Imaging in Spine Pain

Martin Asis, MD
St. Paul Radiology

Eiman Shafa, MD
Twin Cities Spine Center

DISCLOSURE

- Martin Asis, MD
  - No financial disclosures.
- Eiman Shafa, MD
  - No financial disclosures.

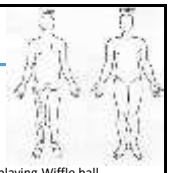
2

OBJECTIVES

- To outline **indications** for specific imaging / radiologic tests in diagnosing spine pain.
- To emphasize the **correlation** of imaging studies with clinical symptoms and physical findings
- To identify subtle findings on imaging studies as guide for surgical referral.
- To identify imaging findings of pathology commonly associated with spine pain.
- To identify imaging findings suggestive unstable spine injury.
- To identify imaging findings suggestive of self-limiting spine pathology.

3

HPI



- 43 yo M
- Teacher and football coach, active lifestyle.

- Episodes of mild self-limiting low back pain in the past.
- 6 months of progressive moderate low back pain.
- 2 months ago had sudden onset of radiating posterior right leg pain when playing Wiffle ball
- Over the past month experiencing progressive ankle plantar flexion weakness

- Worse with bearing down, coughing, sitting, lifting, prolonged standing
- Somewhat improved by leaning to the left and changing positions.

- Tried HEP and some relative rest. Taking NSAIDs.
- Affecting his sleep. Still working. Still coaching.

4

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Exam

- Ht: | Wt: | BMI: 33 | ODI: 38 | VAS leg: 7
- Appears uncomfortable.

- Posture: off-loading right lower extremity and leaning to the left

- Gait: antalgic

- Motor: weakness in right ankle plantar flexion, no atrophy

- Sensory: decreased on right below knee along S1

- DTR: Absent right achilles, 1+ bilateral patella.

- Shoulder/Hip: normal and painless

- Straight Leg Raise: provocative on the left and right for RLE pain

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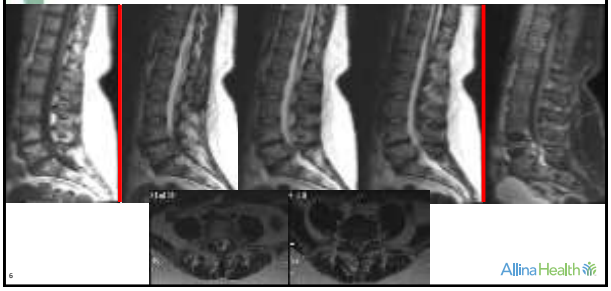
Imaging



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Radiculopathy – Lumbar HNP

- Defining the herniation
  - Protrusion, Extrusion, Sequestration
    - Predicting regression
  - Subligamentous, Transligamentous
    - Predicting regression
  - Zone – Central, Subarticular, Foraminal, Extraforaminal
    - Predicting clinical presentation / pain pattern

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- Protrusion
  - Widest at the base in all planes

Axial Sagittal

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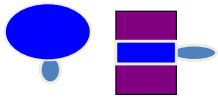
- Extrusion
  - A portion wider than the base in any plane

Axial Sagittal



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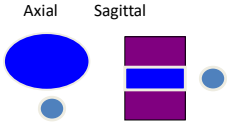
- Sequestration
  - Disc material no longer in continuity with the disc



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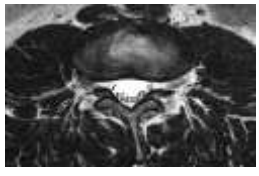
Radiculopathy – Lumbar HNP



Extraforaminal
(Far Lateral)

Subarticular
(Lateral Recess)

11

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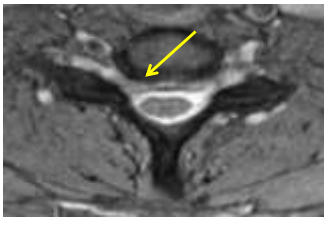
Radiculopathy – Cervical HNP



