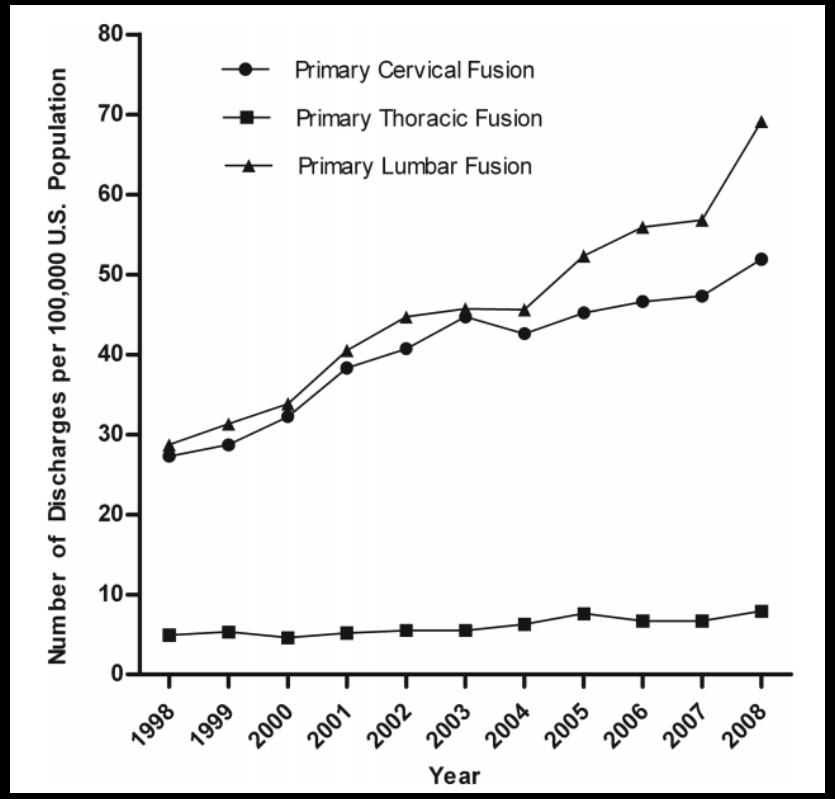
Spine

Postoperative

Takashi Takahashi

Epidemiology (1998 to 2008)

- Spine Fusion is rapidly growing surgery
  - **2.4x** (137%) from 174,223 to 413,171
    - Laminectomy (11.3%)
    - Hip replacement (49.1%)
    - Knee arthroplasty (126.8 %)
    - PTCA (38.8%)
    - CABG (-40.1%)
- Mean age: 48.8→54.2 years
- Mortality rate: 0.29% → 0.25%
- National Bill: 7.9x
  - 4.3 billion → **33.9 billion**



Rajaee, Sean S, Hyun W Bae, Linda E A Kanim, and Rick B Delamarter. 2012. "Spinal Fusion in the United States: Analysis of Trends from 1998 to 2008." *Spine* 37(1): 67–76.

Why spine fusion?

TABLE 5. Most Common Primary Diagnoses Prior to Spinal Fusion in Order of Frequency for 2008 in Comparison With 1998 Data

Primary Diagnosis	ICD-9-CM	2008, % (Frequency)	1998, % (Frequency)
Degenerative disc disease, lumbar	722.52	13.8 (57,046)	9.1 (15,907)
Displacement of disc without myelopathy, cervical	722.0	12.2 (50,428)	19.6 (34,122)
Spinal stenosis, lumbar	724.02	9.0 (37,124)	6.8 (11,774)
Displacement of disc without myelopathy, lumbar	722.1	8.6 (35,329)	10.6 (18,513)
Acquired spondylolisthesis	738.4	6.7 (27,776)	6.7 (11,631)
Spondylosis without myelopathy, cervical	721.0	5.4 (22,396)	5.5 (9677)
Spondylosis with myelopathy, cervical	721.1	5.3 (21,698)	3.6 (6185)
Spondylosis without myelopathy, lumbar	721.3	5.1 (21,175)	3.7 (6514)
Intervertebral disc disorder with myelopathy, cervical	722.71	4.5 (18,670)	3.5 (6065)
Degenerative disc disease, cervical	722.4	3.5 (14,326)	2.0 (3504)
Spinal stenosis, cervical	723.0	3.2 (13,224)	1.6 (2839)
Congenital spondylolisthesis, lumbar	756.12	3.0 (12,284)	2.0 (3471)
Scoliosis (and kyphoscoliosis), idiopathic	737.3	2.3 (9427)	3.0 (5211)

