Imaging Spine Injuries 1

Chad D. Warshel, DC, MS, DACBR

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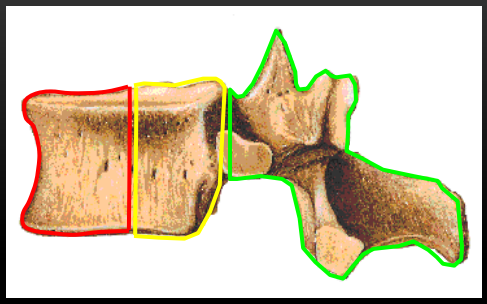
Core Concepts in Spinal Trauma

- Mechanism of Injury
- Instability
  - The injury creates the potential for additional biomechanical or neurological damage
  - Some bony injuries are unstable, e.g. burst fractures
  - Ligamentous injuries
    - Angular kyphotic defects on neutral laterals are concerning
    - Translational or angular instability
      - 3.5mm CS 4.5mm LS
      - 11 degrees greater than adjacent segment CS
      - 15 degrees L1-L4, 20 degrees L4/L5, 25 degrees L5/S1

2

3 Column Theory of Denis

- 3 column theory of Denis
  - Denis F. The three-column spine and its significance in the classification of acute thoracolumbar spine injuries. Spine. 1983;8:817-831.
- Anterior Column
  - Anterior 2/3 of vertebral body
- Middle Column
  - Posterior 1/3 of vertebral body
- Posterior Column
  - Posterior elements



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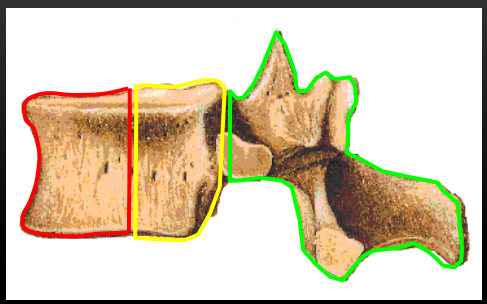
3 Column Theory of Denis

- Fracture is stable if it is one column
  - E.g compression Fx
- 2 or more column involvement is unstable
- The middle column cannot fracture by itself



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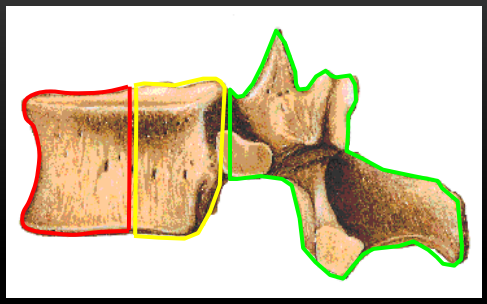
3 Column Theory of Denis

- Caveats
  - As written, for the TL spine, but is also used in the lower CSpine
  - Traumatic posterior limbus bone is an exception to the middle column rule
  - Anterior column involvement only, but greater than 50% height loss is probably an unstable fracture, e.g. burst or Chance



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Cervical Spine Injuries

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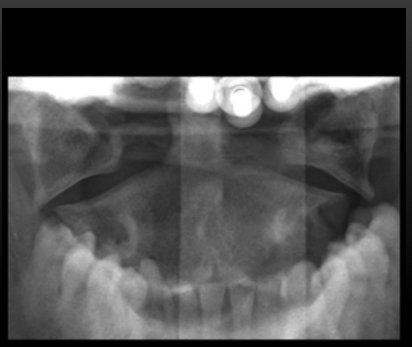
C1: Jefferson Fracture

- C1 burst fracture
- Can be neurologically intact
- Mechanism:
  - Axial compression
- Stability:
  - Unstable
- Radiographic finding:
  - Offset of lateral atlantoaxial alignment
  - Wide paraodontoid space(s)
- Clinical presentation:
  - + Rust sign



Case courtesy of Dr Andrew Dixon, Radiopaedia.org, rID: 9601

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Transverse ligament rupture

- Increased atlantodental interval (ADI)
- Mechanism:
  - Hyperflexion
- Stability:
  - Unstable
  - *Guillotine effect*
  - Steel's rule of 1/3rds
- Limited DDx list for increased ADI
  There are > 26 in total!
  - Transverse ligament rupture
  - Jefferson Fx
  - Down syndrome
  - Rheumatoid arthritis
    - All inflammatory arthropathies have the potential

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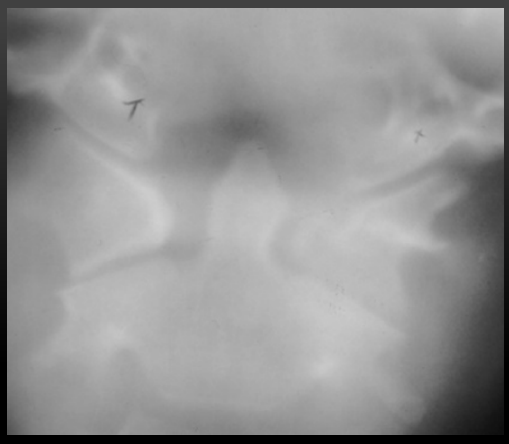
Atlantoaxial Rotary Fixation

- Mechanism
  - Post-traumatic
  - Post-infectious (mainly children, termed Grisel syndrome)
- Stability: unstable
- Clinical presentation
  - Acute torticollis
- Imaging: asymmetric paraodontoid spaces



