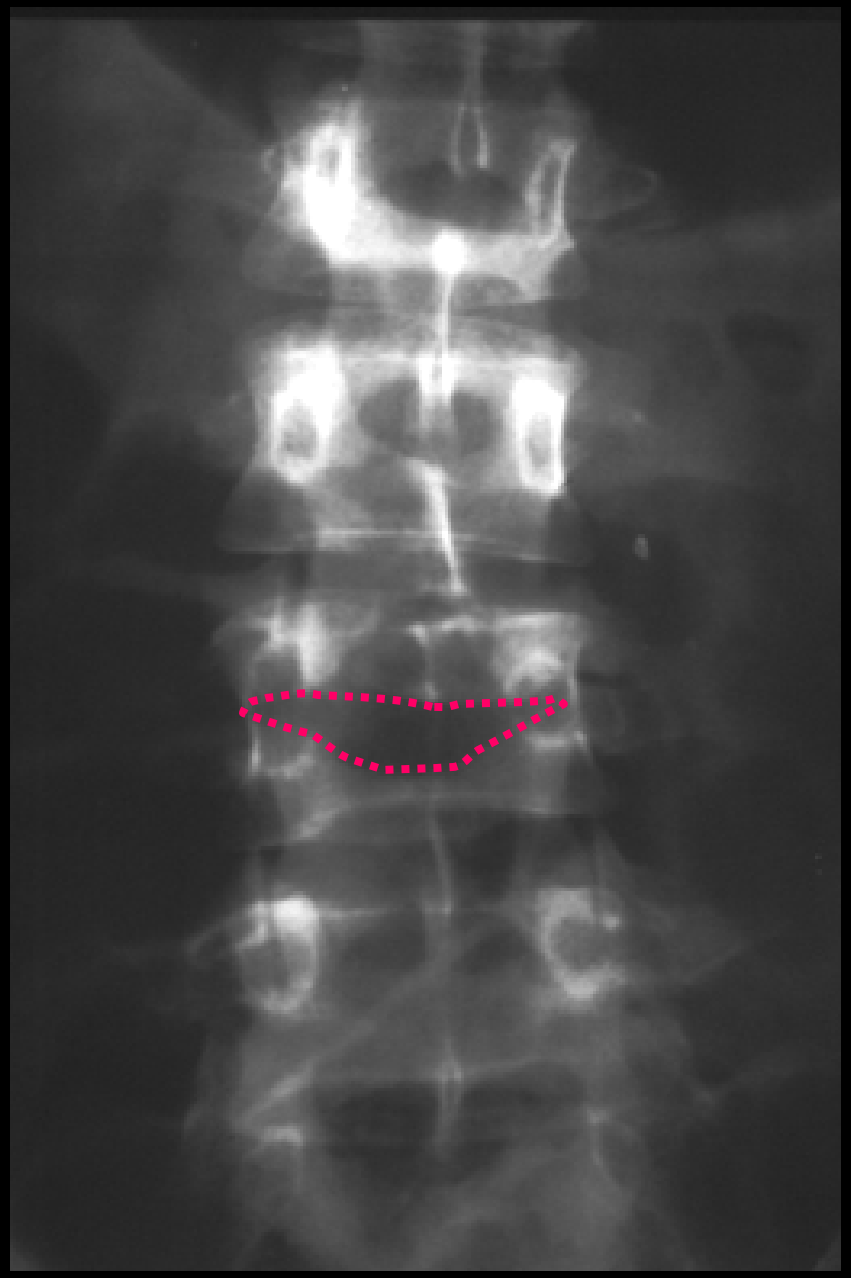
Chance Variants

- Combined osseous / ligamentous
- Pure ligamentous / discal
- Both with worse prognosis for healing / stability than pure osseous