% indicates proportion of all spinal fusion (CCS 158) discharges per year.
CCS indicates clinical classification software; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

ASNR Nomenclature

- Most widely accepted nomenclature standard
- Based on the morphology and pathology
- Lumbar spine disks
- Do **NOT**
  - Imply etiology
  - Suggest type of treatment
  - Distinguish between symptomatic and asymptomatic

http://www.asnr.org/spine_nomenclature

General Classifications

Normal

Congenital/developmental variant

Degenerative/traumatic lesion

Inflammation/infection

Neoplasia

Morphologic variant of unknown significance

Degenerative/Traumatic Lesion

Annular tear

Herniation

- Protrusion
- Extrusion
- Intravertebral

Degeneration

- Spondylosis deformans
- Intervertebral osteochondrosis

Degeneration

- **Spondylosis deformans** (Age related change)
  - Affects annulus fibrosus and apophyses
- **Intervertebral osteochondrosis** (Pathologic)
  - Affects nucleus pulposus, endplates, and extensive fissuring of the annulus fibrosus
  - Pathologic degeneration

Intervertebral Disk Degeneration

Intervertebral Disk Anatomy

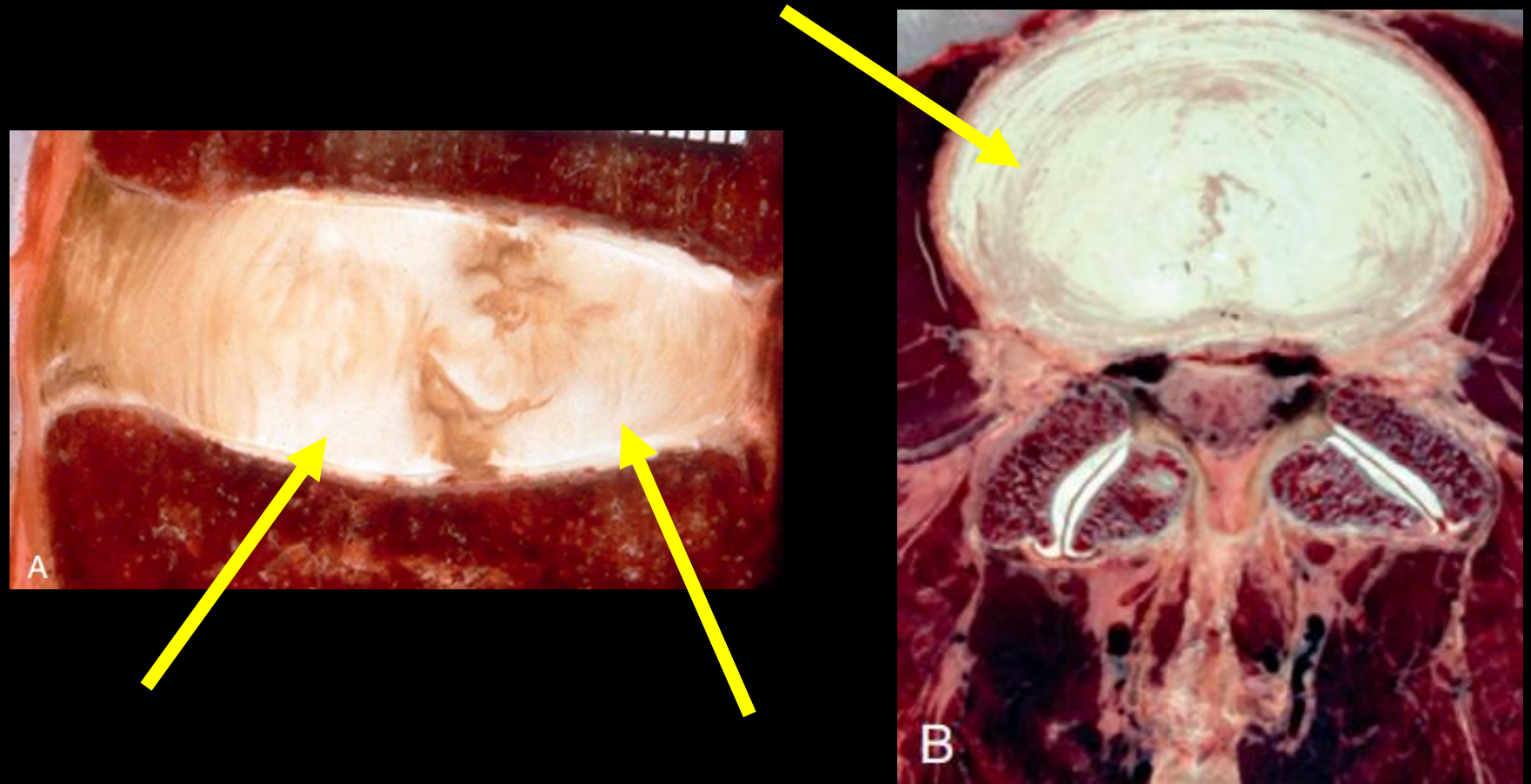
- Outer annulus fibrosus
- Inner annulus fibrosus
- Nucleus pulposus

