Expert MRI

Technology|Science|Evidence

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Can MRIs Be False Negative?

If So

How Does That Affect Your Case?

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Common Possibilities

I. How Can MRIs Miss Injuries (False Negative)?

A. Scanning in the wrong position?
B. Scanning in the wrong Location?
C. Eye-Balling only without Measurements?
D. Medical reports missing important MRI information?
E. Exam Doesn’t get done?

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Common Possibilities

I. How Can MRIs Miss Injuries (False Negative)?

A. Scanning in the wrong position?

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MRI Designs: Closed MRI/Open MRI/ Multi-Positional MRI

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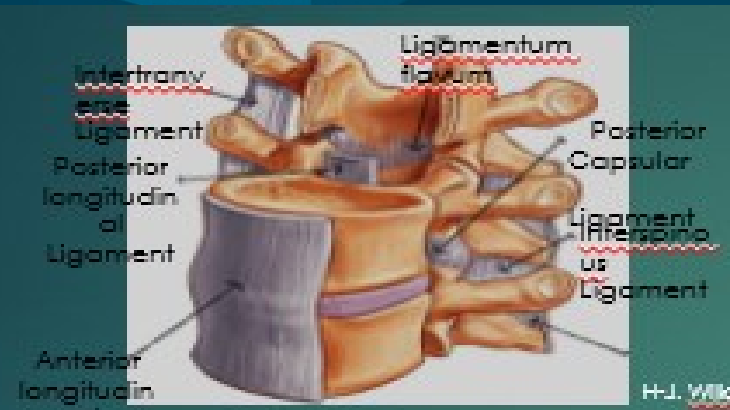
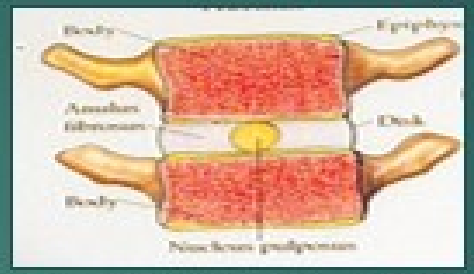
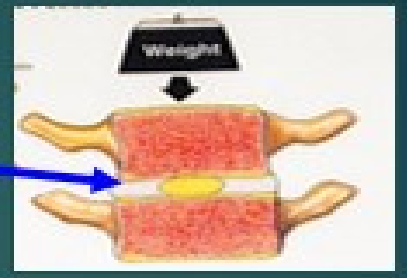
Does Position Matter: Pressure Varies Within the Spinal Disc With Positional Changes



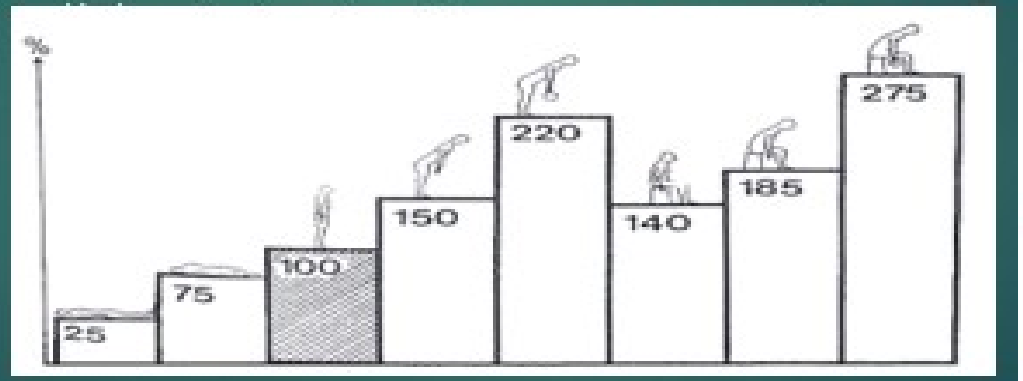
Gravity Matters

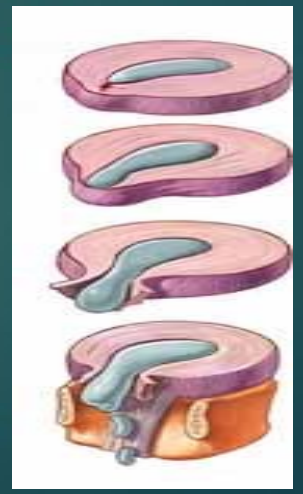




H-J. Wilke, P. Neef, M. Caimi, T. Hoogland and L. E. Claes Spine 24, #8, pp. 755-762, 1999

Relative change in pressure (or load) in the third lumbar disc in various positions in living





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The AMA Guides To The Evaluation of Permanent Impairment, 5th Edition (page 378)

"The dominant motions at both the lower cervical and entire lumbar spine, where most clinical pathology occurs, are *Flexion-Extension*."

EXPERTMRI

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Published Research

Traditional Supine Lumbar MRI → 52% + Missed Rate

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Scientific Data: Patient Outcome

"Positional Upright Imaging of the Lumbar Spine Modifies the Management of Low Back Pain and Sciatica"

F.W. Smith, M.D. et. al.
University of Aberdeen, Scotland

Paper presented at the European Society of Skeletal Radiology (ESSR) Oxford, England (July, 2005)

and published in Clincal MRI Volume15, Issue 3 (2006)

In a study of 25 patients with low back pain and sciatica referred for lumbar spine MRIs following at least one prior "normal" recumbent MRI within 6 months of referral:

13 patients (52%) demonstrated abnormalities "in one or more of the seated postures that were not evident in the ... supine examination"

- 3 cases with lateral disc herniation
- 6 cases with hypermobile disc at one or more levels
- 2 cases with previously unsuspected Grade I spondylolisthesis
- 2 cases with significant spinal stenosis

"Each of the 13 patients has undergone appropriate surgery and 6 months post-surgery they remain symptom free."

The best image is the one that doesn't MISS the pathology

Patient positioning plays a critical role in detecting clinically significant pathology

78 SPONDYLOLYSIS

forearms were supported by two bars to increase stability. For sitting extension, a cushion was placed behind the lumbar spine and the subject was requested to bend backward as much as possible and the forearms were supported with the bar.

Image Analysis

The measurements were made using a personal computer (CPU Pentium 4, 2.4 GHz) using the Osiris software (Digital Imaging Unit, University Hospital of Geneva). The setting of the measurement software was such that 1 pixel was equal to 1.18 mm on sagittal image.

45% 52% 67%

Results

58 Patients Total Study

Healthy discs show less than 2 mm difference in height between supine and seated postures. In 89% of cases, discs showing degenerative changes (Figs. 8.3 and 8.4) decrease in height by more than 2 mm, especially anteriorly on flexion (3–4 mm). Thirty-eight patients with a posterior prolapsed disc showed an increase in the degree of prolapse when seated. In 30 of the 38, the amount of prolapse decreased on flexion and increased on extension. In 67% with lateral disc prolapse, the prolapse was more prominent when seated and decreased on flexion and increased on extension.