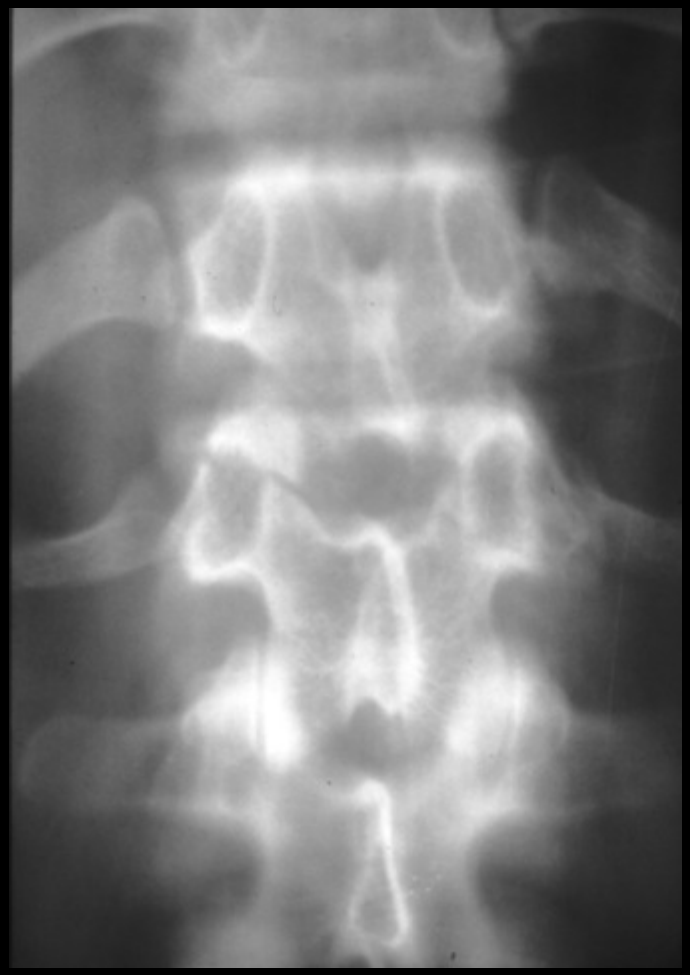
- *Mechanism: abdominal organ injury*

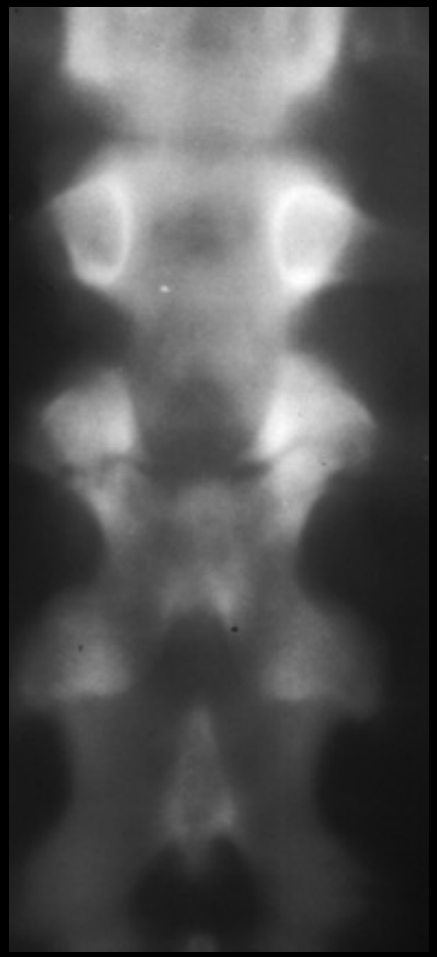
Chance fracture
-pure osseous

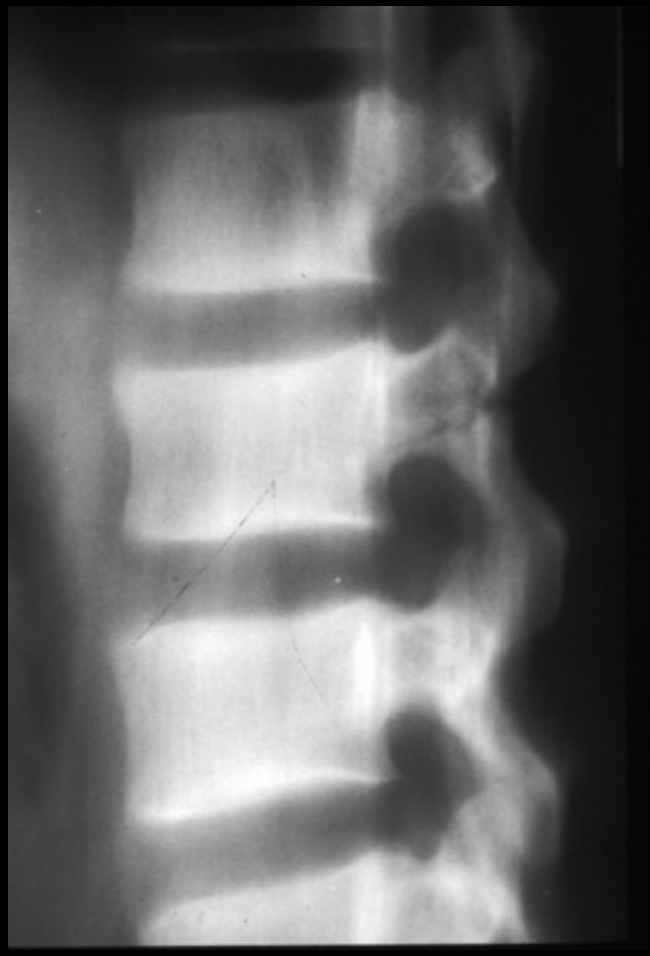




Chance variant
-part osseous
-part ligamentous





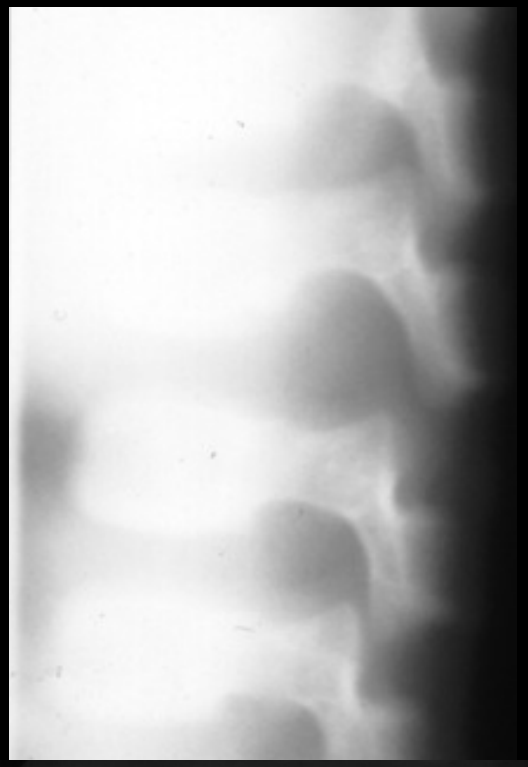


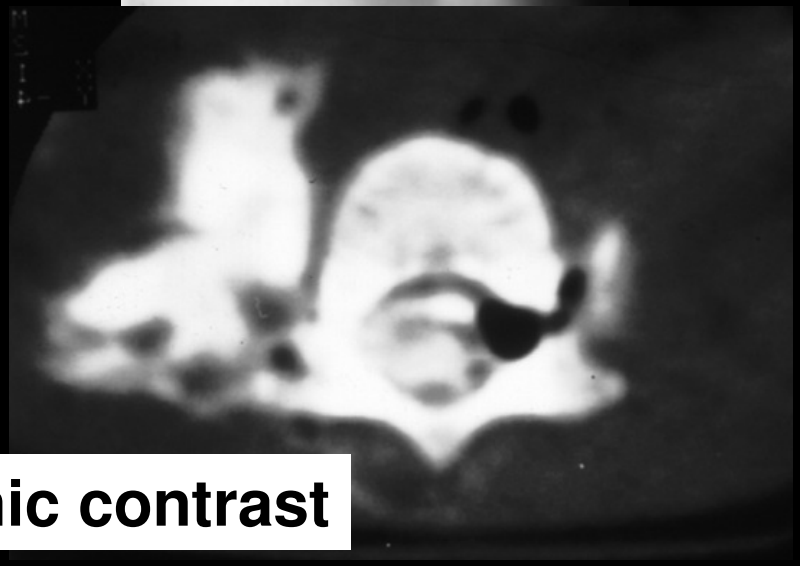
Chance variant
-pure ligamentous
-analogous to bilateral interfacet dislocation (BID) in C-spine

Increased risk of instability compared to osseous type

Pediatric patient

Chance variant
-pure ligamentous
-dural tear



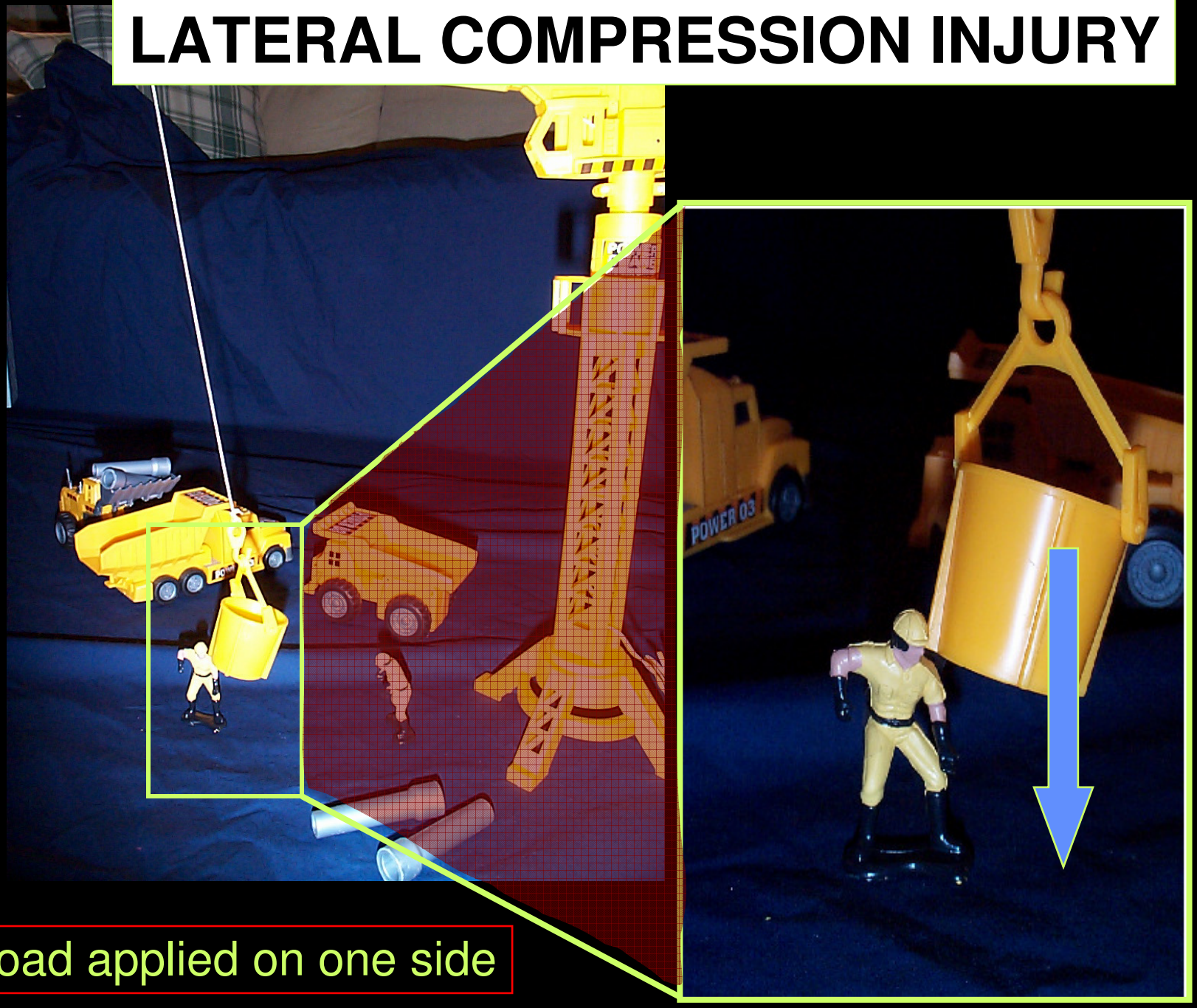


Leakage of myelographic contrast

Lateral Flexion/Compression

- Similar to flexion injury, but force is applied to lateral aspect of vertebra
- Loss of height of lateral vertebral body with acute scoliotic deformity
- Posterior elements often fractured
- Asymmetric burst fracture