Foraminal Disc Extrusion

12

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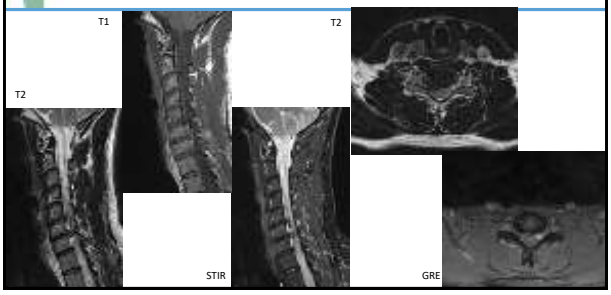
Radiculopathy – Cervical HNP



Resorption characteristics – HNP zone

- Natural history of disc herniation
  - Exposure of herniated disc material to the epidural vascular supply enhances potential for resorption.
- The dorsal epidural space has a richer vascular supply than the ventral epidural space

Sang-Ho. SPINE Volume 25. 2000

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Resorption characteristics – size and location

- A neovascularized zone infiltrated with macrophages develops in the outermost layer of herniated disc tissue
- Macrophage infiltration seems to be more prominent in large HNP because sequesters have 2-3 times more inflammatory cells than extrusions
- Neovascularization is hindered by ligaments and/or annulus fibrosis

Reijo. Spine. Volume 31. 2006

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Resorption characteristics – relation to PLL

- Subligamentous herniations include the extruded or protruded materials beneath the posterior longitudinal ligament (PLL)
- Transligamentous herniations have extruded material partially exposed to the epidural space through the tear of the PLL

Sang-Ho. SPINE Volume 25. 2000

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Resorption characteristics – MRI Signal

- Increased T2 signal in a herniated disc compared to the parent disc is favorable for regression
- Proteoglycan molecules swell when they are released from the collagen matrix
- Degradation of the molecules causes dehydration of the herniated disc and subsequent size reduction

Reijo. SPINE. Volume 31. 2006

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Resorption characteristics – Modic changes

- Modic changes of lumbar endplates are associated with:
  - Poor resorption of disc herniation after conservative treatment
    - Increased cartilage content in herniated material
    - Decreased neovascularization
    - Decreased macrophage infiltration
    - Decreased expression of matrix metalloproteinase-3 gene (key matrix-degrading enzyme)

Ding et al. Cell Biochem Biophys (2015) 71: 1357.

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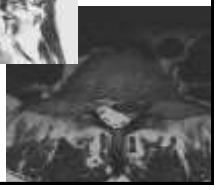
Initial

- Transligamentous
- Bright on T2

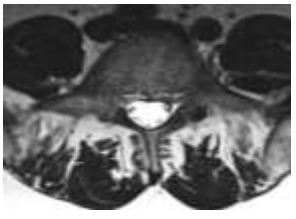
T2



STIR

19

2 Month Follow Up



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STIR Initial

STIR Follow Up

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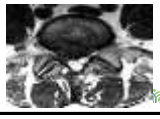
21

Initial

- Largely Subligamentous
- Dark on T2

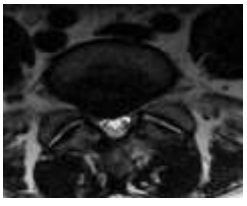
STIR

T2



22

One Year Later



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STIR Initial

STIR Follow Up

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Radiculopathy – clinical perspective

- "shared decision making"
- The clinical picture and patient goals are paramount.

- As clinicians we help patients in making the right decision…
- Understanding the natural history of disease is therefore critical.

Though these two disc herniations can present with similar radicular pain symptoms, they (often) do not share the same natural history.