Outer annulus fibrosus

- Thick lamellae of dense connective tissue (collagen)

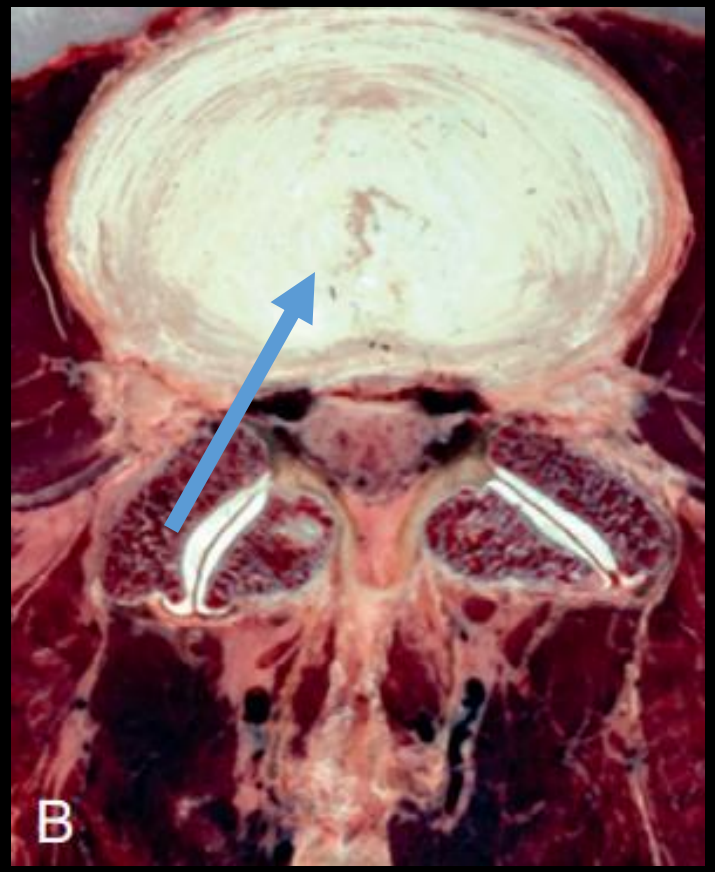
Inner annulus fibrosus

- Cartilaginous matrix associated with collagen fibers