LATERAL COMPRESSION INJURY



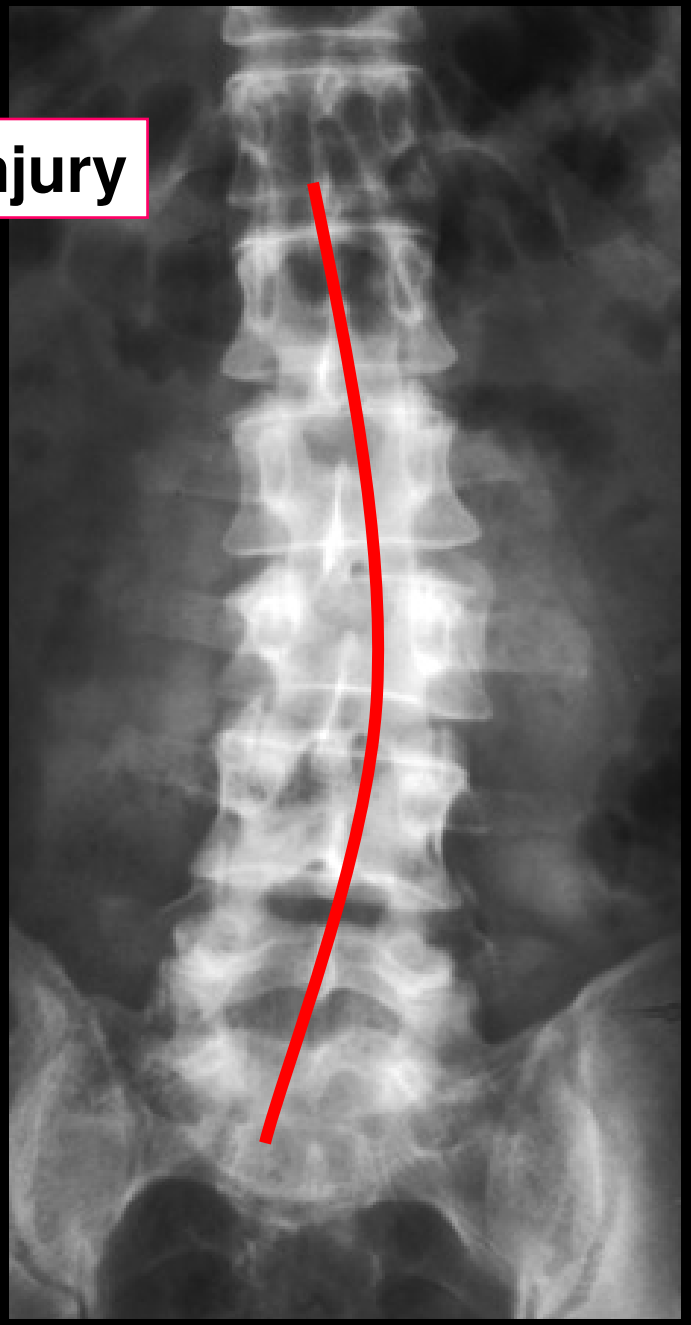
Axial load applied on one side

LATERAL FLEXION INJURY

Struck from side

Lateral flexion/compression injury

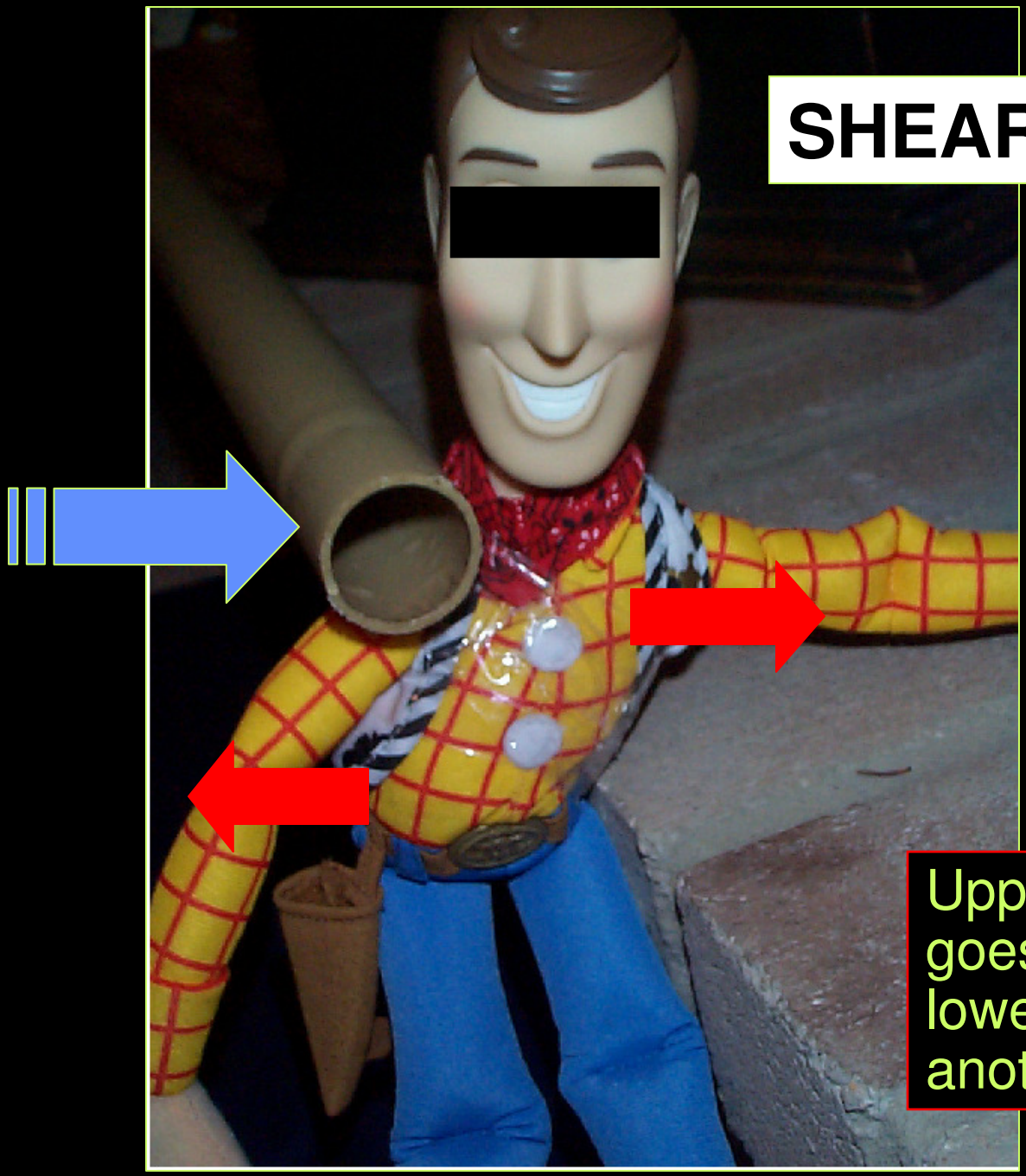
Focal scoliosis
Asymmetric burst fx



Shear Injury

- Results in severe ligamentous disruption
- Listhesis, anterior / posterior or lateral
- Fracture of posterior elements common, especially at facets
- Can result in dislocation
- Severe neurologic compromise common