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Radiculopathy – foraminal narrowing

- Spondylolisthesis
  - May be dynamic or static
  - Sagittal MRI; X-Rays weightbearing and flexion/extension
- Asymmetric disc space narrowing
  - Assess AP weightbearing X-Ray
  - Can cause foraminal or lateral recess narrowing

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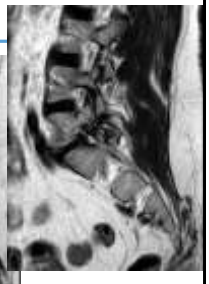
Assessment of imaging in spondylolisthesis:
- Foraminal SAG slices T1 > T2
- Assess for reparative tissue in foramen
- Standing X-Ray vs Supine SAG MRI

27



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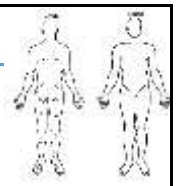
HPI



- 65 yo M
- Multiple years of self-limiting low back pain
- Progressively limited in walking or standing over past year
- Wife reports increased forward leaning posture. Needing
- Routine and self-care activities now impacted.

- Symptoms improved with sitting. "I can sit all day."
- Symptoms provoked with lifting, standing, or laying flat in bed.

- No subjective weakness or B/B dysfunction.

- Has tried changing activities, therapy, HEP, Chiropractic care, trigger point inj, epidural injections

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Exam

- Ht:68" | Wt: 232 lbs| BMI: 35 | ODI: 32| VAS: 7
- Engaged with exam. Alert and appropriate.
- Posture: Forward flexed.
- Gait: Prefers using walker. Symmetric gait
- Motor: No focal deficits assessed in a seated position.
- Sensory: intact to light touch BLE
- DTR: Symmetrically decreased BLE
- Shoulder/Hip: limited IR in both hips but painless.
- SLR: Negative bilaterally
- Trunk extension test: Positive for bilateral buttock and tight pain.

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Imaging

T2

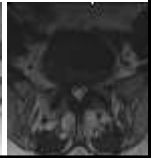
T1

L2-L3

L3-L4

L4-L5

L5-S1



30

Congenital Spinal Stenosis

- Narrow canal resulting from congenitally short pedicles.
  - Central canal ovoid in shape
  - Canal with smaller cross-sectional area
- Often become symptomatic in the third, fourth, or fifth decade
- Relatively few degenerative changes at time of Sx onset
- Mild degenerative changes, that would otherwise be well-tolerated, cause clinically symptomatic canal narrowing in this population.

Katz, et al. N Engl J Med 2008;358:818-25.

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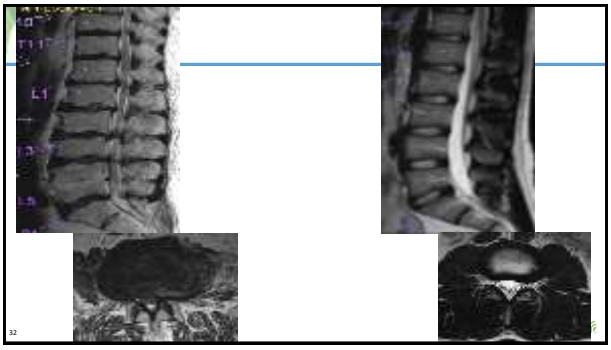

32

Acquired Degenerative Stenosis

- Most frequently observed type of spinal stenosis.
- Arises in conjunction with age-associated degeneration of the lumbar disks and facet joints.
- Usually slowly progressive
- Usually presents later in life compared to congenital stenosis.
- Often more focal; involves fewer spinal segments compared to congenital stenosis

Katz, et al. N Engl J Med 2008;358:818-25

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Spinal Canal Stenosis – clinical correlation

- Canal volume on axial MRI correlated with walking tolerance
  - The smaller the minimum cross-sectional area (mCSA), the shorter the walking distance before onset of pseudoclaudication
  - ≥ 500 m, average mCSA mCSA 68.8 mm^2
  - < 500 m, average mCSA 53.5 mm^2
  - mCSA between these two groups was significantly different ($p < 0.001$)
  - Avg mCSA was not correlated with gender, age, or vertebral level