In foraminal stenosis, there was an increase in extension (Figs. 8.5 and 8.6). In 14 cases with Grade 1 spondylolisthesis, the anterolisthesis was more evident in the seated posture (Figs. 8.7 and 8.8). In 10 of the 14 cases, the degree of spondylolisthesis increased on flexion and was seen in association with tears of the interspinous ligament.

Important changes were also seen as a function of posture in cases of multilevel instability (Fig. 8.9) and in fluctuating spinal stenosis (Figs. 8.10 and 8.11).

Discussion

The ability to image the spine in different postures adds significantly to the diagnostic accuracy of the MRI examination. For more than 50% of the patients examined in our study, a better understanding of the conditions of the spine was obtained, resulting in improved management.

REFERENCES

Recumbent MRI misses RATABLE factors, see Arrows

Recumbent	Upright/Weight-Bearing

13% WPI?

DRE method
(Guides page 384)

78% WPI

Cauda Equina Syndrome verified

DRE + CST method
(Guides page 384-395)

Clinical history of L4-S1 Laminectomy and Fusion now with radicular pain and incontinence with significant lower extremity impairment as indicated by atrophy and loss of reflexes, pain, and sensory changes.

1. Radiculopathy verified on EMG but without motion segment integrity are present (DRE Cat. III 13%).
2. a. Both radiculopathy and alteration of motion segment integrity are present (DRE Cat. V 28%).
   b. Also rated using the neurology tables for cortical spinal tract Impairment (page 396-397)
   Numbness, weakness, decr. Dexterity of both lower extremity bilaterally = class III 39% WPI. Bladder impairment = class IV 50% WPI --->

Combining 50%, 39% and 28% results in a combined WPI of 78%

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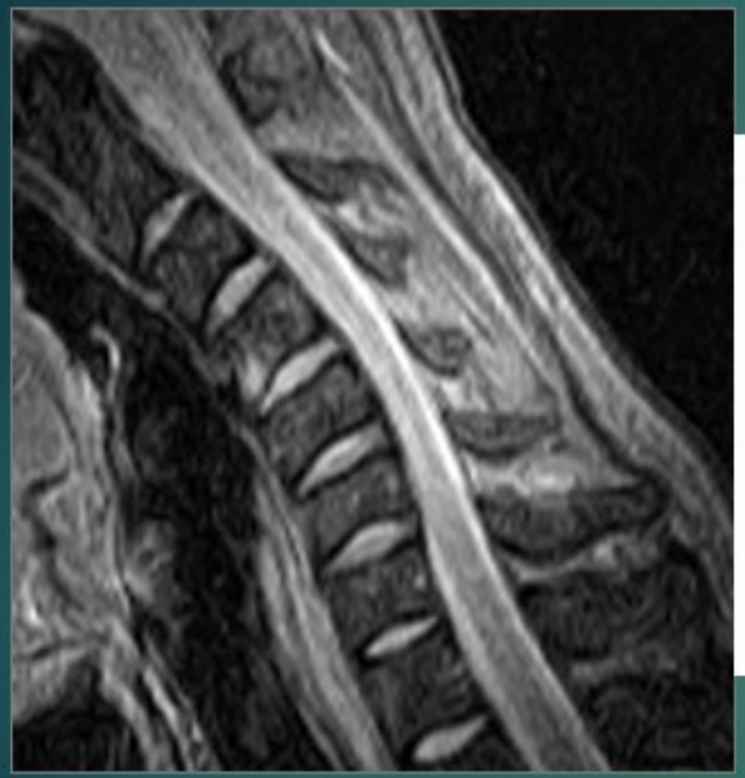
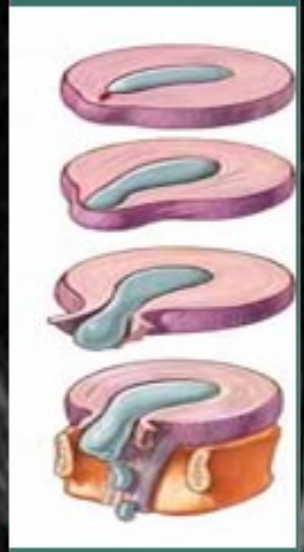
Wrong Location? No!! Wrong Position Extension





Disc Herniation Size May Fluctuate with Positional Change of Pressure

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Career Saving Application

Posterior Subluxation of the Lateral Meniscus

Recumbent

Upright/Weight-Bearing

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Positional MRI of the Shoulder