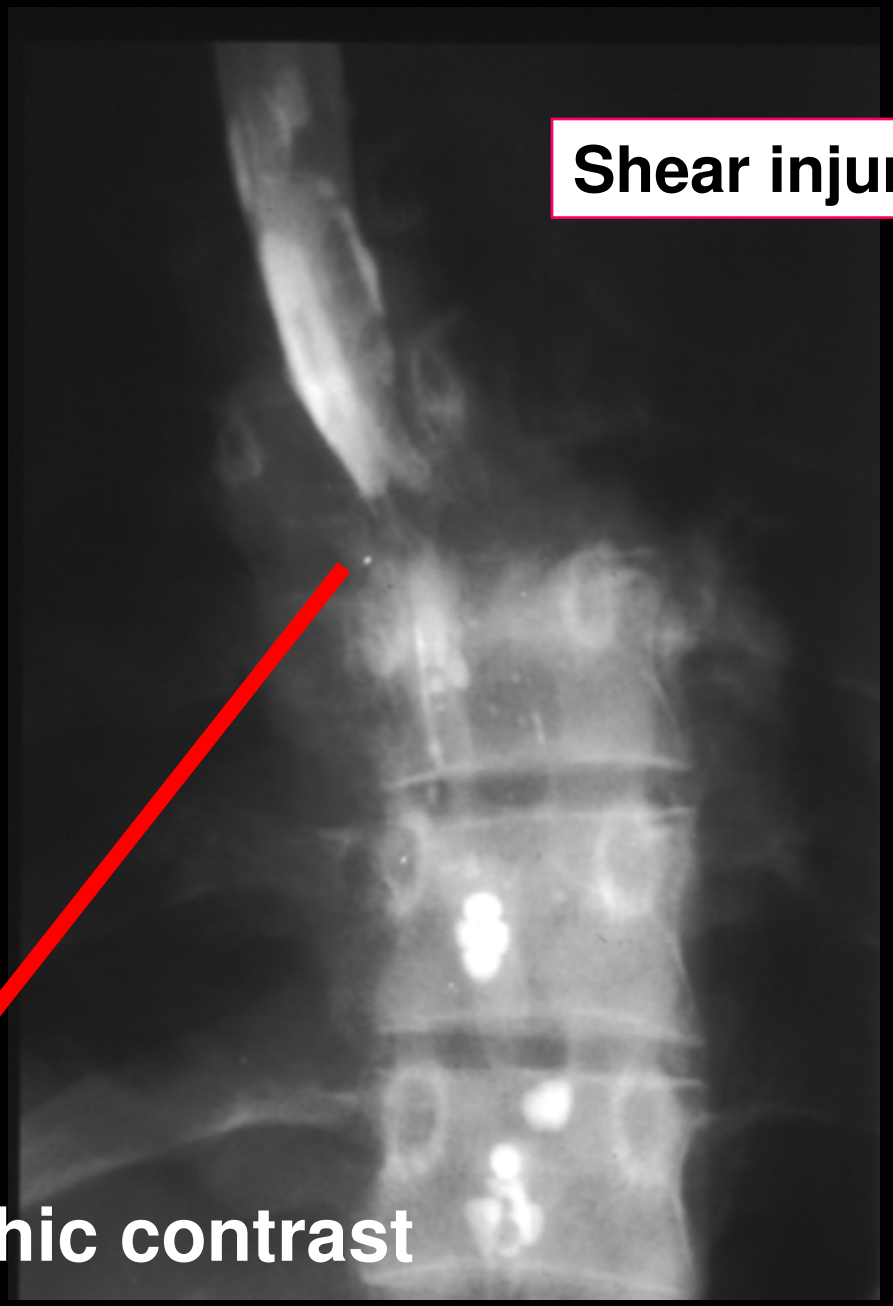
SHEAR INJURY



Upper body goes one way, lower goes another

Shear Injury

Lateral dislocation

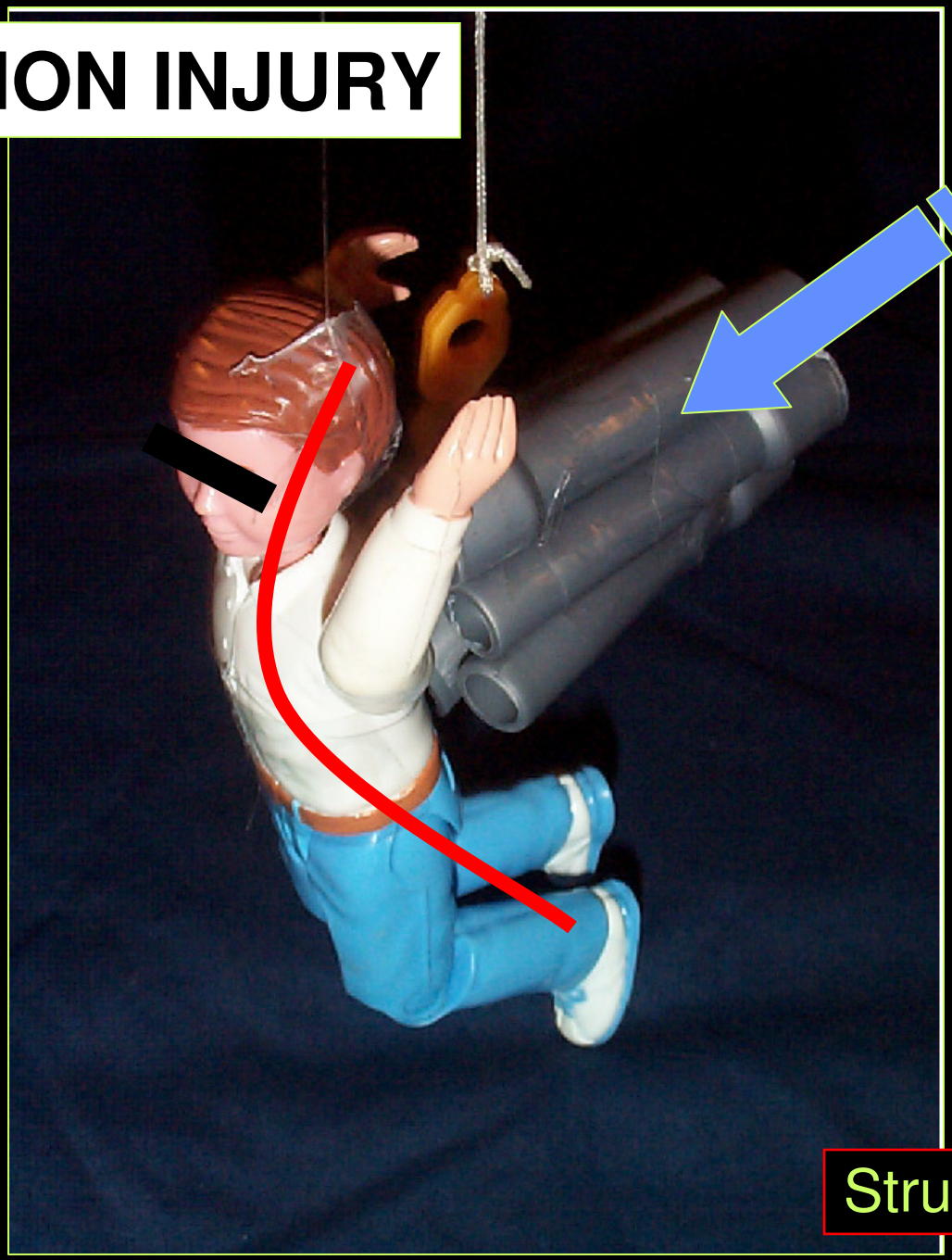


Severe compromise
of spinal canal
- blockage of myelographic contrast

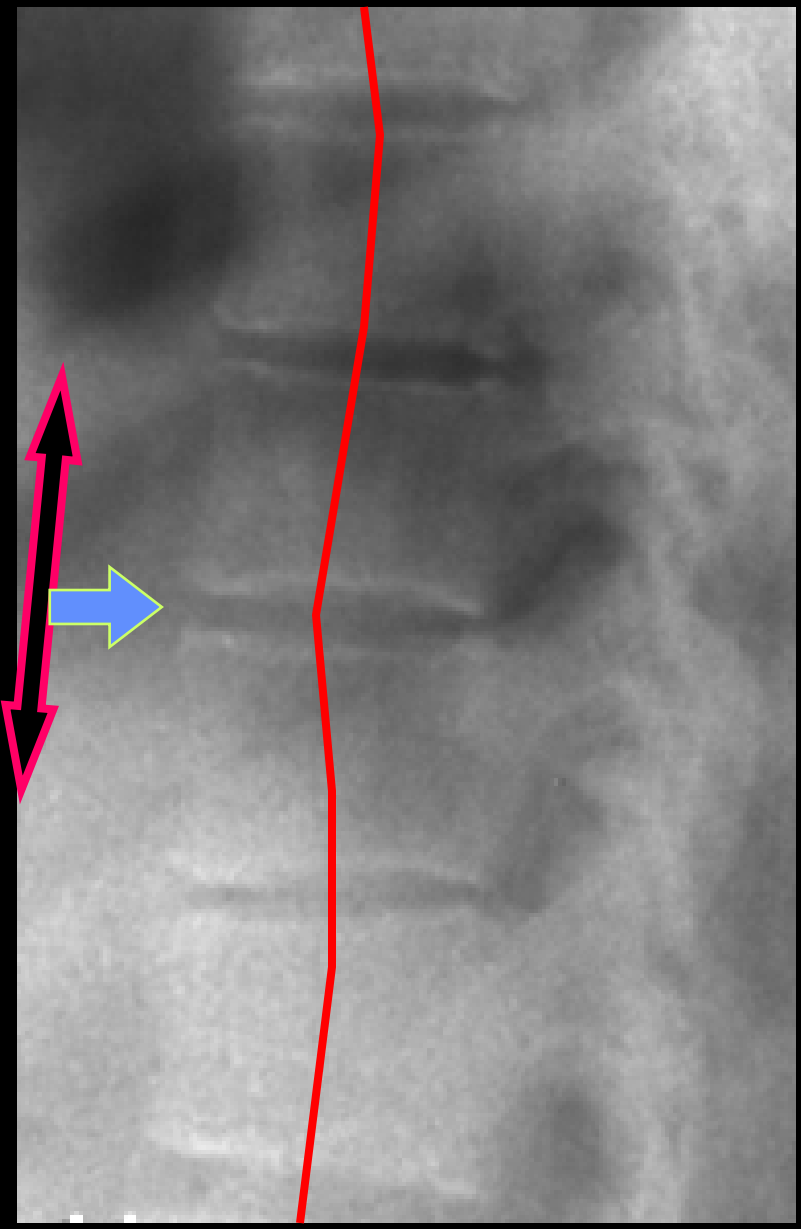
Extension

- Anterior distraction
  - *ALL, anterior annular fibers injured*
  - *avulsion anterior endplate*
- Posterior compression
  - *'crush' fracture*
- Usually neuro intact, but with more severe injury - retrolisthesis, posterior crush
  - *'lumberjack fracture / dislocation'*
- Xray: anterior disc widening - can be subtle - CT for posterior element fx