Source: Nic Poirier, DC, DACBR

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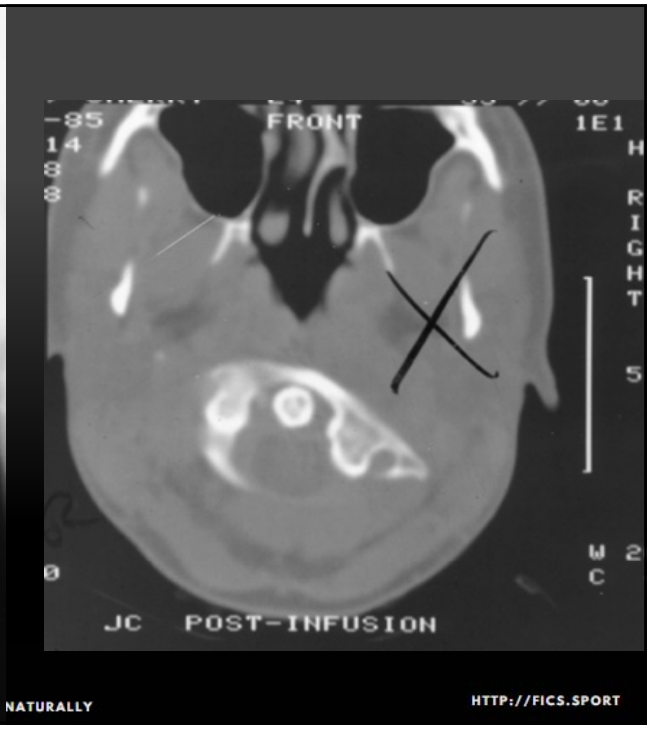

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C2: Hangman Fracture

- Mechanism:
  - Hyperextension
- Stability
  - Unstable
  - Patients often neurologically intact at presentation
- 25% have other hyperextension injuries
  - Teardrop Fx

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Teardrop fracture

- Mechanism:
  - C2-C4 hyperextension
    - ALL rupture
  - C3-C7 hyperflexion
    - Complete posterior ligamentous rupture
- Stability:
  - Unstable
  - Flexion worse than extension

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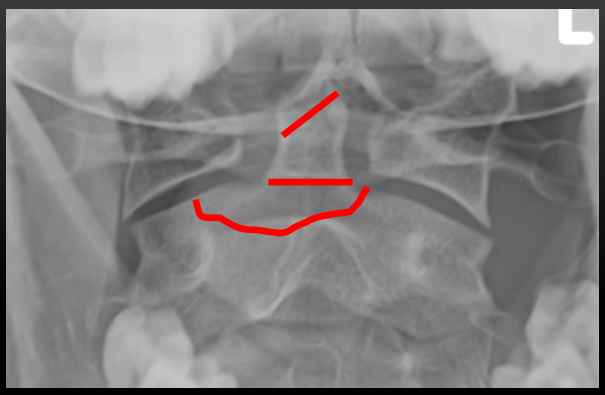
Odontoid (Dens) Fractures

- 3 types 1, 2, 3
- Mechanism:
  - 1: distraction (avulsion)
  - 2: flex/ext, osteoporosis
  - 3: flex/ext
- Stability
  - 1: stable, variable
  - 2: unstable
  - 3: variable
- Get a CT if there is any question



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Odontoid fractures: type 2

- Most common
- Mechanism:
  - M/C hyperextension
  - Often in older individuals with some degree of osteopenia
- Stability:
  - Unstable
  - *Guillotine Effect*
- Non-union
- DDx: os odontoideum

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Odontoid fractures: type 3

- Less common
- Mechanism:
  - Hyperflexion or hyperextension
- Stability:
  - (un)stable**
- Intra-articular

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Cervical Compression Fracture

- Mechanism:
  - Compressive hyperflexion
- Stability:
  - Stable
- No neurologic deficit
- Uncomplicated healing

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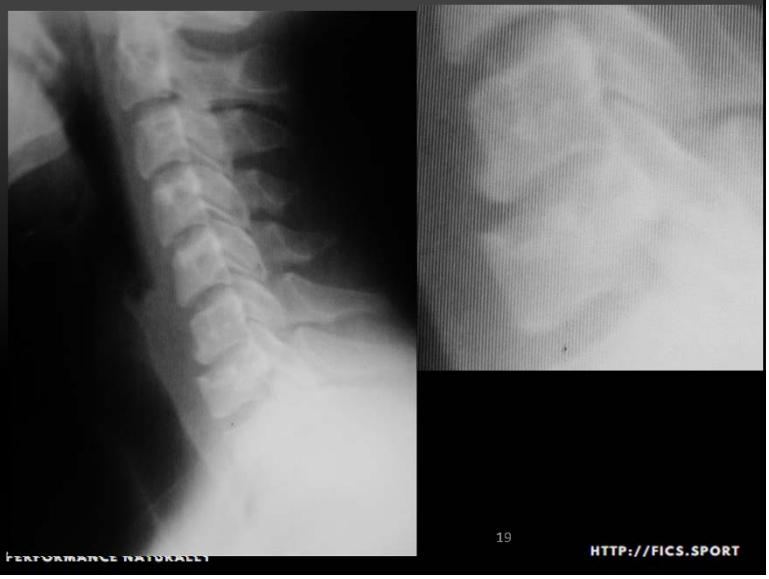
Cervical Burst Fracture

- Mechanism:
  - Axial compression w or w/o flexion
- Stability:
  - Unstable
  - 85% neurologic deficit



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Cervical Burst Fracture

- Radiographic findings
  - Loss of anterior and posterior body height
  - Retropulsion
  - Angular kyphosis, spinous fanning, facet dislocation

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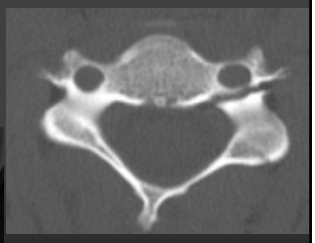
Articular Pillar Fracture

- C4-C7, usually unilateral
- Mechanism:
  - Hyperextension w/wo lateral flexion
- Stability: stable
- Findings:
  - Loss of pillar height
- Frequent associated Fx
  - Pedicle, lamina
- Best seen with CT
- DDx: asymmetric pillars