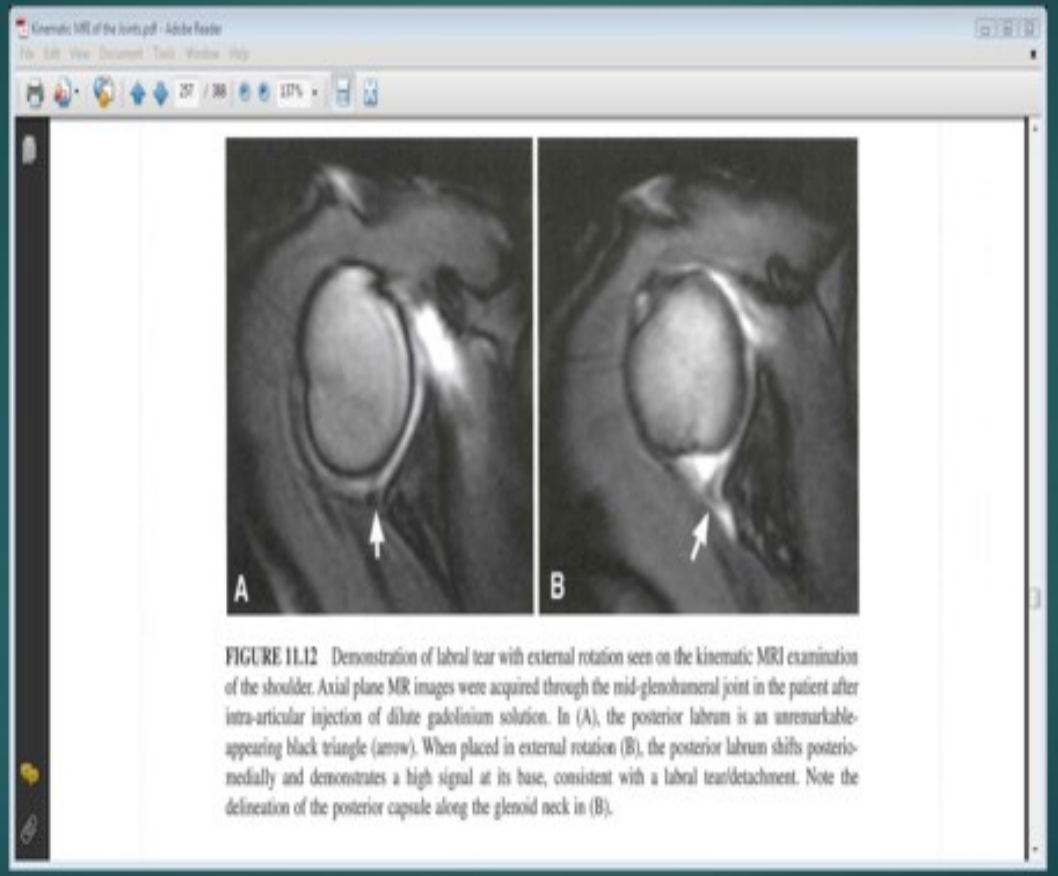
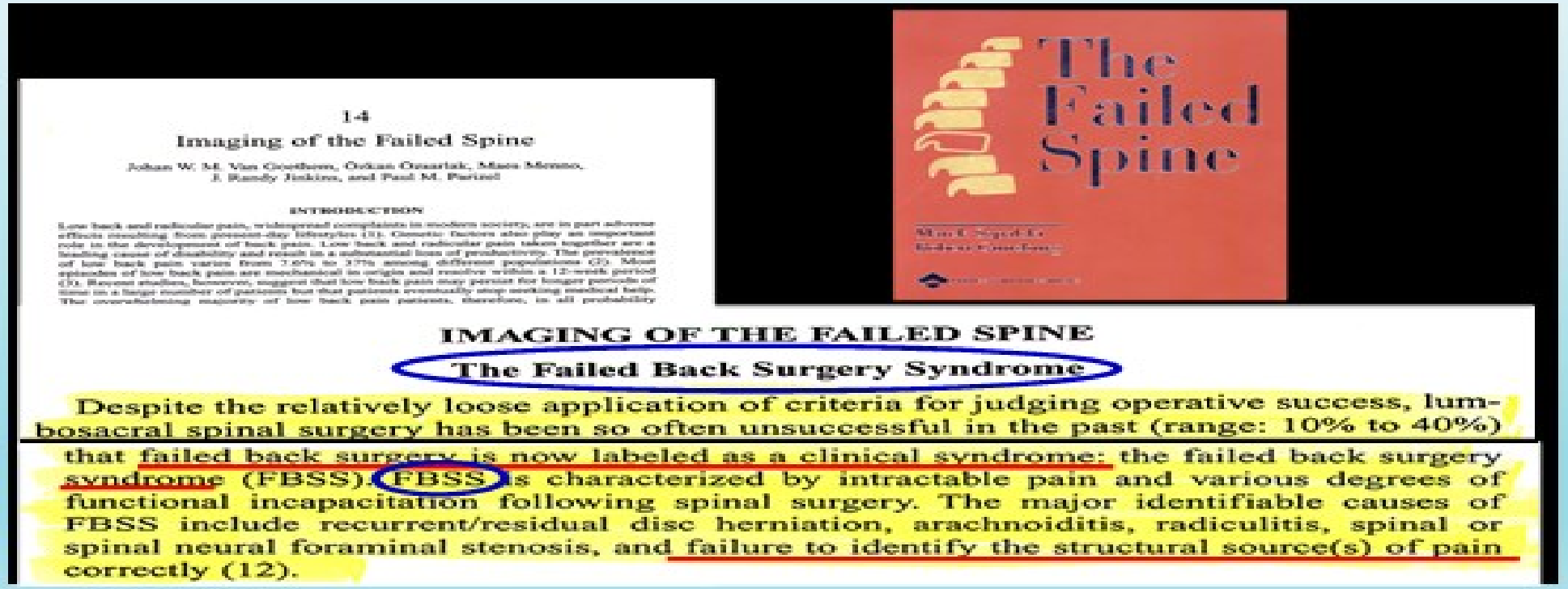


FIGURE 11.12 Demonstration of labral tear with external rotation seen on the kinematic MRI examination of the shoulder. Axial plane MR images were acquired through the mid-glenohumeral joint in the patient after intra-articular injection of dilute gadolinium solution. In (A), the posterior labrum is an unremarkable-appearing black triangle (arrow). When placed in external rotation (B), the posterior labrum shifts posterio-medially and demonstrates a high signal at its base, consistent with a labral tear/detachment. Note the delineation of the posterior capsule along the glenoid neck in (B).

CONSEQUENCE

Inaccurate or Incomplete Diagnosis = Inaccurate Treatment
Everybody Suffers (Patients, Doctors, Ins. Companies)



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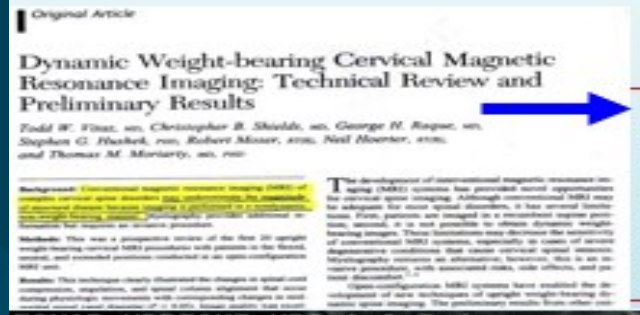
Failed Back Surgeries



Original Article

Dynamic Weight-bearing Cervical Magnetic Resonance Imaging: Technical Review and Preliminary Results

The Southern Medical Journal (2004) University of Louisville School of Medicine, Department of Neurological Surgery

Conclusions: "When only static supine MRI scanning is performed on these patients, the true abnormality may be overlooked and [redacted] instituted because of a lack of illustration of the changes that occur with movement.[13,14,16,17]"

Successful Surgical Outcome ?

"Any sound surgical treatment would have to include both levels. This is what a surgeon needs to know."
Richard Marks, MD, Orthopedic Surgeon, Dallas, Texas.

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Common Possibilities

I. How Can MRIs Miss Injuries (False Negative)?

A. Are we looking in the correct position?
B. Scanning in the wrong Location?

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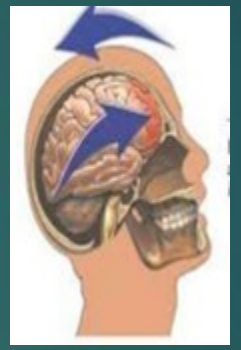
WHIPLASH INJURY

TERM USED TO DESCRIBE CERVICAL INJURIES CAUSED BY SUDDEN NECK MOVEMENTS THAT OCCUR DURING AND AFTER AN ABRUPT CERVICAL ACCELERATION-DECELERATION (CAD) EVENT

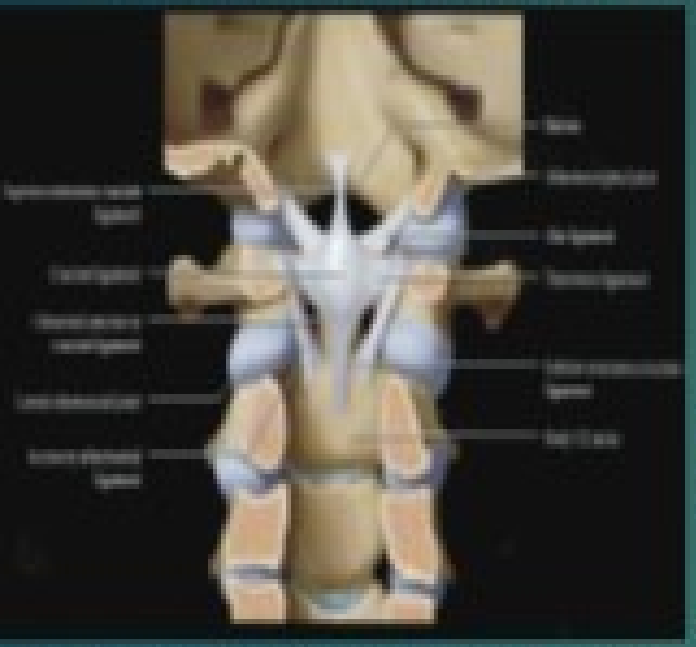


CAUSES: MOTOR VEHICLE ACCIDENT (MVA), AMUSEMENT PARK RIDES, BUNGI JUMPING, ATHLETIC ACTIVITIES (SKIING) , PHYSICAL ASSAULTS