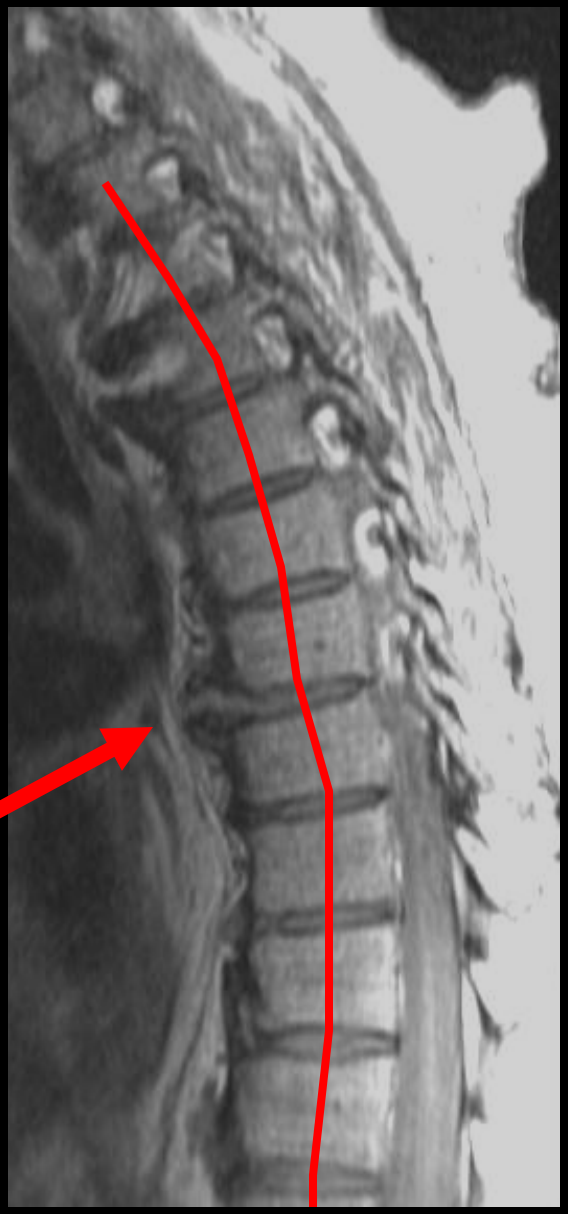
EXTENSION INJURY



Extension injury

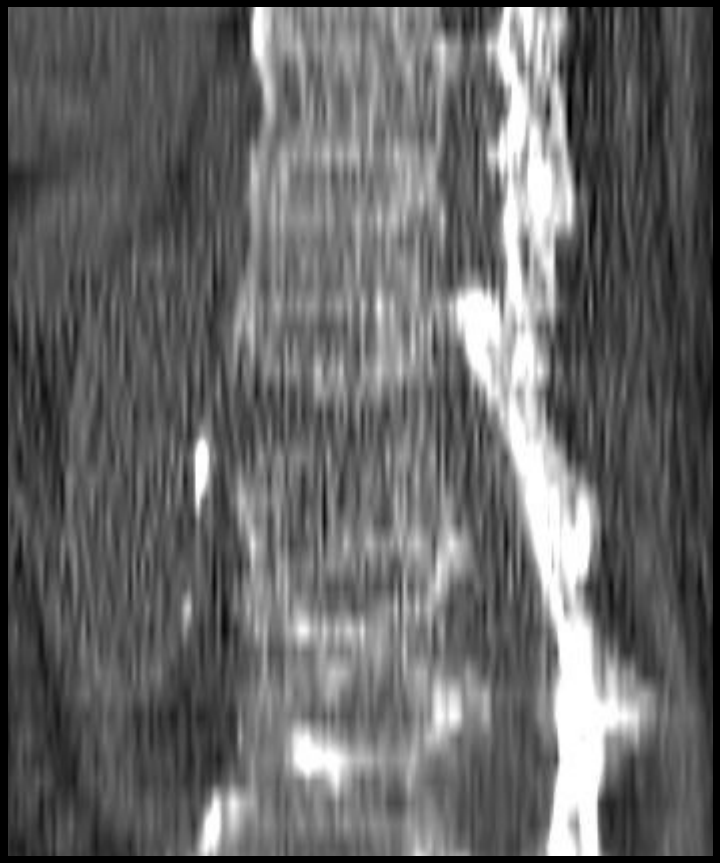


-Anterior disc widening
-Focal lordosis



Extension injury

-Anterior ST edema
-Anterior disc widening /anular disruption
-Focal lordosis

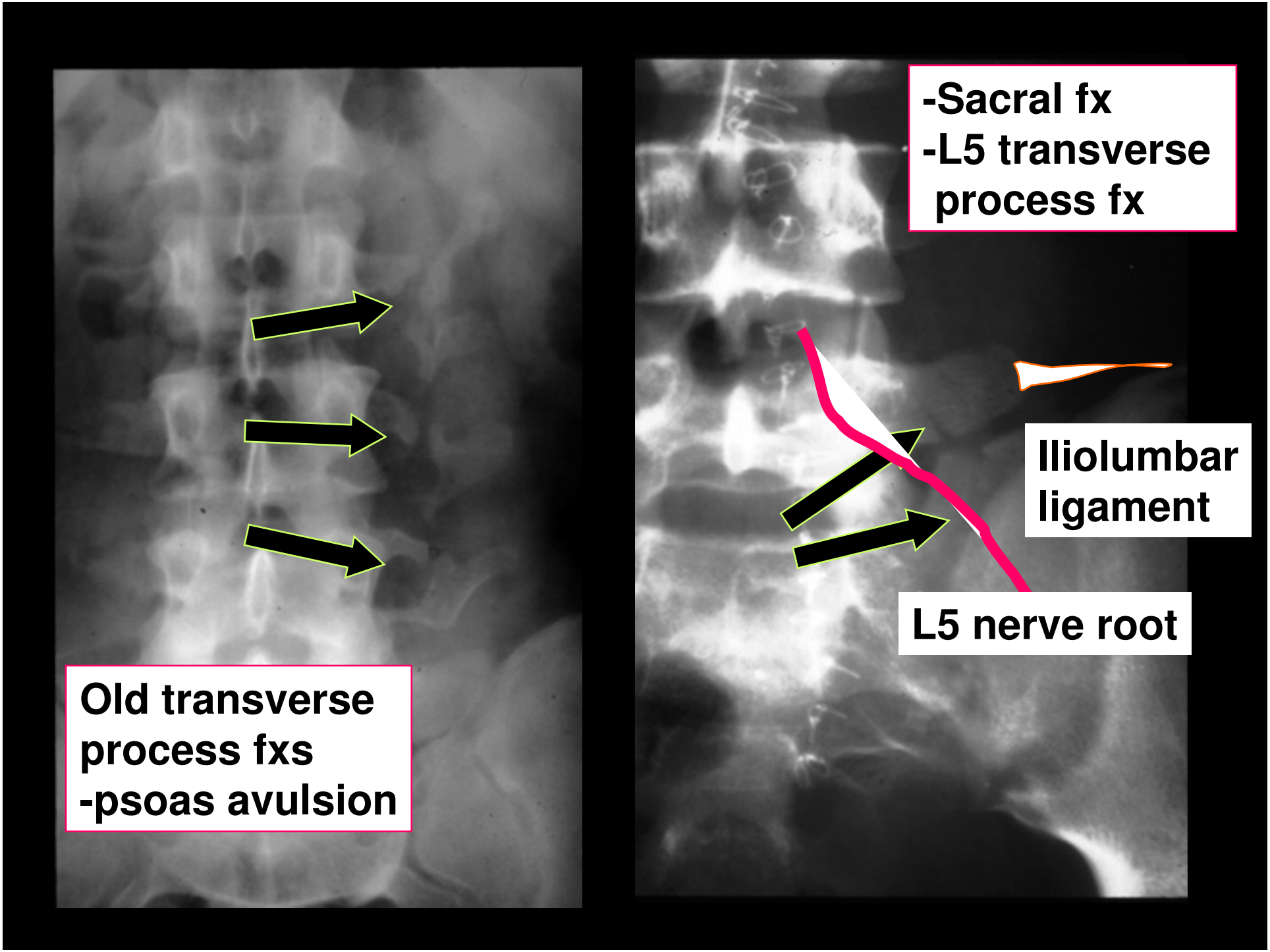


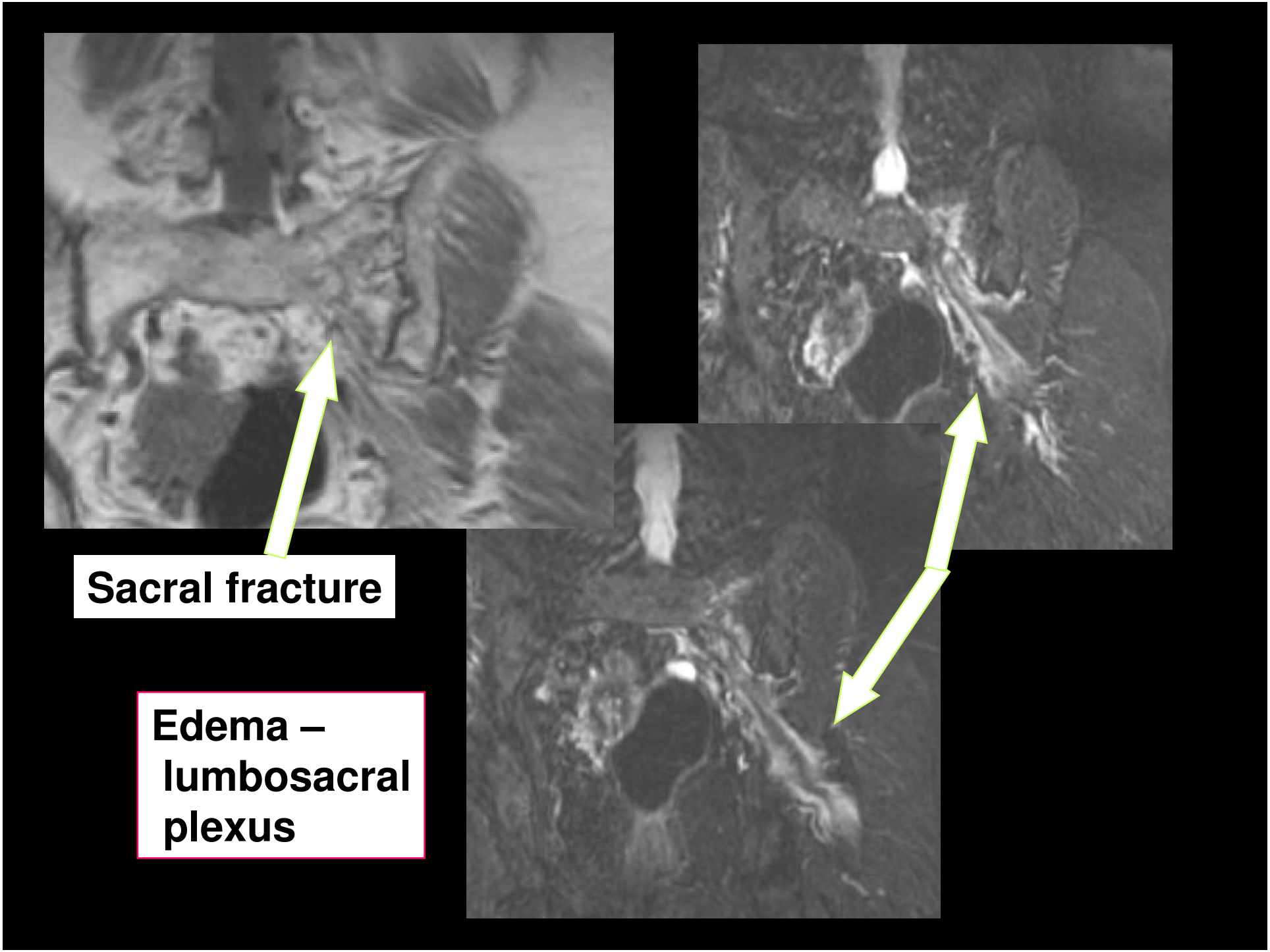
Acute
Extension Injury

-Fracture in elderly osteoporotic patient

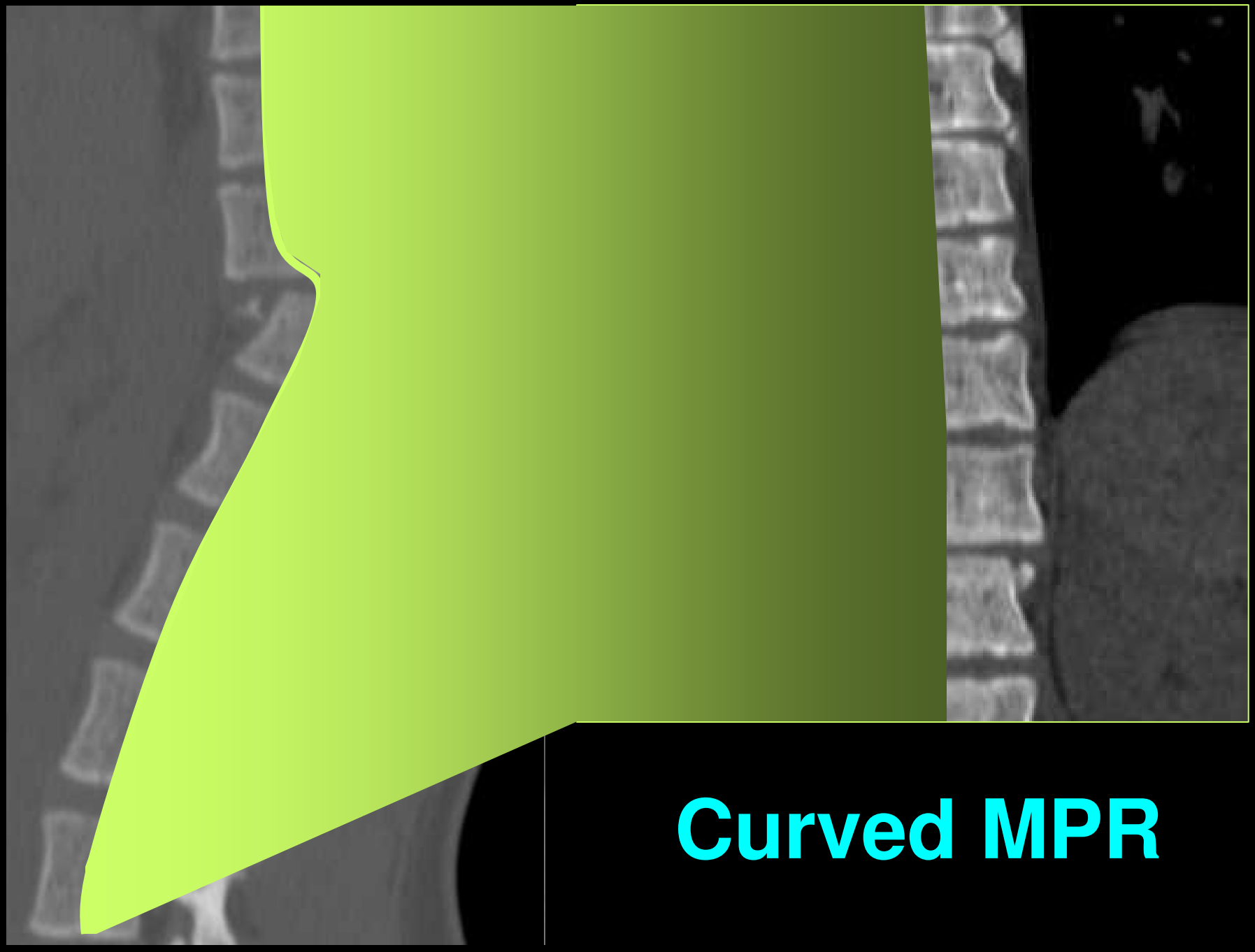
Transverse process fracture

- Often at multiple adjacent levels
- If isolated, stable - usually a result of avulsive stress from psoas / paraspinal muscle contraction
- Can signify more severe injury
  - L5 transverse process fracture associated with sacral fracture
  - nerve root injury (esp L5)