Ogikubo, O. et al, Spine. 2007. 32(13); 1423–1428

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Spinal Canal Stenosis

- Findings suggest the threshold for clinically significant stenosis is about 70 mm^2
- Other studies: neurogenic claudication related to spinal canal stenosis occurs between 60 and 80 mm^2

Ogikubo, O. et al, Spine. 2007. 32(13); 1423–1428

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Spinal Stenosis – clinical perspective

- Slowly progressive
- Sx are often a combination of radicular and neuroclaudicatory
- Management is usually a quality of life concern.
- Very rarely a cause of neurogenic bowel/bladder dysfunction.
- DDx: vascular claudication, neuromuscular disorders, etc.

36

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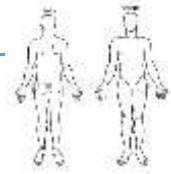
HPI



- 25 yo M
- "years" of on/off self-limited low back pain w/ 6 mo of progression
- Describes his pain as constant, severe, limiting, and frustrating
- No specific incidental; 6 months ago he started training for a race
- Pain localized in the low back
- Denies subjective leg pain, numbness, tingling, or weakness
- Provoked by bending, twisting/reaching, and prolonged sitting or standing.
- Prior treatment includes: physical therapy, chiropractic care, home exercises, and ↓activity

37

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Exam

- Ht: 74" | Wt: 186 lbs| BMI: 24 | ODI: 28 | VAS: 4-7/10
- Pleasant mood. Engaged with exam. Alert and appropriate.
- Moves around exam room to achieve comfortable position.
- Posture: balanced erect posture in COR and SAG planes grossly.
- Gait: symmetric, steady, non-antalgic.
- Motor: No deficits. 5/5 in bilateral lower extremities.
- Sensory: No deficits. Intact to light touch in bilateral lower extremities.
- DTR: Symmetrically 2+ BLE patella and achilles; No long tract signs.
- Hip: Normal painless ROM
- SLR: Negative bilaterally

38

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Imaging

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Axial back pain – Disc

- Disc features most closely associated with pain
  - Herniation
  - Narrowing
  - Radial tears (peripheral in particular)
- Features variably associated with pain
  - Endplate irregularity (may be painful when acute)
  - Schmorl's nodes (may be painful when acute)
- Not associated with pain
  - Signal intensity

Adams M. SPINE. Volume 31. 2006

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Prevalence in Asymptomatic Patients

- "Bulging": 10% to 81%
- Protrusion: 3% to 63%
- Extrusion: 0% to 24%
- Decreased MRI T2 signal: 20% to 83%
- Disc Narrowing: 3% to 56%
- Annular Tears: 6% to 56%
- Schmorl's Node: 8% to 19%

Battie et al. Spine Volume 29. 2004

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Disc Height Loss

- Loss of annulus height increases the mechanical load on the posterior elements.
- Narrowed discs

→ Facet osteoarthritis

→ Neural foraminal narrowing

Howard. SPINE Volume 29. 2004

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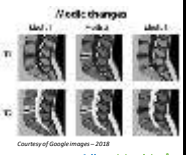
Modic Changes

- Type I: Bone Marrow Edema and Inflammation
  - Hypointense T1WI
  - Hyperintense T2WI
- Type II: Ischemic Conversion of Red to Fatty Marrow
  - Hyperintense T1WI
  - Hyperintense T2WI
- Type III: Subchondral Bone Sclerosis
  - Hypointense T1WI
  - Hypointense T2WI
- Can have mixed Modic 1/2 and 2/3 findings

Courtesy of Dr Matt Skolski, Radiopaedia.org



Courtesy of Google Images – 2018

Rahme. AJNR 29. May 2008

Modic

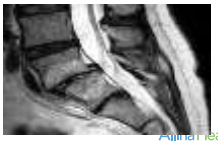
- Dynamic
  - Convert from one type to another with time
- Type I
  - Likely reflect active degeneration and instability
  - Likely to be inflammatory
  - Seem to be strongly associated with active low back pain
  - Predict good outcome after fusion
- Type II
  - Seem to indicate a more biomechanically stable state
  - Less clearly associated with low back pain
  - Superimposed stress may cause reversion to type I
- Type III
  - Exact nature and significance remains largely unknown