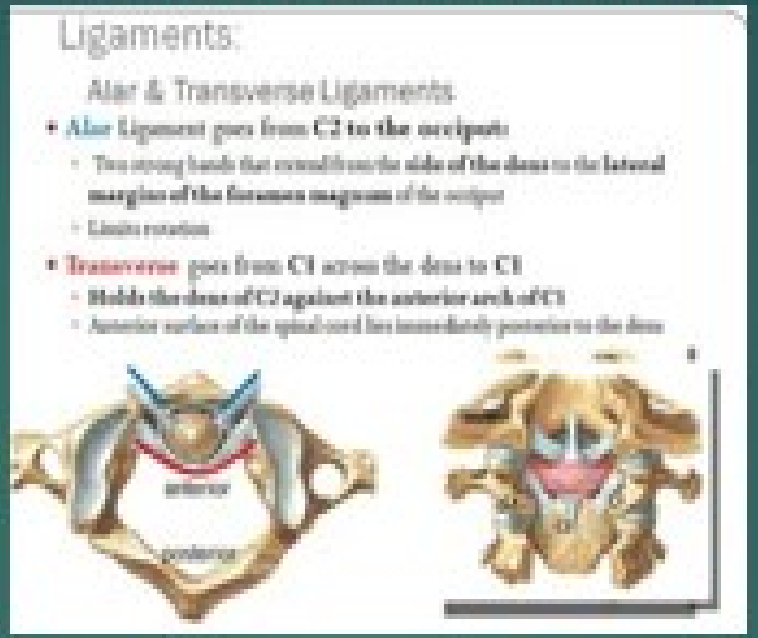
SYMPTOMS: NECK PAIN, NECK STIFFNESS; SHOULDER STIFFNESS; HEADACHES; TINNITUS , DIZZINESS, VERTIGO, LIGHT-HEADEDNESS, UNSTEADINESS

HOW OFTEN DOES THE MRI COME BACK MINIMAL OR NORMAL?

The Cranio-Cervical Junction
Base of Skull and Vertebral Column Attachment



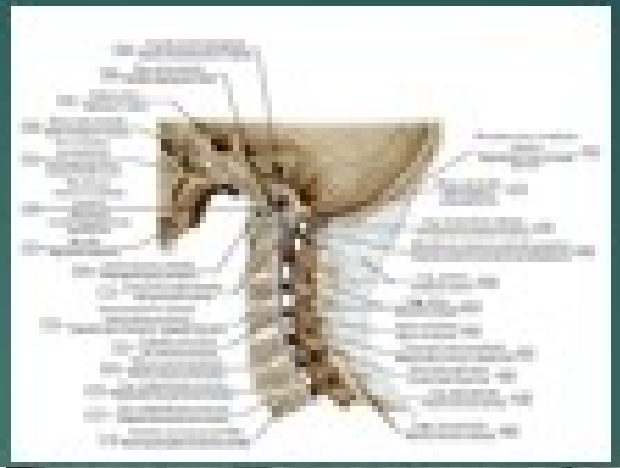
Alar ligaments: one of 5 groups of small but tough soft tissue structures that connect the skull to the cervical spinal column

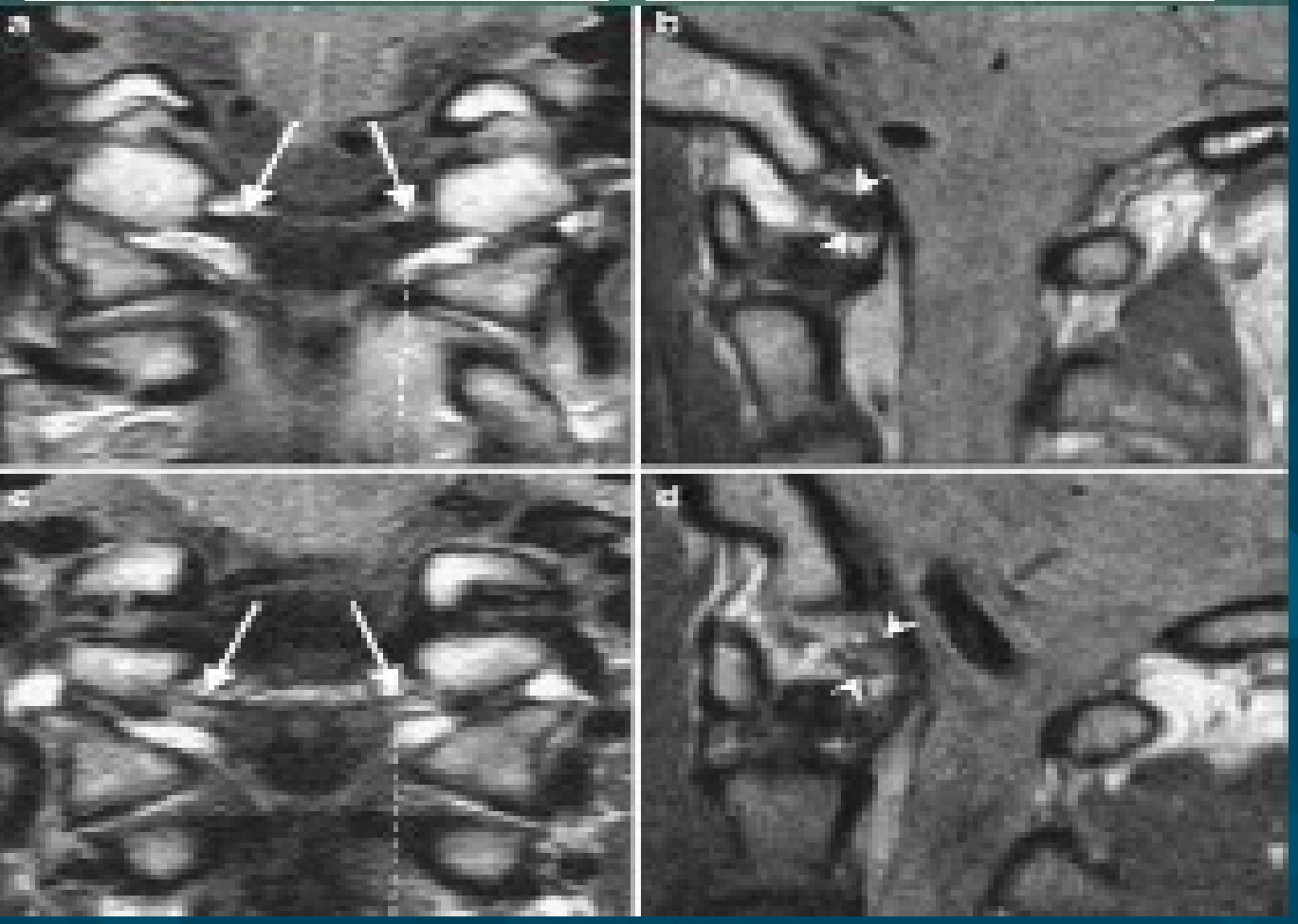


Two of these five considered "major stabilizers": transverse ligaments and alar ligaments