Old transverse process fxs
-psoas avulsion
-Sacral fx
-L5 transverse process fx
Iliolumbar ligament
L5 nerve root


Sacral fracture
Edema – lumbosacral plexus

Multidetector CT


Curved MPR

Diagnosis - T/L trauma

- **Checklist**
  - *cortical discontinuity*
  - *abrupt transition*
  - *spondylolisthesis*
  - *focal kyphosis/lordosis/scoliosis*
  - *facet widening*

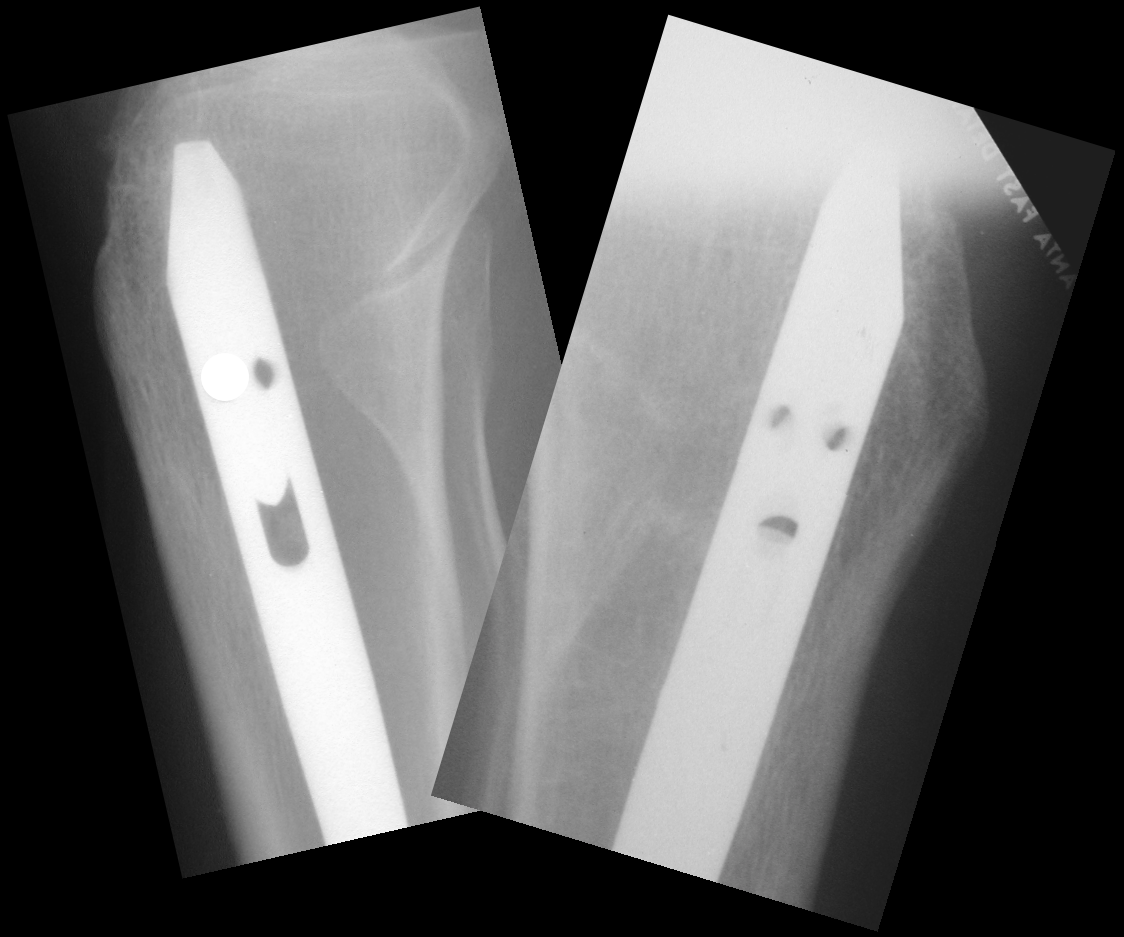
Diagnosis - T/L trauma

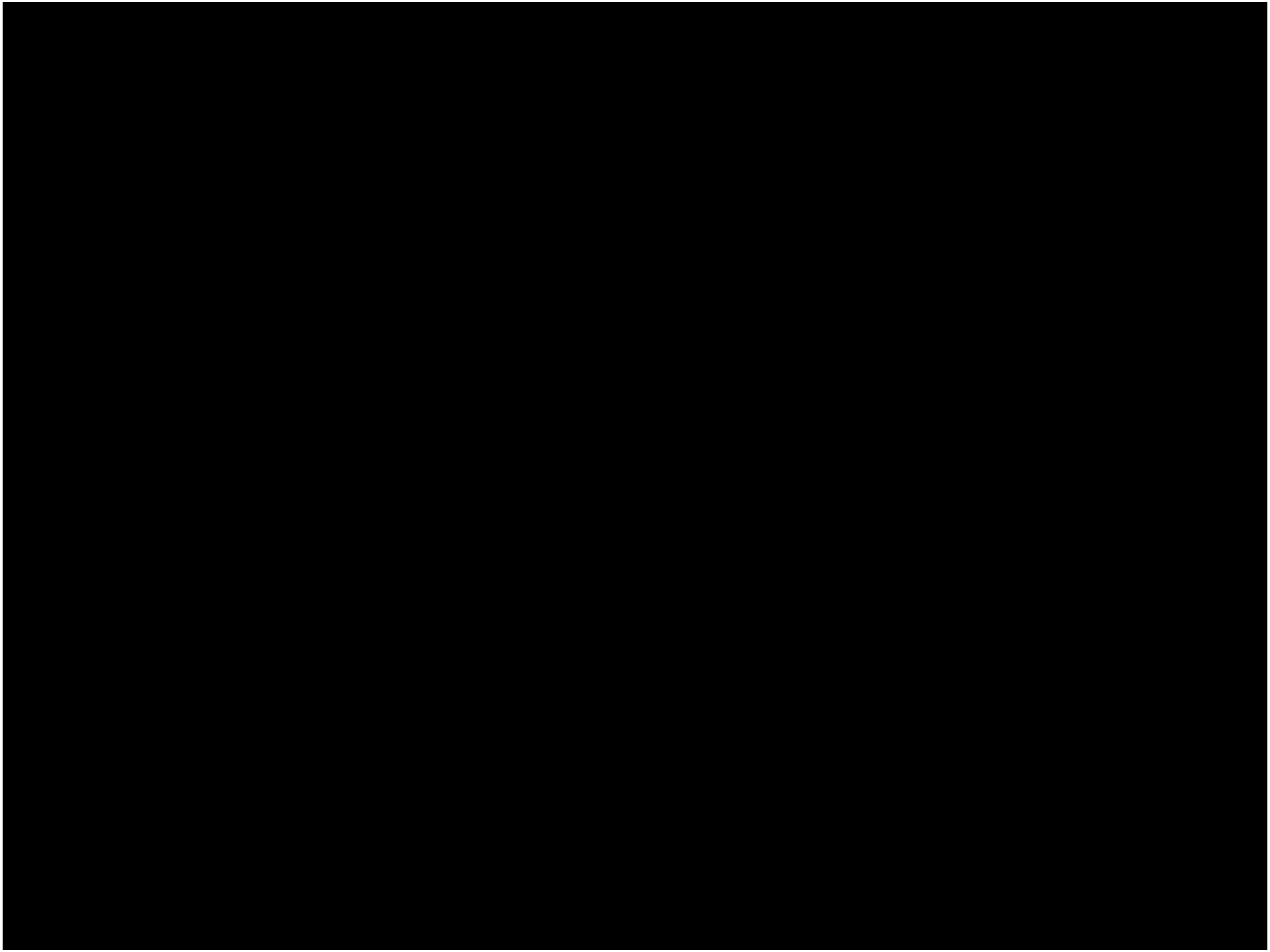
- **Checklist**
  - *disc widening anterior or posterior*
  - *widening of interpedicle distance*
  - *widening / offset spinous processes (unreliable - variation)*
  - *focal soft tissue prominence (T-spine), loss of psoas shadow (L-spine – insensitive)*