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Clay Shoveler Fracture

- C6-T2
- Mechanism
  - Flexion avulsion
    - Shoveling heavy wet snow
  - Direct impact
- Stability:
  - Stable
  - Heals non-union
- Findings:
  - Spinous displaces inferiorly
  - "Double spinous" sign on AP view
- DDx:
  - Nuchal bone

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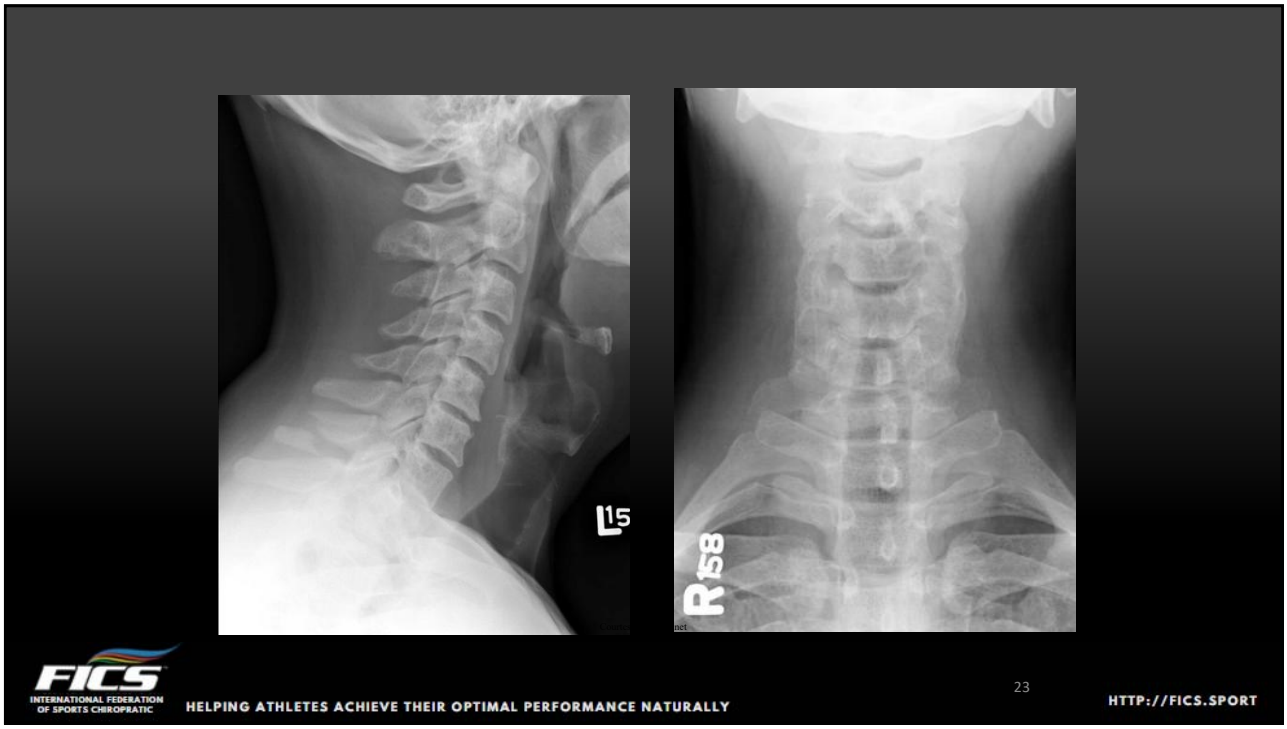
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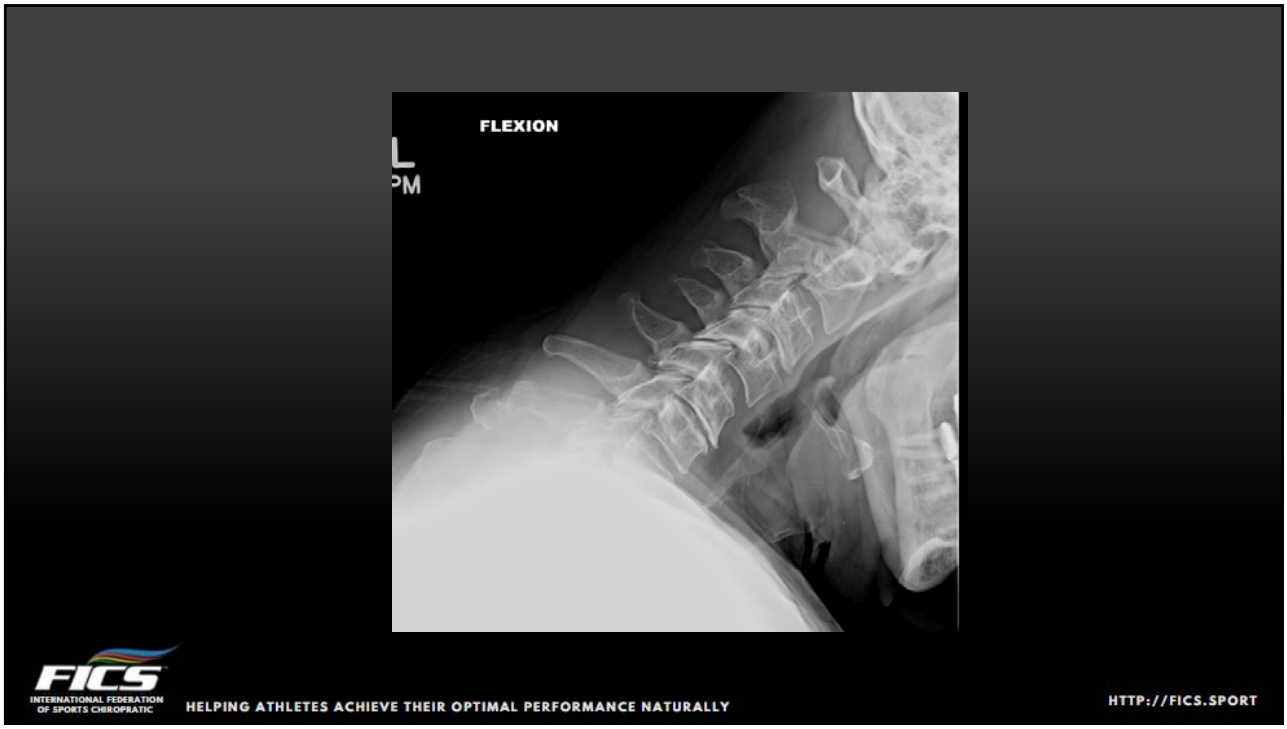
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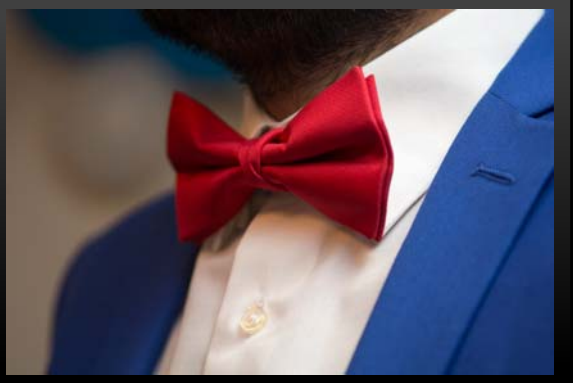
Unilateral facet dislocation