52/92 (57%) whiplash patients: grade 2 or 3 lesions of the Alar Ligaments with
No grade 2 or 3 lesions in normal control patients

Krakenes J [2002] MRI assessment of the alar ligaments in the late stage of whiplash injury – a study of structural abnormalities and observer agreement. Neuroradiology [2002] 44: 617–624





Alar Ligament Damage

NORMAL

Paired “black” fan-shaped or rectangular structures with smooth regular borders12

Normal ligaments have near-total low signal (homogeneously dark) on all sequences1

Surrounded by normal fatty tissue

ABNORMAL (Acute)

Acutely injured ligament contains hemorrhage and edema, seen as a bright area interspersed within the dark collagen fibers

Specific coronal views of the cranio-cervical junction to show the position of the odontoid peg

Normal position of the odontoid peg

The alar ligaments are intact (arrows)

The odontoid peg is deviated to the right

The alar ligaments are not clearly seen due to them being damaged

- ✓ Symptomatic activation of previously quiescent Chiari Type I malformations as a result of exposure to traumatic injury has been reported (5 – 8)

5. Milhorat TH, Chou MW, Trinidad EM, Kula RW, Mandell M, Wolpert C, Speer MC. Chiari 1 malformation redefined: clinical and radiographic findings for 364 symptomatic patients. Neurosurgery 1999, 44:1005-1017.

6. Wan MJ, Nomura H, Tator CH. Conversion to symptomatic Chiari I malformation after minor head or neck trauma. Neurosurgery. 2008 Oct;63(4):748-53; discussion 753.

7. Pratticò F, Perfetti P, Gabrieli A, Longo D, Caroselli C, Ricci G. Chiari I malformation with syrinx: an unexpected diagnosis in the emergency department. Eur J Emerg Med. 2008 Dec;15(6):342-3.

8. Bunc G, Vorsic M. Presentation of a previously asymptomatic Chiari I malformation by a flexion injury to the neck. J Neurotrauma. 2001 Jun;18(6):645-8.

Cerebellar Tonsils

- ✓ It is not clear is how trauma plays a role in the activation of symptoms attributed to a Chiari Type I malformation.
- ✓ Are the symptoms merely coincidental to the trauma?
- ✓ Is the condition symptomatically “awakened” by the trauma?
- ✓ Could the Chiari be caused by the trauma?
- ✓ This last question is important, since quite often the presence of tonsular ectopia is not discovered until after trauma, and acquired tonsular herniation is radiographically indistinguishable from a pre-existing Chiari Type I (9)

9. Payner TD, Prenger E, Berger TS, Crone KR. Acquired Chiari malformations: incidence, diagnosis, and management. Neurosurgery. 1994 Mar;34(3):429-34.

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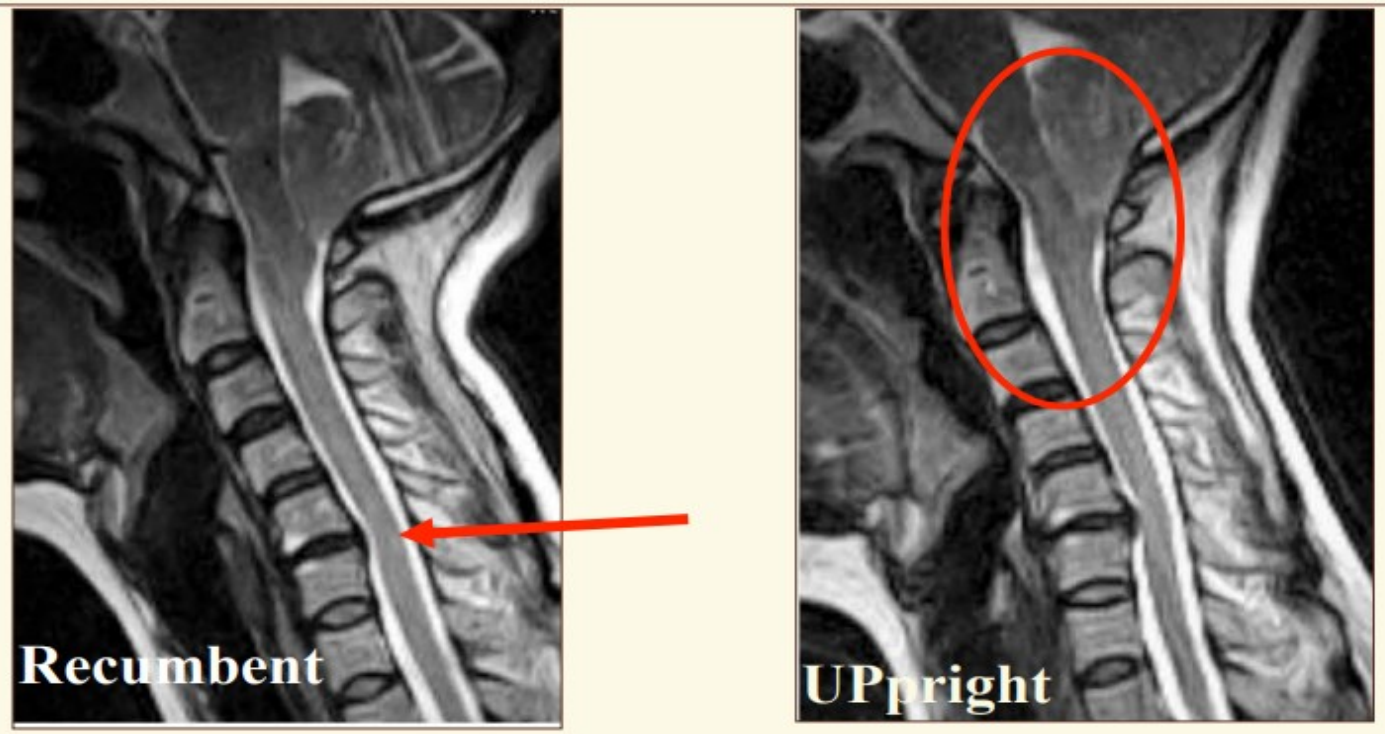
The recumbent cervical MRI shows a C5-6 disc bulge in a patient with neck pain which sometimes radiates to the arms



The **UPRIGHT** MRI shows a position-related downward herniation (Chiari I malformation) with compression of the brain stem. This correlates with the additional complaints of dizziness and occasional drop attacks when bending forward.