Rahme. AJNR 29. May 2008

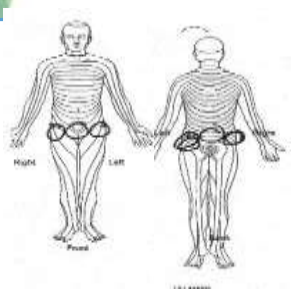
5/2004 MODIC I 4/2008

T1

T2



MODIC I



46

Modic I

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MODIC II

T1 T2 STIR

48

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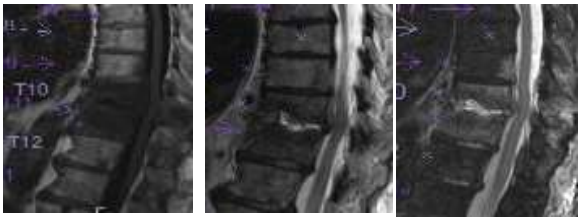
Something different…



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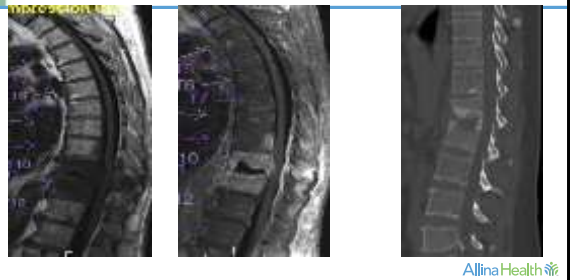

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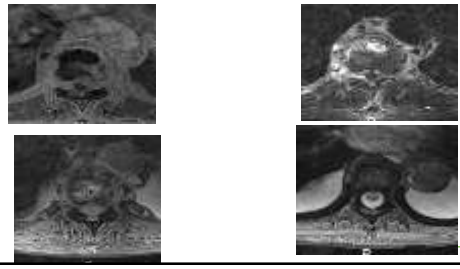
Discitis



51

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Hemangioma: MRI

52

Hemangioma: CT

Malignancy: MRI

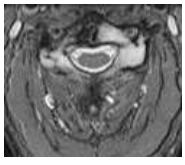
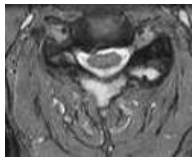
54

Malignancy: MRI



55

Malignancy: MRI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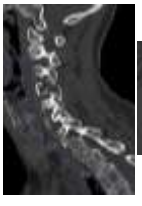
Malignancy: CT



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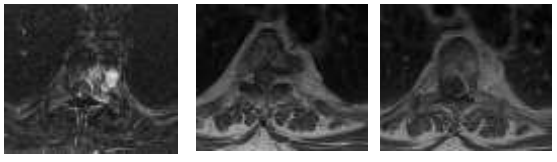
Aggressive Hemangioma: MRI

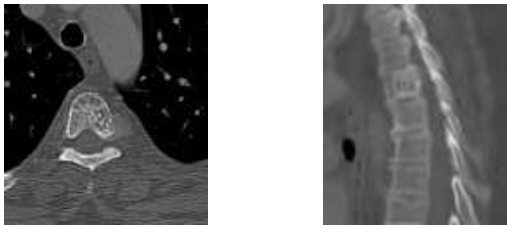
58

Aggressive Hemangioma: MRI



59

Aggressive Hemangioma: CT



60

Intraosseous Hemangioma

- Benign lesion composed of blood vessels
- Most commonly in the veterbral bodies but can originate in posterior elements
- 33% are multifocal
- Classic appearance is bright on T1 and T2
- Coarse trabeculations=corduroy pattern
- Typically incidental