Summary

- *Compare with levels above and below - transition of morphology and height should be smooth*
- *Remember mechanisms of injury - knowing patterns of injury can help with detection of subtle fractures, and 'second fracture'*
- *CT any suspicious areas*

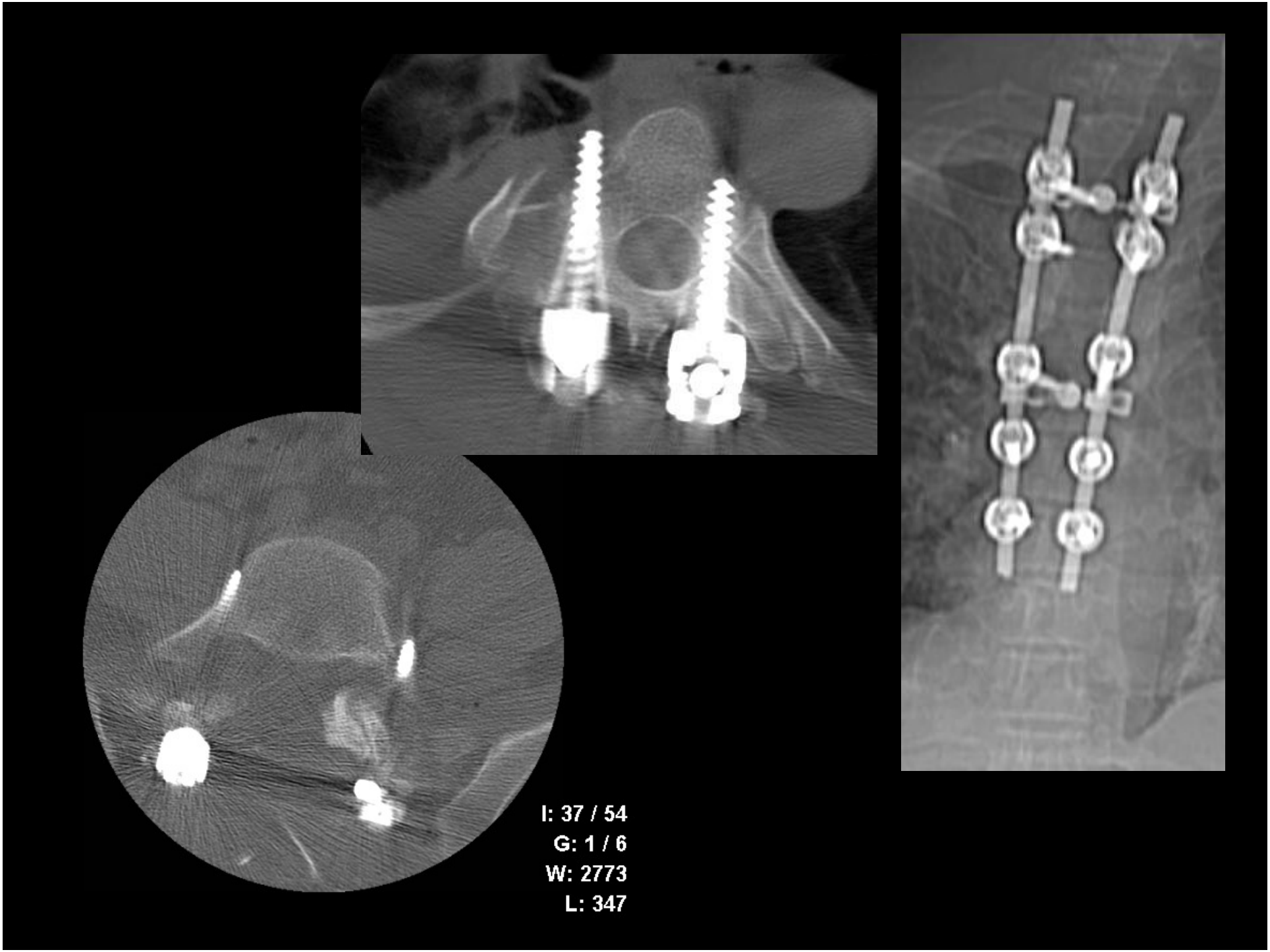
Thank You!