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Long Term Consequences of Whiplash Injury
Published Research Studies

Symptoms: Neck Pain and Stiffness; Shoulder Stiffness; Headaches; Tinnitus
Dizziness, Vertigo, Light-headedness, Unsteadiness

10.8 years POST INJURY:
researchers reviewed 43 patients OF WHICH only 12% had recovered completely 88% suffered from residual symptoms.
Gargan MF, Bannister GC. Long-Term Prognosis of Soft-Tissue Injuries of the Neck. Journal of Bone and Joint Surgery (British); Vol. 72-B, No. 5, September 1990, pp. 901-3.

15.5 years after injury:
The authors documented that 70% of the patients continued to complain of symptoms referable to the original accident.
Squires B, Gargan MF, Bannister CG. Soft-tissue Injuries of the Cervical Spine: 15-year Follow-up. Journal of Bone and Joint Surgery (British). November 1996, Vol. 78-B, No. 6, pp. 955-7.

17 years after injury:
The authors documented that 55% of the patients still suffered from pain caused by the original trauma 17 years later.
Bunketorp L, Nordholm L, Carlsson J; A descriptive analysis of disorders in patients 17 years following motor vehicle accidents; European Spine Journal, June 2002; 11:227-234.

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Common Possibilities

I. How Can MRIs Miss Injuries (False Negative)?

A. Scanning in the wrong position?
B. Scanning in the wrong Location?
C. Eye-Balling only without Measurements?

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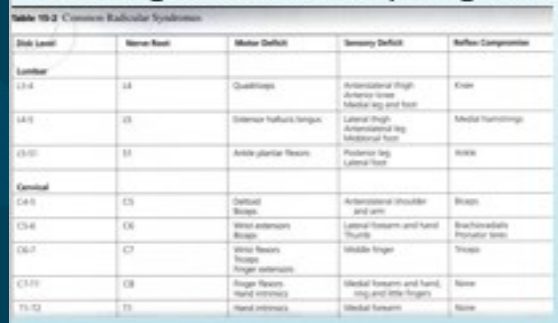
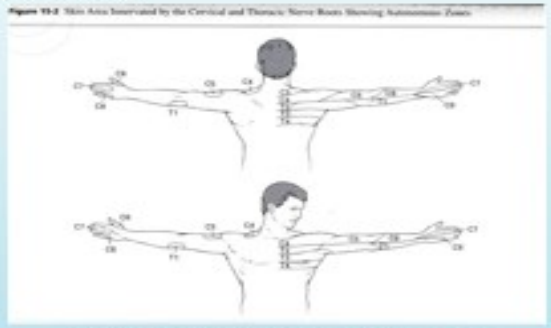
AMA Guides Based Anatomical Measurements for Ligamentous Damage and Instability in the Spine

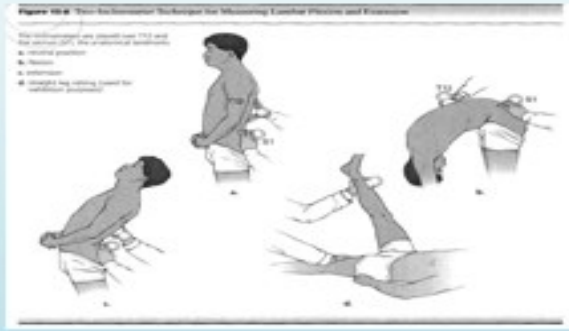
Time Intensive Reporting: Clinical + Anatomical Assessments

Detailed Clinical Examination (e.g., Spasms, Radiculopathy, motor and sensory neurological assessments, Range of Motion, etc...)



Disk Level	Nerve Root	Motor Deficit	Sensory Deficit	Reflex Compromise
Lumbar				
L3-4	L4	Quadriceps	Anterolateral thigh Anterior knee Medial leg and foot	Knee
L4-5	L5	Extensor hallucis longus	Lateral thigh Anterolateral leg Midplantar foot	Medial hamstrings
L5-S1	S1	Ankle plantar flexors	Posterior leg Lateral foot	Ankle
Cervical				
C4-5	C5	Deltoid Biceps	Anterolateral shoulder and arm	Biceps
C5-6	C6	Wrist extensors Biceps	Lateral forearm and hand Thumb	Brachioradialis Pronator teres
C6-7	C7	Wrist flexors Triceps Finger extensors	Middle finger	Triceps
C7-T1	C8	Finger flexors Hand intrinsics	Medial forearm and hand, ring and little fingers	None
T1-T2	T1	Hand intrinsics	Medial forearm	None





Detailed Anatomical Analyses

(e.g., Angular Motion, Translation motion; Fractures; Intervertebral Discs or other soft tissue lesions; Spondylolysis, Spondylolisthesis, Spinal Stenosis, Segmental Instability : Operated on or non-Operated on, etc...)

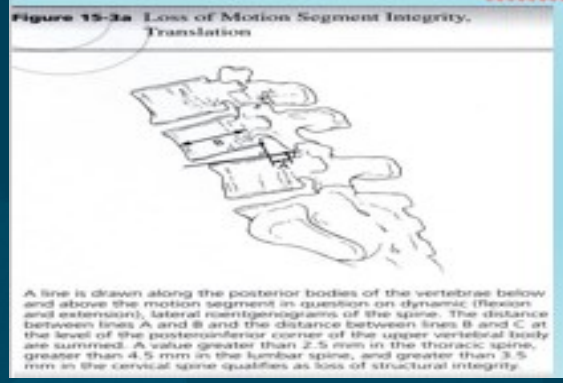


Figure 15-3a Loss of Motion Segment Integrity, Translation

A line is drawn along the posterior bodies of the vertebrae below and above the motion segment in question on dynamic (flexion and extension), lateral roentgenograms of the spine. The distance between lines A and B and the distance between lines B and C at the level of the posteroinferior corner of the upper vertebral body are summed. A value greater than 2.5 mm in the thoracic spine, greater than 4.5 mm in the lumbar spine, and greater than 3.5 mm in the cervical spine qualifies as loss of structural integrity.

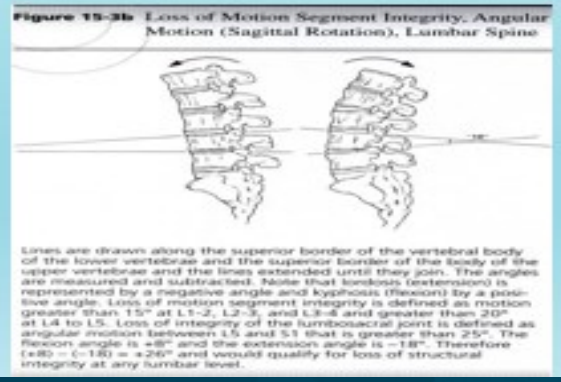


Figure 15-3b Loss of Motion Segment Integrity, Angular Motion (Sagittal Rotation), Lumbar Spine

Lines are drawn along the superior border of the vertebral body of the lower vertebrae and the superior border of the body of the upper vertebrae and the lines extended until they join. The angles are measured and subtracted. Note that lordosis (extension) is represented by a negative angle and kyphosis (flexion) by a positive angle. Loss of motion segment integrity is defined as motion greater than 15° at L1-2, L2-3, and L3-4 and greater than 20° at L4 to L5. Loss of integrity of the lumbosacral joint is defined as angular motion between L5 and S1 that is greater than 25°. The flexion angle is +8° and the extension angle is −18°. Therefore (+8) − (−18) = +26° and would qualify for loss of structural integrity at any lumbar level.