- Mechanism:
  - Flexion with rotation
- Stability:
  - Stable until reduced
  - Requires fusion post reduction
  - Rupture of interspinous and facet capsular ligaments



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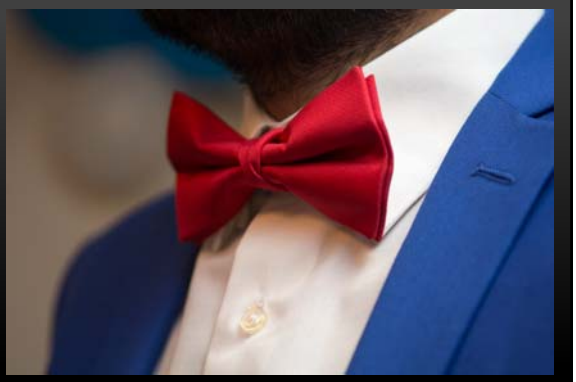
Unilateral facet dislocation

- Findings:
  - Bow tie sign (x-ray)
  - Focal rotation on AP
  - < 50% anterolisthesis
  - Articular process fractures are common
- Neurologic deficit in 25% of patients



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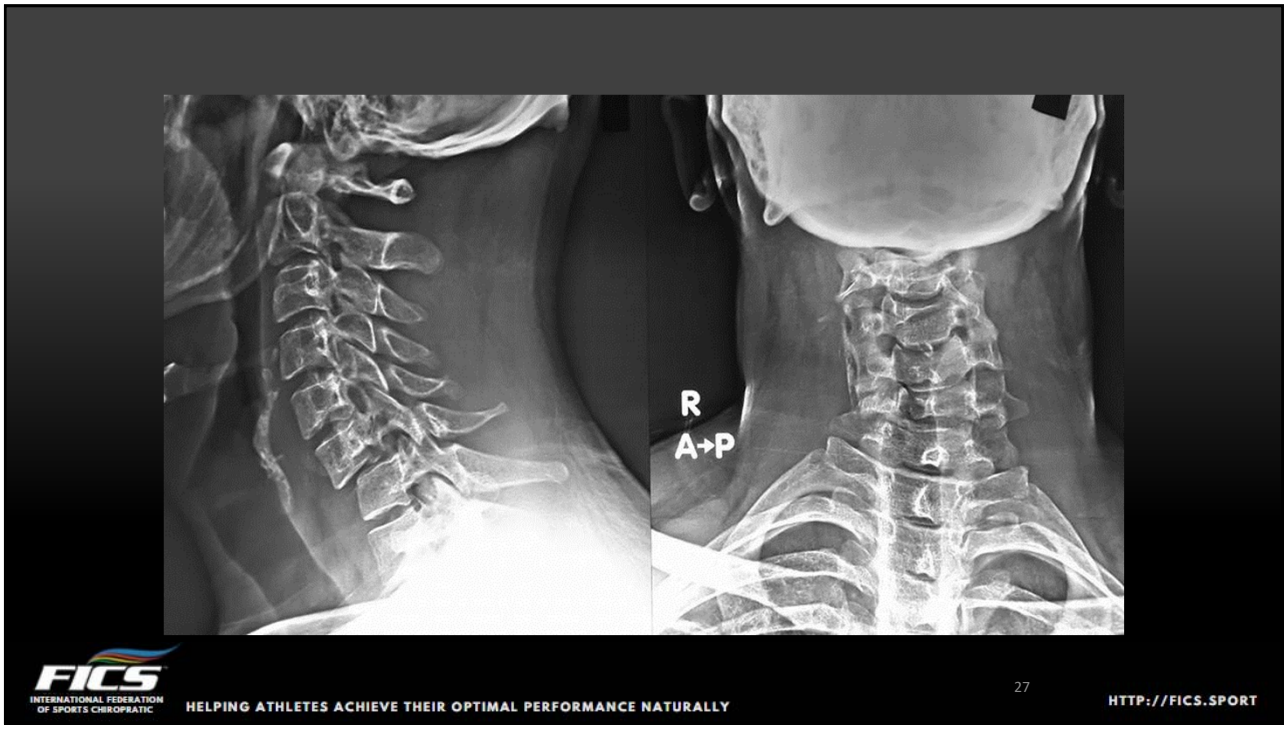