61

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Intraosseous Hemangioma

- Asymptomatic lesions are not treated
- Rarely can be associated with fracture
- Rarely associated with diffuse infiltration of bone or soft tissue
  - May require bx
  - Embolization
  - Resection

62

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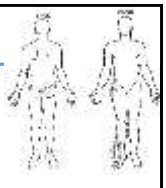
HPI



- 39 yo F
- 10+ years of LBP – previously intermittent, now constant and limiting.
- 2-3 years of radiating right leg pain (infrequently experiences left leg pain)
- Symptoms progressively over prior 2 years.
- Limited by both back and right leg pain.
- Worse with prolonged activity, lifting, bending, and standing.
- Partial relief with laying supine
- Denies subjective weakness.
- Has tried limiting activity, oral steroids, NSAIDs, narcotics, muscle relaxers, physical therapy and ESIs.

63

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Exam – stay brief

- Ht:65" | Wt: 178 lbs| BMI: 29.7 | ODI: 50 | VAS back: 9, VAS leg: 7
- Appears to have pain. Engaged with exam. Alert and appropriate.
- Posture: Erect posture.
- Trunk ROM: Avoids both extension and deep flexion
- Motor: 4/5 right EHL and Peroneal, hip Abduction along with remainder of motor exam is intact
- Sensory: decreased anterolateral lower leg
- DTR: intact, symmetric
- Hip: normal painless ROM
- SLR: positive for right leg pain

64

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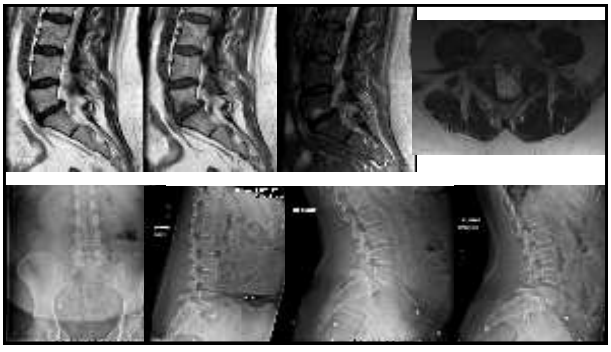

Axial back pain – segmental instability

- Dynamic instability
  - Failure of posterior elements
    - Facet, Pars interarticularis, Posterior ligamentous complex
  - Failure of disc integrity
- Subtle (relative) instability
  - "Vacuum" disc
    - Best assessed on supine CT or extension X-Ray
  - Synovial facet cyst
    - Excess facet motion → facet capsule hypertrophy → cyst enlargement.
    - Can have thin or thick walls.
    - Most frequently with radicular symptoms
    - Can cause canal stenosis if large

- Resnick et al. Radiology 1981. 139(2): 341-8
- Lin et al. BMC Musculoskeletal Disorders. 2014;15:325

66

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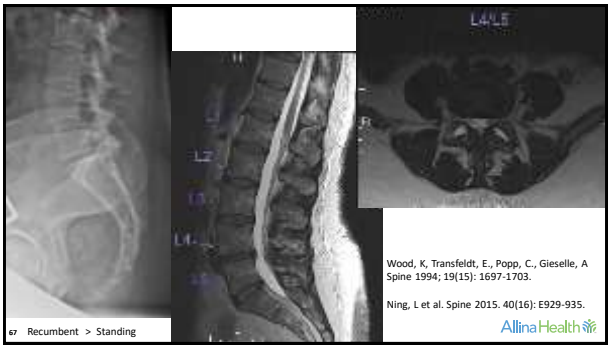

67 Recumbent > Standing

Wood, K, Transfeldt, E., Popp, C., Gieselle, A Spine 1994; 19(15): 1697-1703.

Ning, L et al. Spine 2015. 40(16): E929-935.