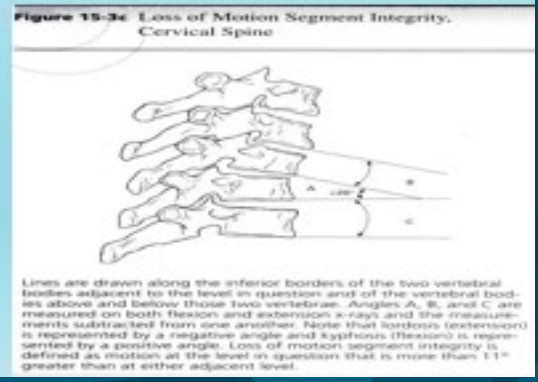


Figure 15-3c Loss of Motion Segment Integrity, Cervical Spine

Lines are drawn along the inferior borders of the two vertebral bodies adjacent to the level in question and of the vertebral bodies above and below those two vertebrae. Angles A, B, and C are measured on both flexion and extension x-rays and the measurements subtracted from one another. Note that lordosis (extension) is represented by a negative angle and kyphosis (flexion) is represented by a positive angle. Loss of motion segment integrity is defined as motion at the level in question that is more than 11° greater than at either adjacent level.

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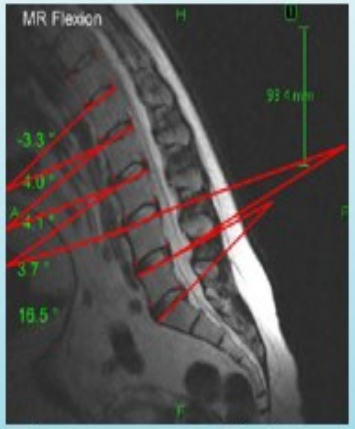
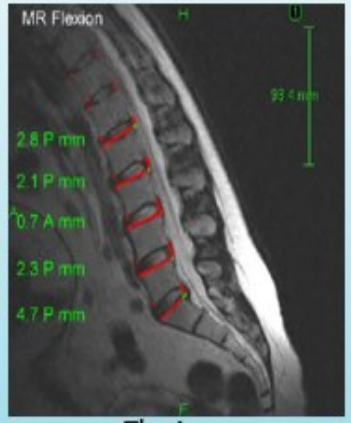
Angular Motion Integrity



Level	Flexion	Extension	Difference
L1-L2	3.3	-4.9	8.2
L2-L3	4.0	-2.5	6.5
L3-L4	4.1	-12.1	16.2*
L4-L5	3.7	15.1	11.4
L5-S1	16.5	24.7	8.2

Translational Motion Integrity



Level	Flexion	Extension	Difference
L1-L2	- 2.8	-2.7	0.1
L2-L3	-2.1	-1.5	0.6
L3-L4	0.7	-3.3	4.0
L4-L5	-2.3	-3.2	0.9
L5-S1	-4.7	-4.5	0.2

EXPERTMRI

Common Possibilities

I. How Can MRIs Miss Injuries (False Negative)?

A. Scanning in the wrong position?
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D. Medical reports missing important MRI information?

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30 Second Radiology Can Be Problematic

Wrong Nomenclature, Misdiagnosis or Missed Diagnosis may Severely Undermine Care and Case Outcome

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Colossus Compliant Nomenclature

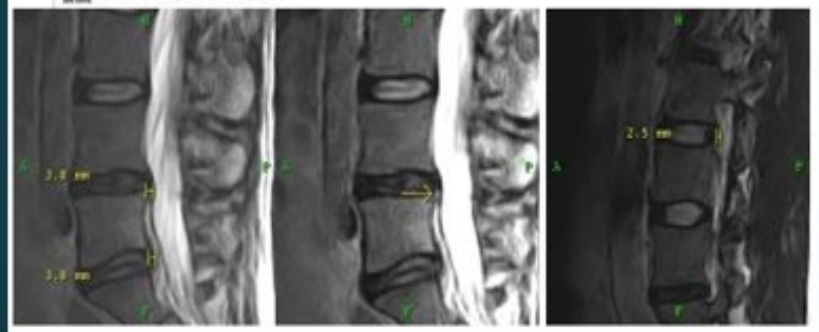
First Read Findings:

CONCLUSION: Mild broad-based central disc protrusion at L4-5 with peripheral annular defect. This results in mild thecal sac compression.

AiM Radiology's Findings (Second Read):

IMPRESSION

1. L2-3, 2.5 mm right paracentral disc protrusion that abuts the thecal sac and produces mild right neuroforaminal narrowing.
2. L4-5, 3.8 mm disc protrusion that abuts the thecal sac and produces mild spinal canal narrowing and moderate left and mild right neuroforaminal narrowing. Posterior annular tear.
3. L5-S1, 3.8 mm disc protrusion that abuts the thecal sac and produces moderate right and mild left neuroforaminal narrowing.



Careful Reporting

First Read Findings:

CONCLUSION: Mild leftward curve of the thoracic spine. No disc pathology.

AiM Radiology's Findings (Second Read):

IMPRESSION

1. Mild old compression fracture at T10. Correlate clinically and comparison with prior imaging may be helpful.
2. T7-8, 2.0 mm cranially dissecting disc extrusion that abuts the thecal sac.
3. T9-10, 2.0 mm disc protrusion that abuts the thecal sac.
4. T11-12, 2.8 mm left paracentral disc protrusion that abuts the thecal sac and produces mild left neuroforaminal narrowing.

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How Frustrating are your MRI Reports?

First Read Findings:

CONCLUSION: Degenerative disc and facet disease as described. No nerve root impingement or spinal stenosis.

AiM Radiology's Findings (Second Read):

IMPRESSION

- Mild spinal canal narrowing at L2/L3 - L4/L5 due to facet arthrosis and disc bulges.
- Moderate degenerative disc disease with a small to moderate circumferential disc bulge that effaces the thecal sac at L4/L5. There is bilateral hypertrophy of the facet joints.
- Mild degenerative disc disease with a small to moderate circumferential disc bulge that effaces the thecal sac at L3/L4. There is bilateral hypertrophy of the facet joints.
- Moderate degenerative disc disease with a small to moderate circumferential disc bulge that effaces the thecal sac at L2/L3. There is bilateral hypertrophy of the facet joints.
- Moderate degenerative disc disease with a small to moderate circumferential disc bulge that effaces the thecal sac at L1/L2.
- Moderate degenerative disc disease with a small circumferential disc bulge that effaces the thecal sac at L5/S1.
- Probable lumbosacral transitional segment at L5. Comparison with radiography to confirm vertebral level is recommended.