Complications of Fixation

- Placement
  - fracture
  - laminar wires / hooks - neural foramen
  - pedicle screws - canal/lateral soft tissues
  - nerve impingement, pain, abnormal motion/instability, progressive collapse /deformity, penetration of adjacent structures
  - overdistraction/overcompression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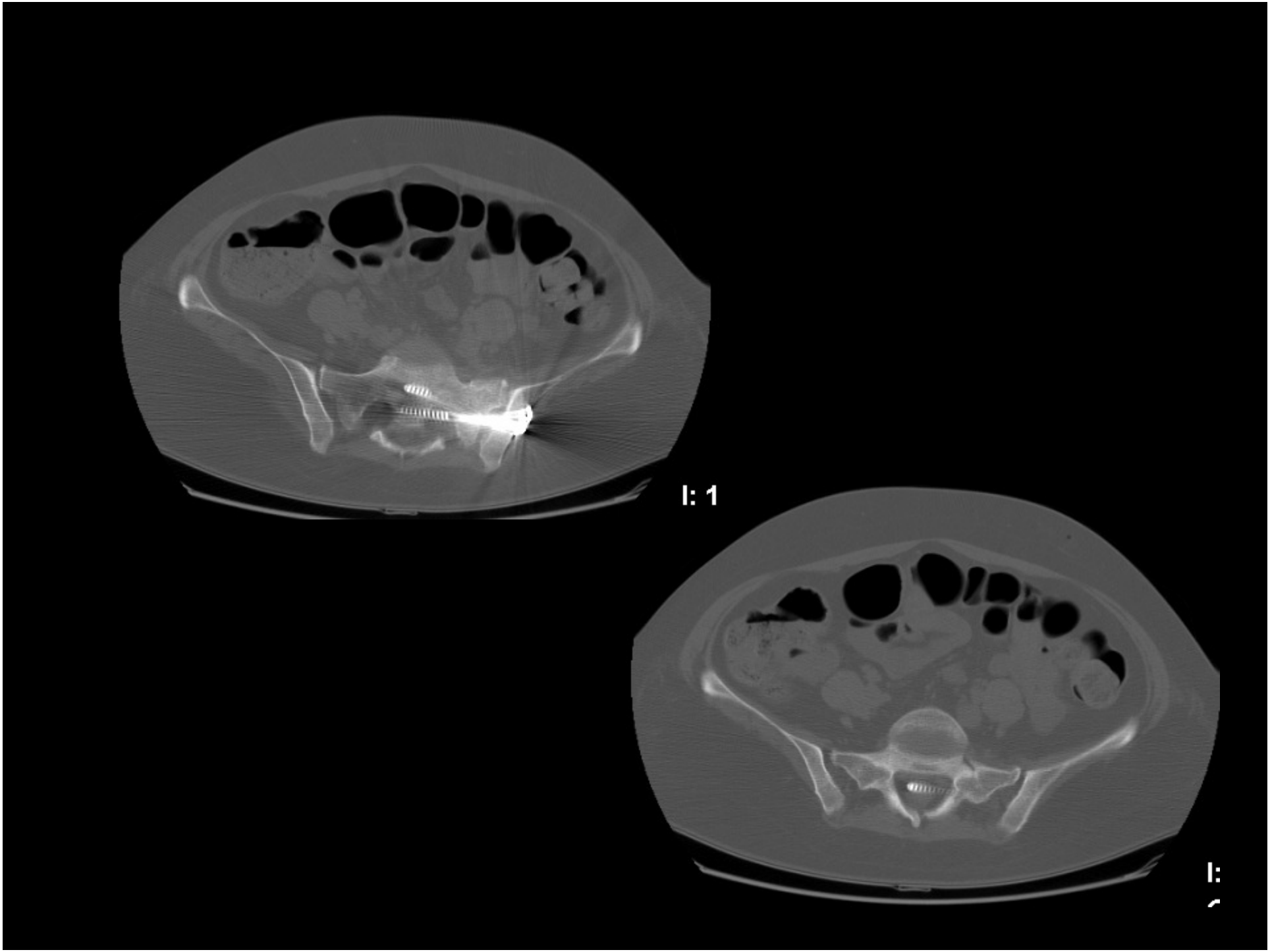
G: 1 / 6
W: 2773
L: 347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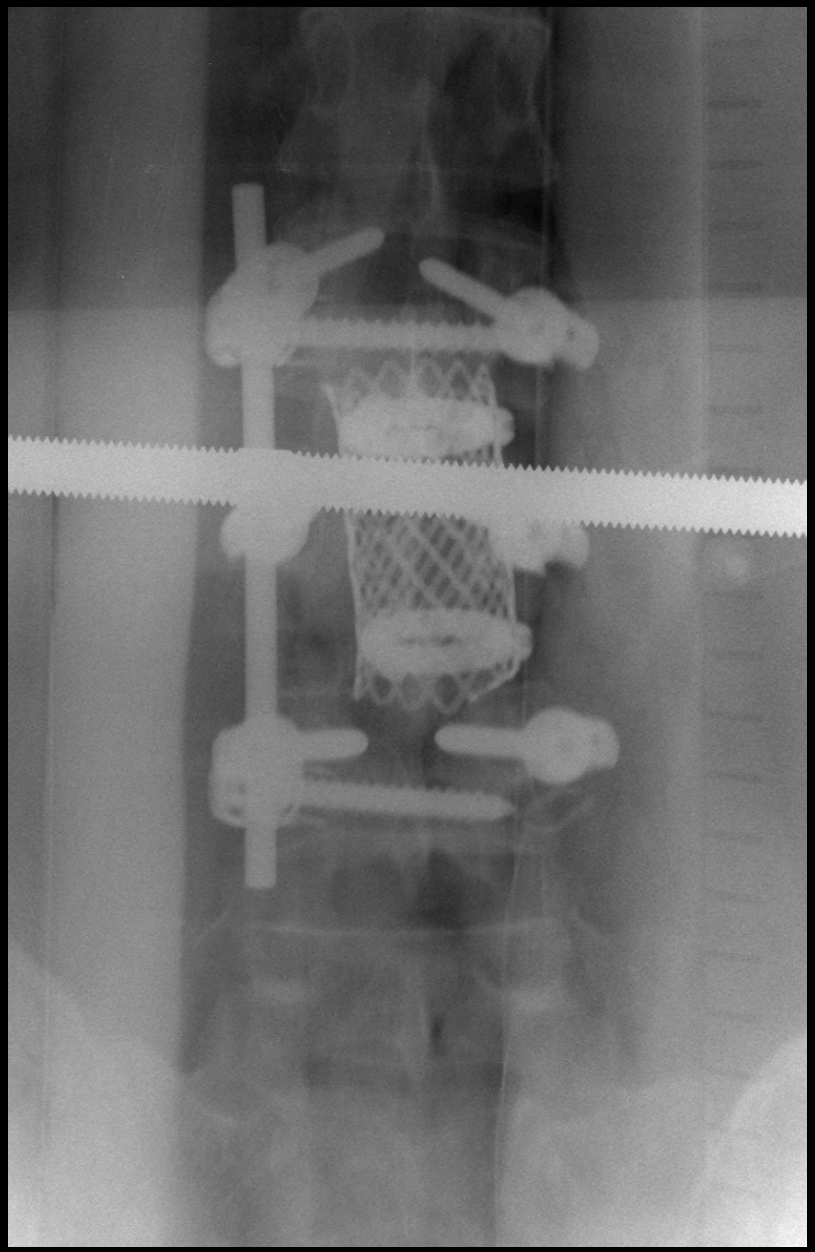
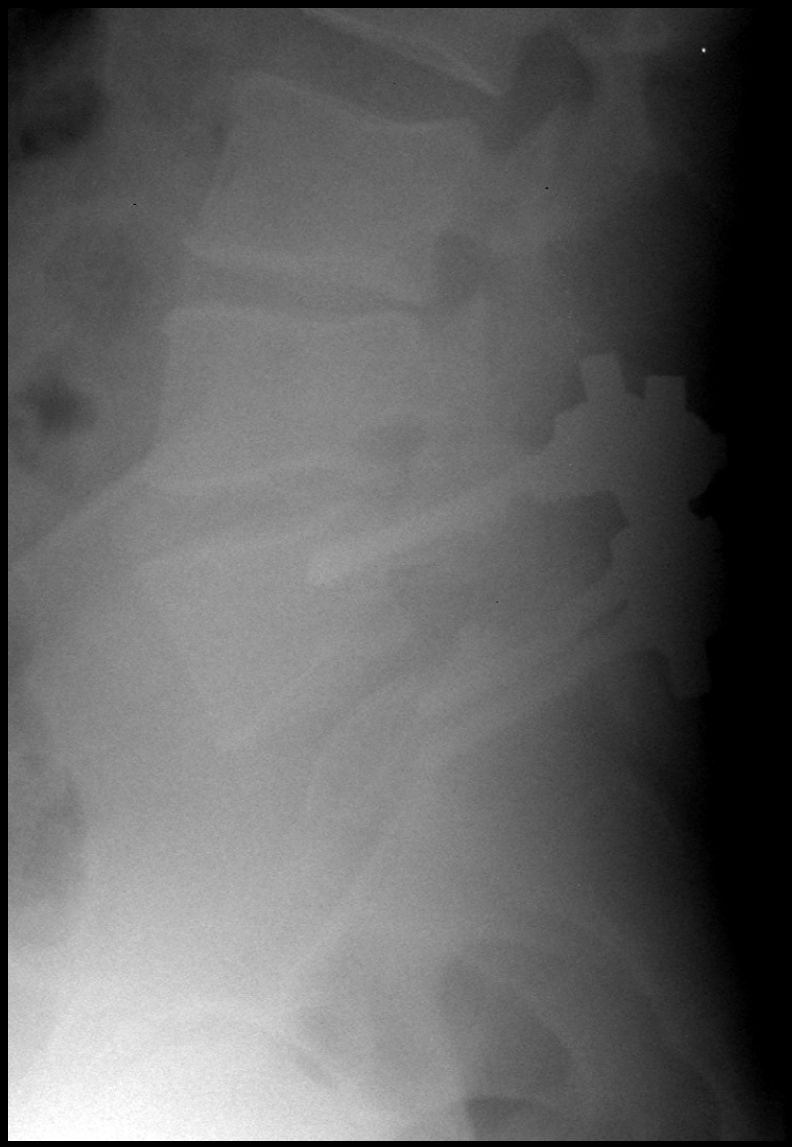
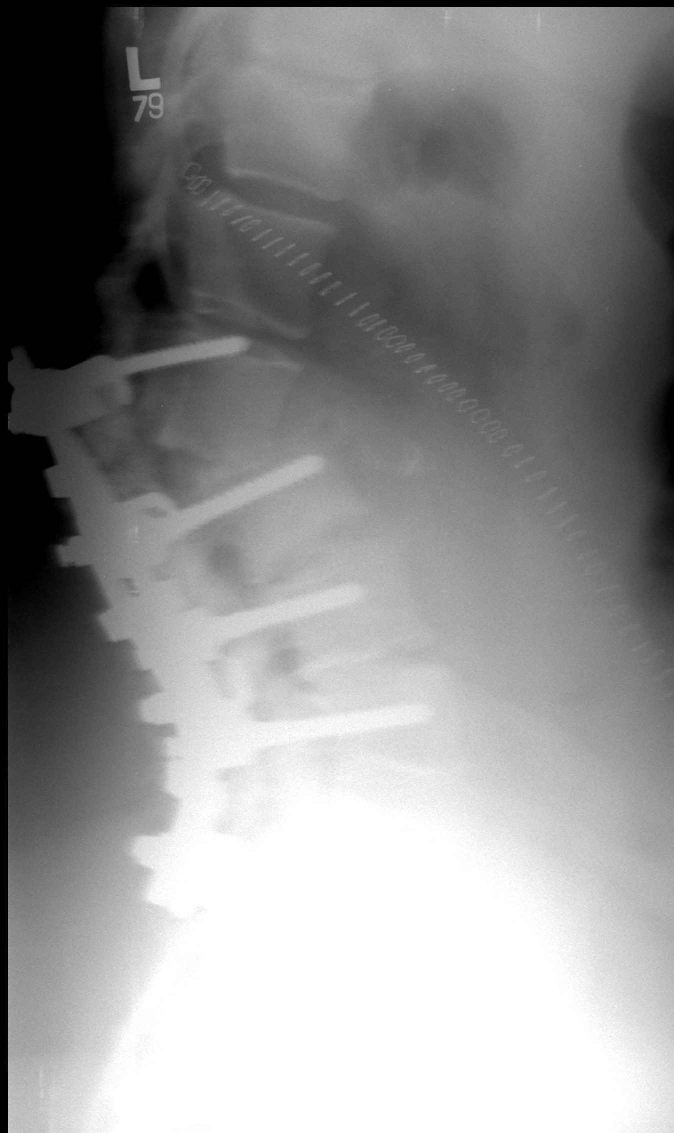
I:



Complications of Fixation

- Loosening / instability
  - rod / screw / hook detachment, fracture
  - inadequate fixation
  - progressive deformity
- Infection - direct implantation
- Disc protrusion with compression
- Dural tear - CSF leak




L
79

Post-operative evaluation

- Hardware placement - canal/NF/disc/soft tissues/vascular
- fractured fixation - can be subtle
  - ANY angulation / offset
- rod / hook separation / displacement
- loosening - lucency around fixation, motion on flexion / extension
- infection - bone destruction, lucency around fixation, neurologic deterioration, soft tissue abscess
- progressive collapse / deformity
- comparison with prior radiographs essential - esp post-op