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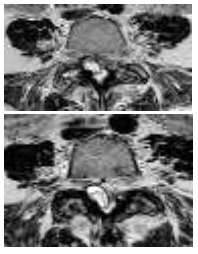
Synovial Cyst



68

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HPI

- 83 yo F
- Lives at nursing home.

- Back pain as long as she can recall, worse over the prior 2-3 days after a fall in her apartment.
- Has avoided mobilizing out of bed for routine activities.

- Reports moderate mid-back pain at rest.
- No radiation into the extremities

- Brought to ED by nursing home for evaluation

69

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Exam

- Ht: 63" | Wt: 118 lbs | BMI: 21.6
- Examination is limited due to pain
- Posture: Alignment assessed in bed. Multiple pillows support hyperlordotic neck and kyphotic thoracic back
- Gait assessment: Deferred
- Rang of motion: Quite limited.
- Motor: Global weakness BLE; BUE symmetrically intact.
- Sensory: Appears intact to light touch
- DTR: Decreased symmetrically
- Hip: limited but painless
- Straight Leg Raise: negative
- No ankle clonus, propioception decreased in the feet, Babinski exam equivical

70

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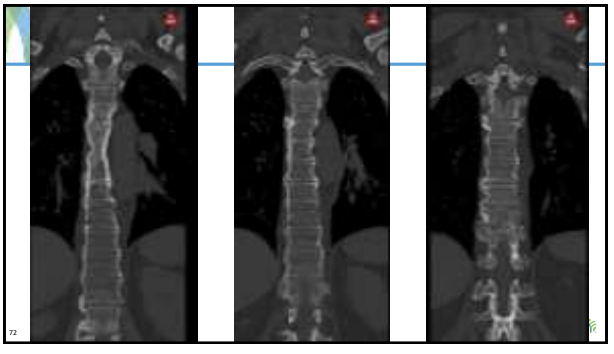
71



72

73

Ankylosing Spine Disorders

- Two primary types
  - Ankylosing Spondylitis (AS)
  - Diffuse idiopathic skeletal hyperostosis (DISH)
- Both are associated with poor bone quality
  - Stress Shielding
- Fractures are highly unstable
  - "long bone fracture" analogous to a femur fracture
  - Long lever arms of force above and below fracture site

74

DISH

- "Flowing" anterior vertebral osteophtyes
- Minimal disc disease
- Facet arthropathy – absent facet ankylosis

75

Ankylosing Spondylitis

- Thin ossification at vertebral margins
- "Bamboo" spine
- Ankylosed facets
- Accelerated disc degeneration in unfused segments

76

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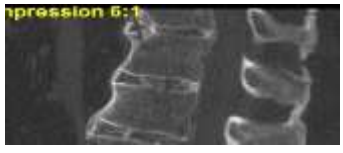

77

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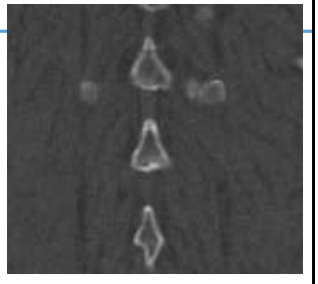

78

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Ankylosing Spinal Disorders

- 122 spine fractures in 112 consecutive pts over a 7 year period
- Ground level fall, most common injury (39%)
- 81% at least 1 major medical comorbidity
  - HTN 41%
  - Cardiac dz 33%
  - Pulmonary dz 15%
  - Morbid obesity 13%
- 15% too medically unstable for surgery

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Ankylosing Spine Disorders

- 58% had a spinal cord injury
- 67% required surgery
- 19% had a delayed diagnosis of fx
  - Resulting neuro compromise in 81%
- Fx location
  - 55% C-spine (75% with SCI)
  - 21% T-Spine (33% with SCI)
  - 16% T-L Spine (23% with SCI)
  - 8% L spine (33% with SCI)

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81

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- THANK YOU

82

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TO CONTACT ME

- Eiman Shafa, MD
  - 612-775-6200
  - eshafa@tcspine.com

83

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