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Common Possibilities

I. How Can MRIs Miss Injuries (False Negative)?

A. Scanning in the wrong position?
B. Scanning in the wrong Location?
C. Eye-Balling only without Measurements?
D. Medical reports missing important MRI information?
E. Exam Doesn't get done?
    A. Claustrophobia, Sedation, Patient Size/Weight, Inability to lay down, Radiation Exposure of Modality

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Scoliosis and Increased Radiation Exposure

Scoliosis occurs in approximately 2 percent of girls and 0.5 percent of boys. It is commonly diagnosed in early adolescence and may gradually progress as rapid growth occurs. Scoliosis patients typically undergo routine X-rays of the spine throughout their adolescent growth spurt to monitor curvature progression so that corrective action may be taken. The [redacted] in the study, who received an average of [redacted], were found to have a [redacted] than women in the general population. J. Of Spine, 2000.

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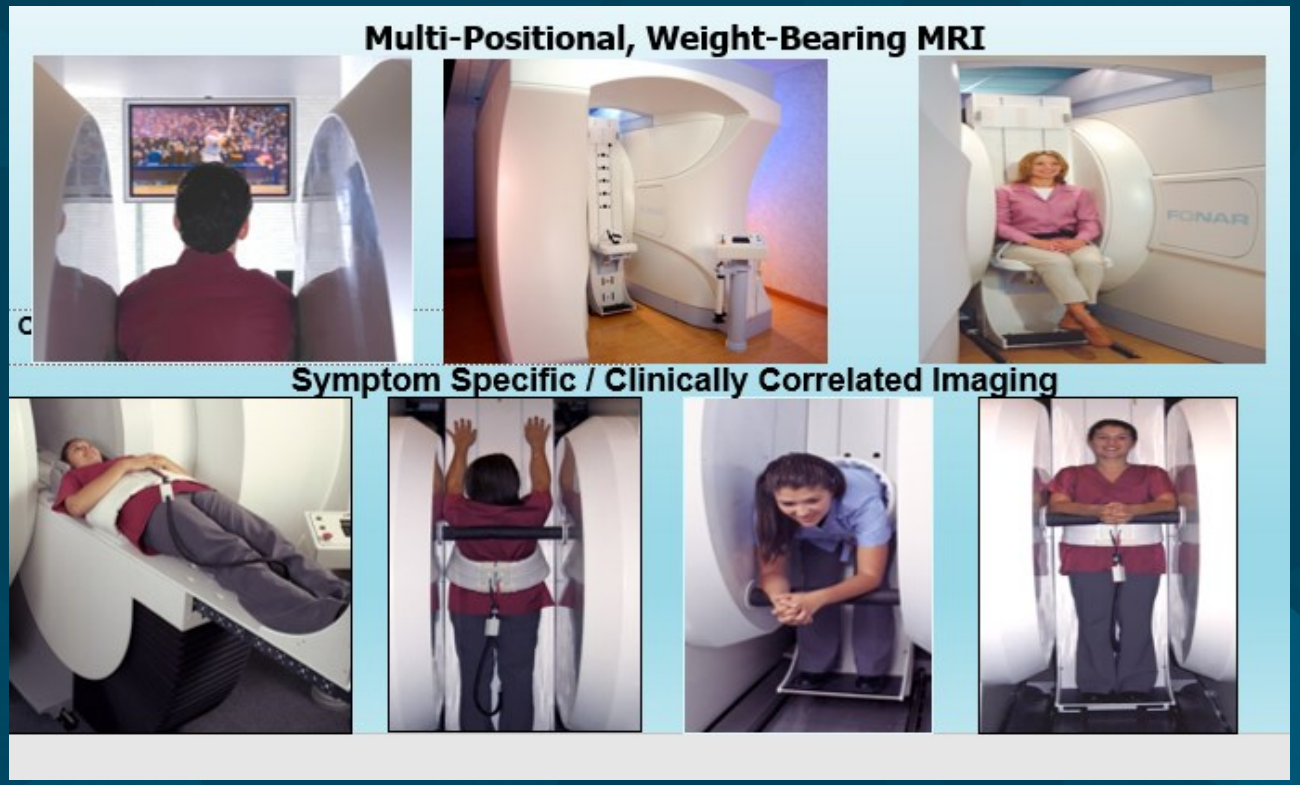
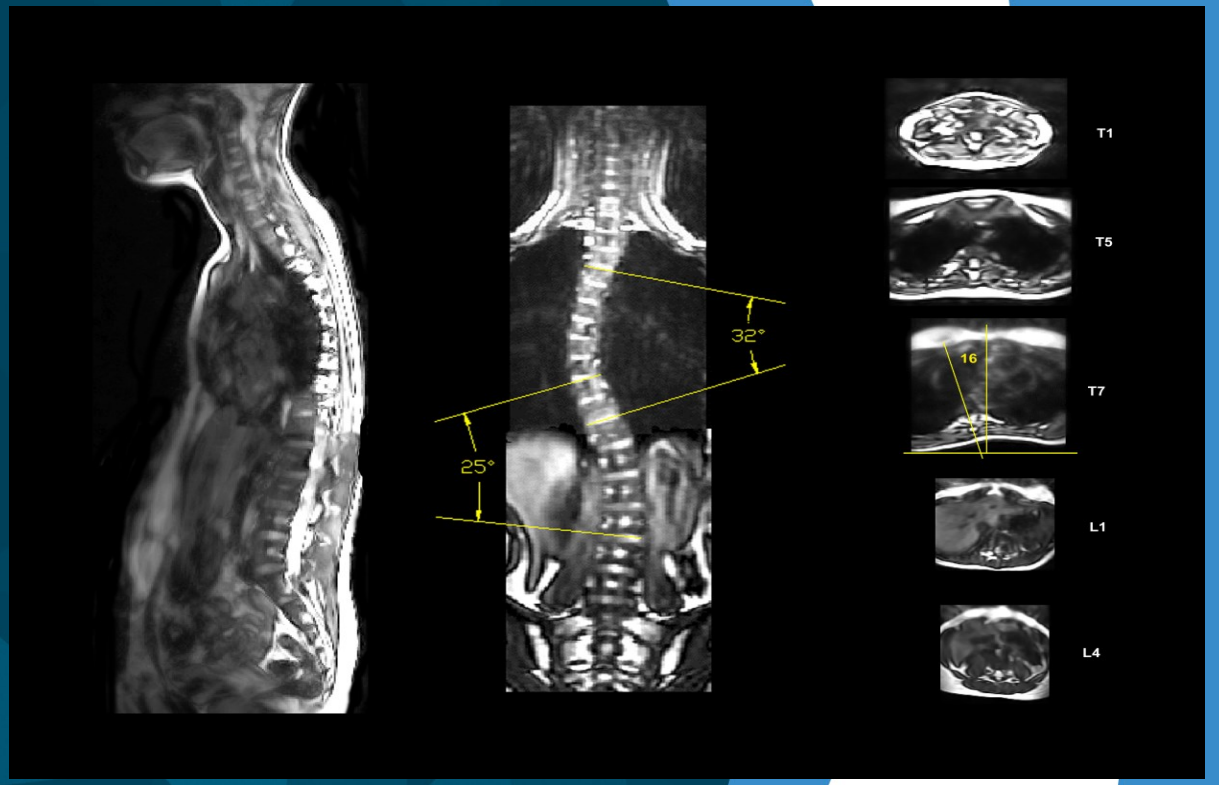
StandUp MRI:
A No Radiation Alternative for Scoliosis Imaging





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