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Bilateral facet joint dislocation

- Mechanism
  - Hyperflexion
- Stability:
  - Unstable
    - Interspinous ligament
    - Ligamentum flavum
    - Facet capsules
    - PLL
    - 50% have disc herniation

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Bilateral facet joint dislocation

- Findings:
  - > 50% anterolisthesis
  - Widened interspinous space
  - NO bow tie sign
- Neurologic deficit in 75% of patients

Case courtesy of Sandra Norton

Thoracolumbar Spine Injuries

Classification of Disc Pathology

- Originally published by ASNR in 2001
- Redesigned in 2014
  - Lumbar Disc Nomenclature: Version 2.0
  - The Spine Journal 14 (2014) 2525-2545
- Disc herniations are categorized as a degenerative disc condition, but can also be traumatically induced

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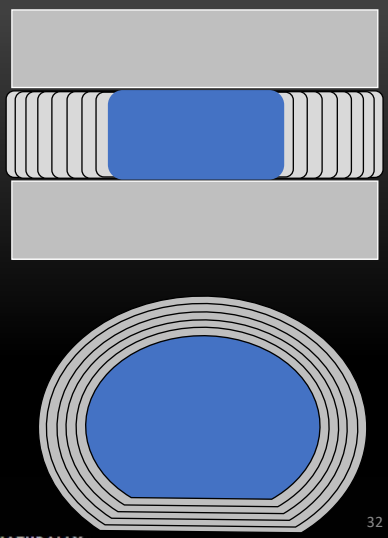
Annular Fissures

- aka
  - Annular tears
  - High intensity zones (HIZ)
- DOES NOT necessarily represent a traumatic etiology
- M/C in the posterior disc
- 3 types
  - Transverse
  - Concentric
  - Radial ****
    - Only radial are important



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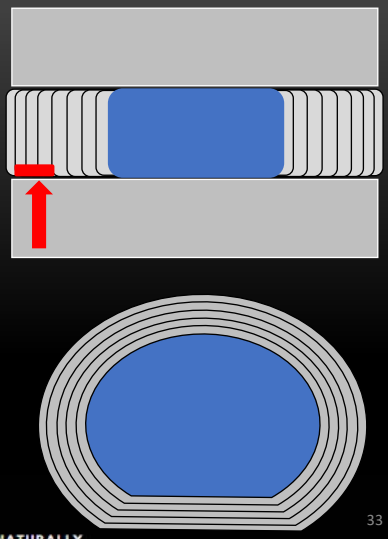
Annular Fissures

- Transverse
  - Involves the peripheral annulus
  - Represents an separation of disc insertion fibers (Sharpey's fibers) at the cartilaginous endplate
  - Can be seen as a vacuum cleft on plain film
  - Rarely seen on MRI
  - No clinical significance



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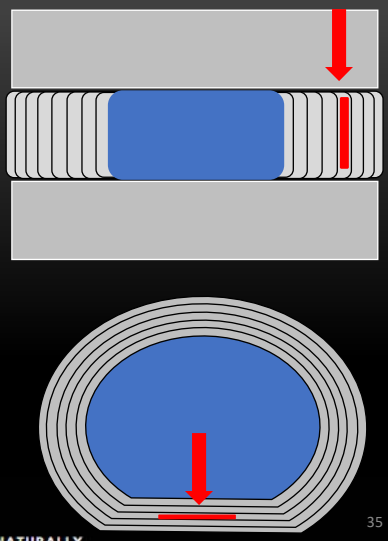
Annular Fissures

- Concentric
  - Vertically oriented separation between annular layers
  - No evidence of symptoms



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C. Warshel Pathfile

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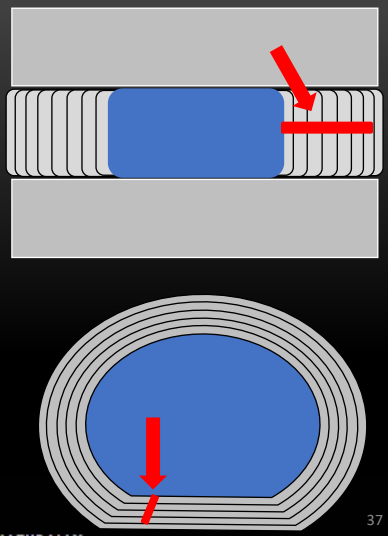
Annular Fissures

- Radial
  - Longitudinal fissuring extending from the nucleus through multiple layers of annulus
  - Can allow for significant nuclear migration
  - Considered to be associated with symptoms of discogenic pain
    - Growth of vascularized granulation tissue in the tear
    - Chemical and mechanical irritation to the outer (innervated portion) of the annulus



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Intervertebral Disc Herniation

- Herniation is a general term
  - Displacement of disc material beyond the normal disc margins by 2mm or more
- Good for clinical discussion, but non-specific
- Terminology has historically been imprecise
- ASNR standardized the nomenclature

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Disc Herniation Classification

- Morphology
  - Bulge: NOT a herniation
  - Protrusion — Contained
  - Extrusion
  - Sequestered Fragment — Uncontained
- Location
  - Central
  - Subarticular (formerly paracentral)
  - Foraminal
  - Extraforaminal
- Neurologic involvement

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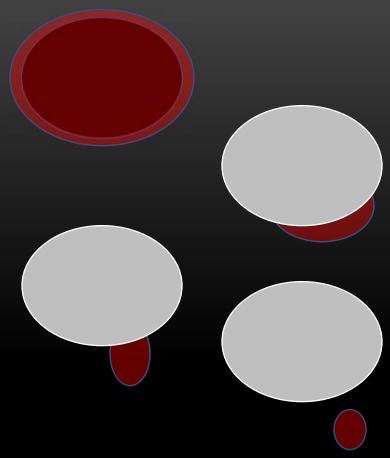
Disc Herniation Morphology

- Classification of disc herniation type requires viewing BOTH axial and sagittal images



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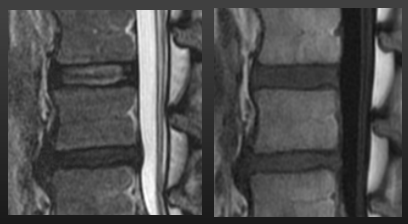
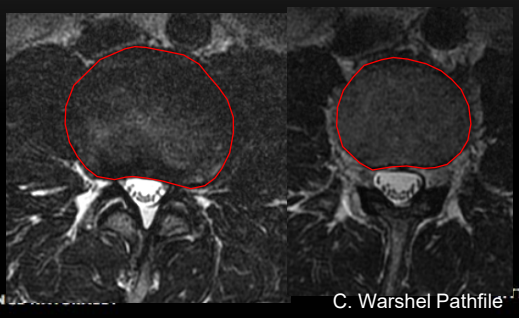
Disc Bulge

- Frequently associated with degeneration
  - Disc looses height, expands outward
- Disc extends beyond body margin generally less than 3mm
- Involves greater than 25% of the circumference





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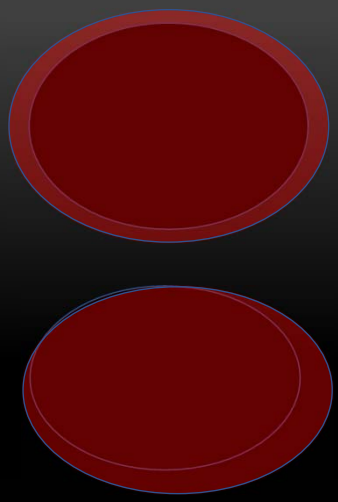
Disc Bulge

- Bulges can be
  - Symmetric
  - Asymmetric



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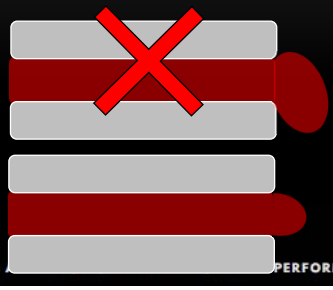
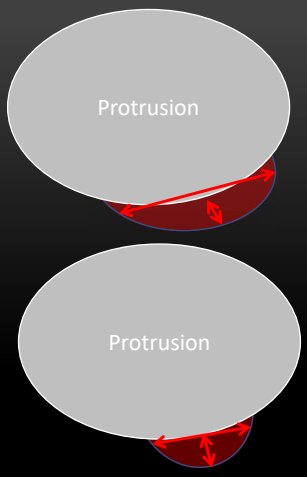
Disc Protrusion

- Focal extension of disc beyond the vertebral body margin
- The base is greater than the depth in both sagittal and axial dimensions





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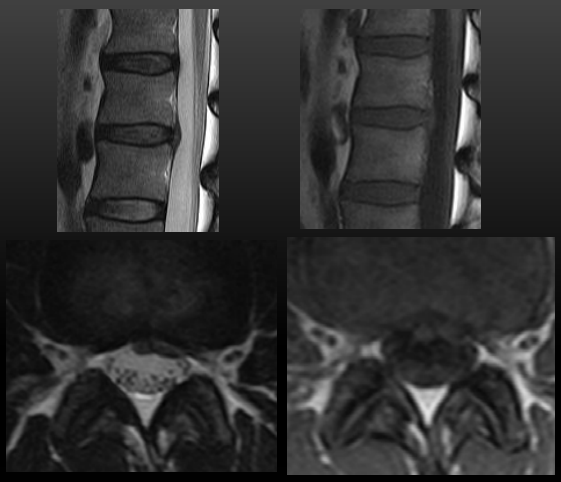
Disc Protrusion

- Often ASx
  - 1/3-2/3 of the ASx population has a protrusion
- Just because there is a structural lesion there do not have to be symptoms



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Disc Extrusion

- Nuclear material not contained by the outer annular fibers
- Maintains continuity with the parent disc
- Base is narrower than the depth in either the sagittal or axial plane
- Acute extrusions may show high intensity on T2 and postcontrast T1 due to surrounding granulation tissue

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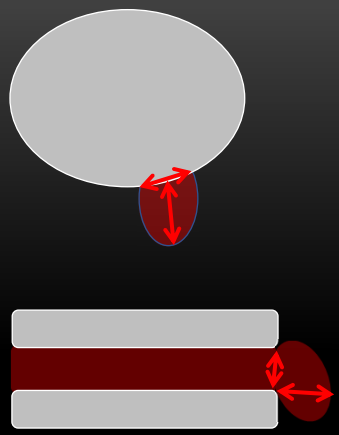
Disc Extrusion

- Base is narrower than the depth
- MUST compare the axial and sagittal
- Disc material can look like a protrusion in one plane and an extrusion in the other
  - If either looks like an extrusion, it is an extrusion NOT a protrusion



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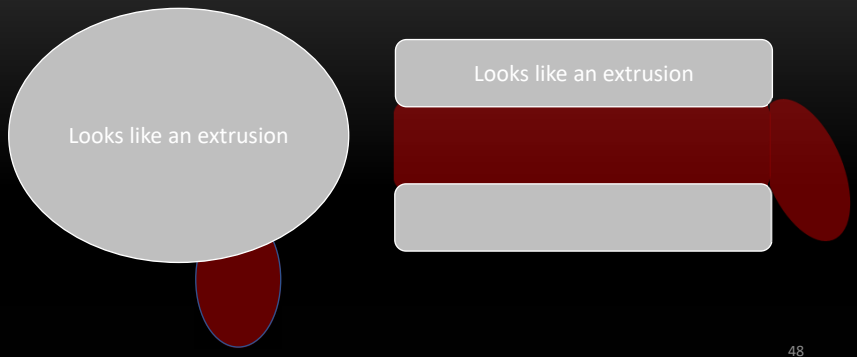

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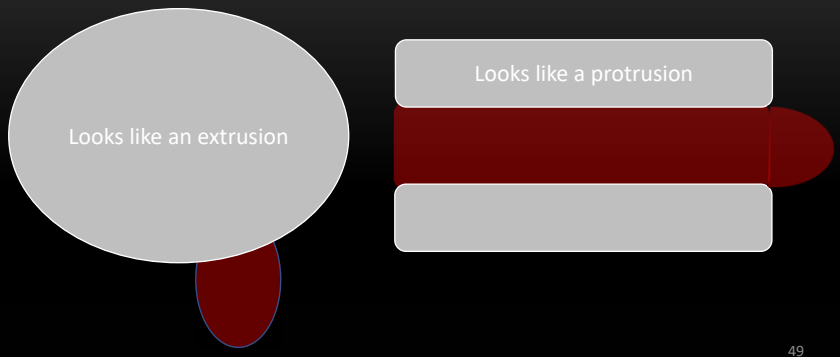

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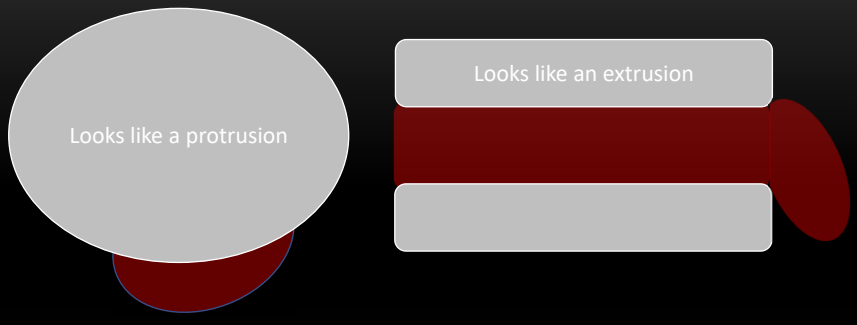

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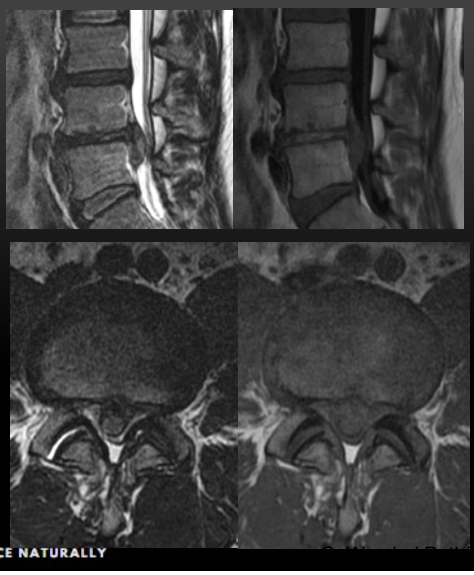
Disc Extrusion

- Extrusions have been shown to reduce in size with time
- ~90% of extrusions with radiculopathy managed non-operatively with aggressive conservative management have been shown "to do well" (Kaplan)(from Saal SPINE 14(4) 431-437)
- Pain more likely from chemical causes than mechanical compression



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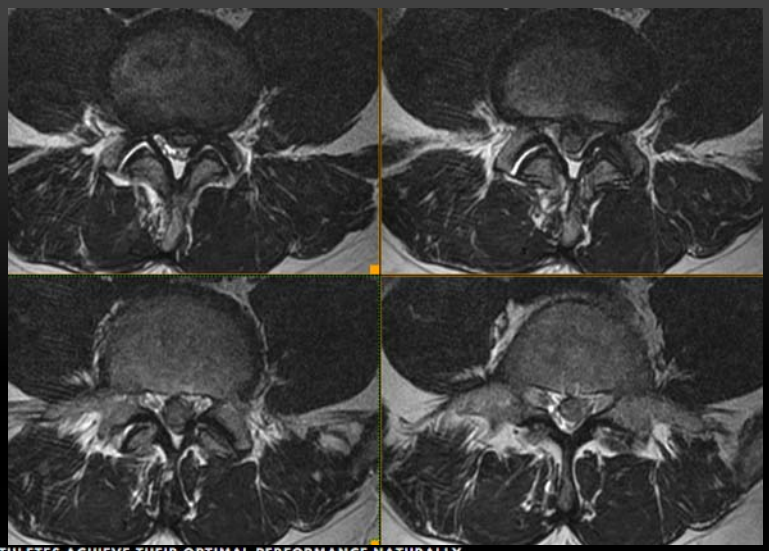
Disc Extrusion



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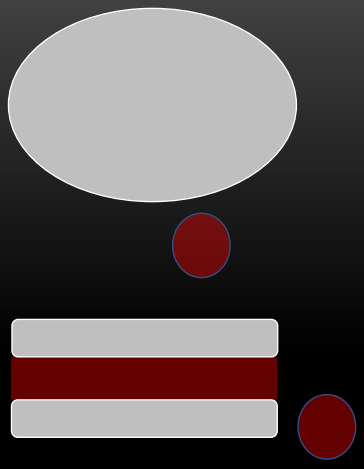
Sequestered Fragment

- Uncontained disc material
- NOT connected to the parent disc
- Can migrate in the spinal canal
  - Usually ~ 5mm
  - Can migrate significantly 2-3 levels
  - Can affect multiple nerve roots
- Acute sequestration may have surrounding high T2 and postcon T1 signal from vascular granulation tissue



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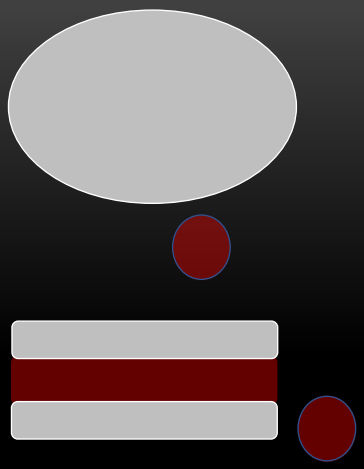
Sequestered Fragment

- Can be very subtle and easy to overlook
- Examine the entire series, not just the midsagittal and the disc plane axials
- Sequestration makes minimally invasive spine surgery less than optimal, generally requires an open procedure



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Sequestered Fragment

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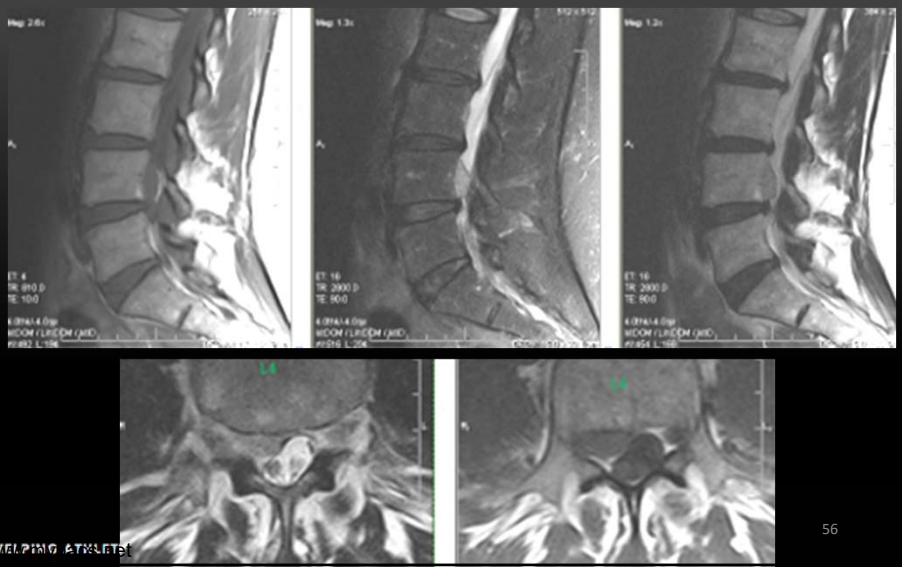
Sequestered Fragment



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Sequestered Fragment

T1 PostCon w w/o FatSat

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Disc Herniation Locations

- Location
  - Central
  - Subarticular
  - Foraminal
  - Extraforaminal
- ~92% are central and subarticular
  - 4% foraminal
  - 4% extraforaminal

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Modic Changes

- Changes in marrow in response to degenerative changes
- Necessary to recognize, so that they are not confused with other pathologies
- Typical spinal marrow is cellular red marrow
- 3 types of change can occur

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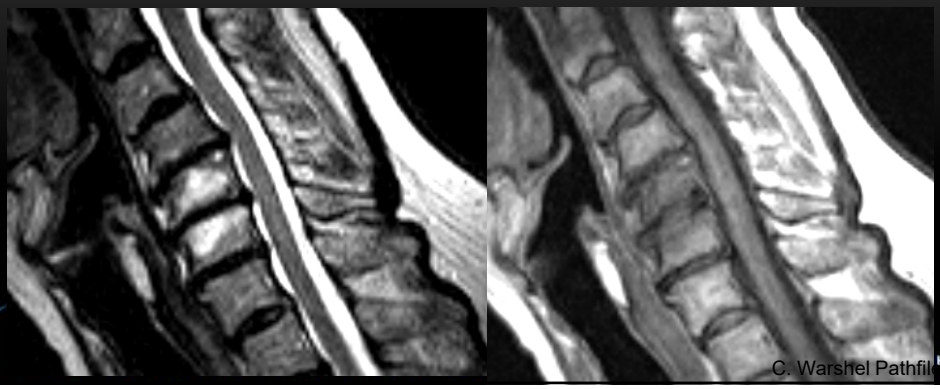
Modic Type 1

- Type 1: ↓T1 ↑T2
  - Replacement with fibrovascular tissue
  - Edematous, acute, thought to be associated with Sx



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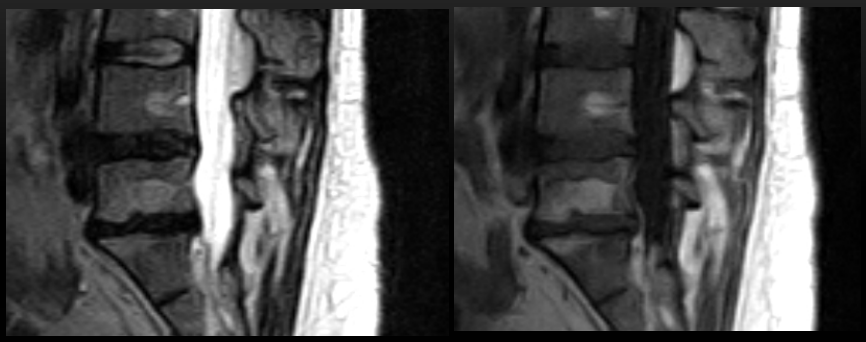
Modic Type 2

- Type 2: ↑T1 ↓↑T2
  - Fatty replacement of red marrow
  - Considered chronic, not associated with Sx



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Modic Type 3

- Type 3: ↓T1 ↓T2
  - Replacement of marrow space by bony sclerosis
  - Signal approaches that of cortical bone

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End of Spinal Trauma 1
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