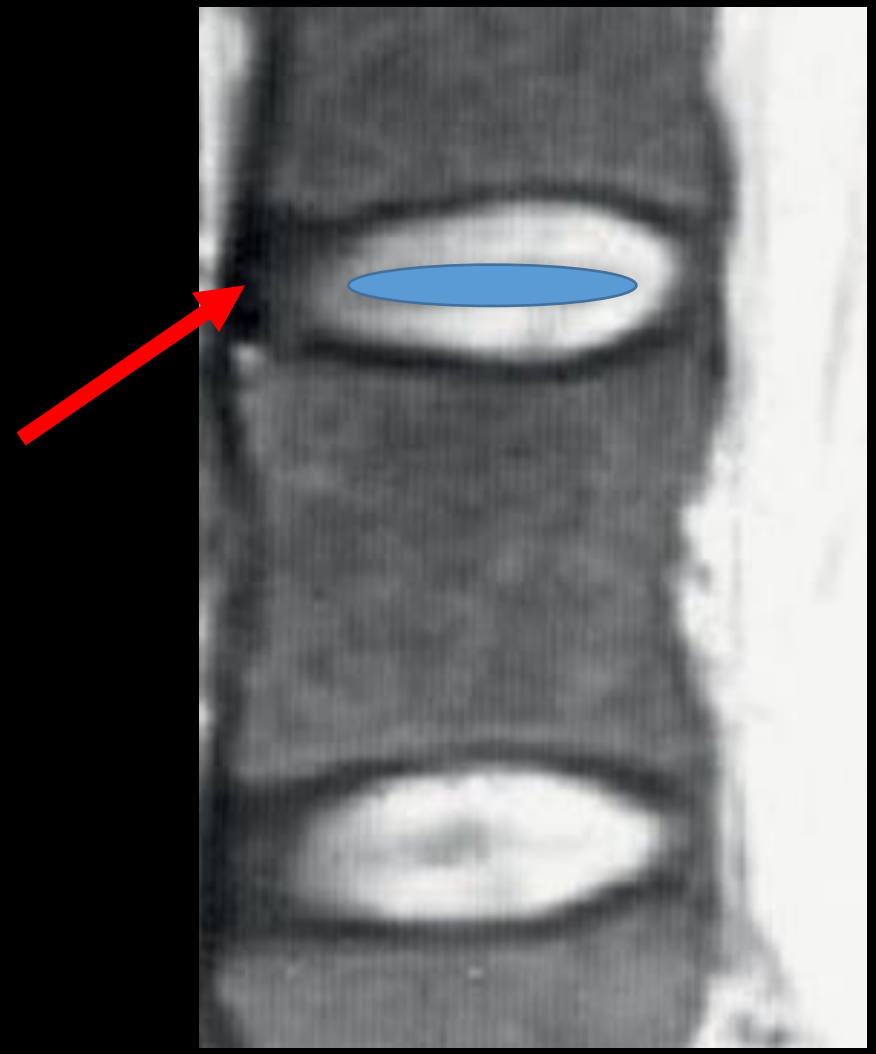


Nucleus pulposus

- Amorphous with less fibers, and relatively high glycosaminoglycans and water

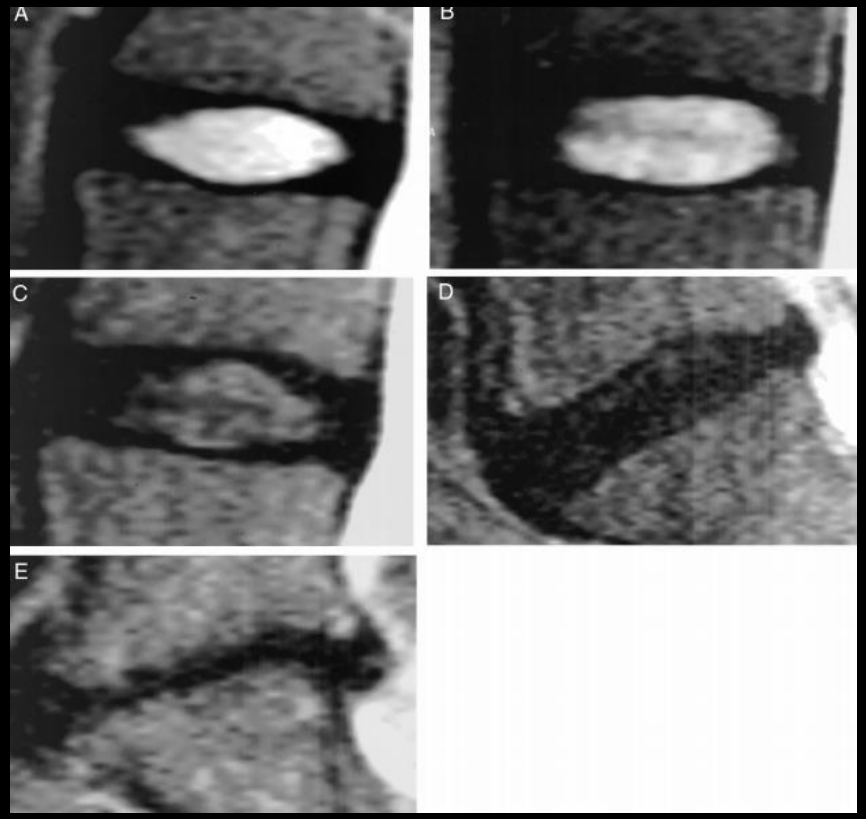


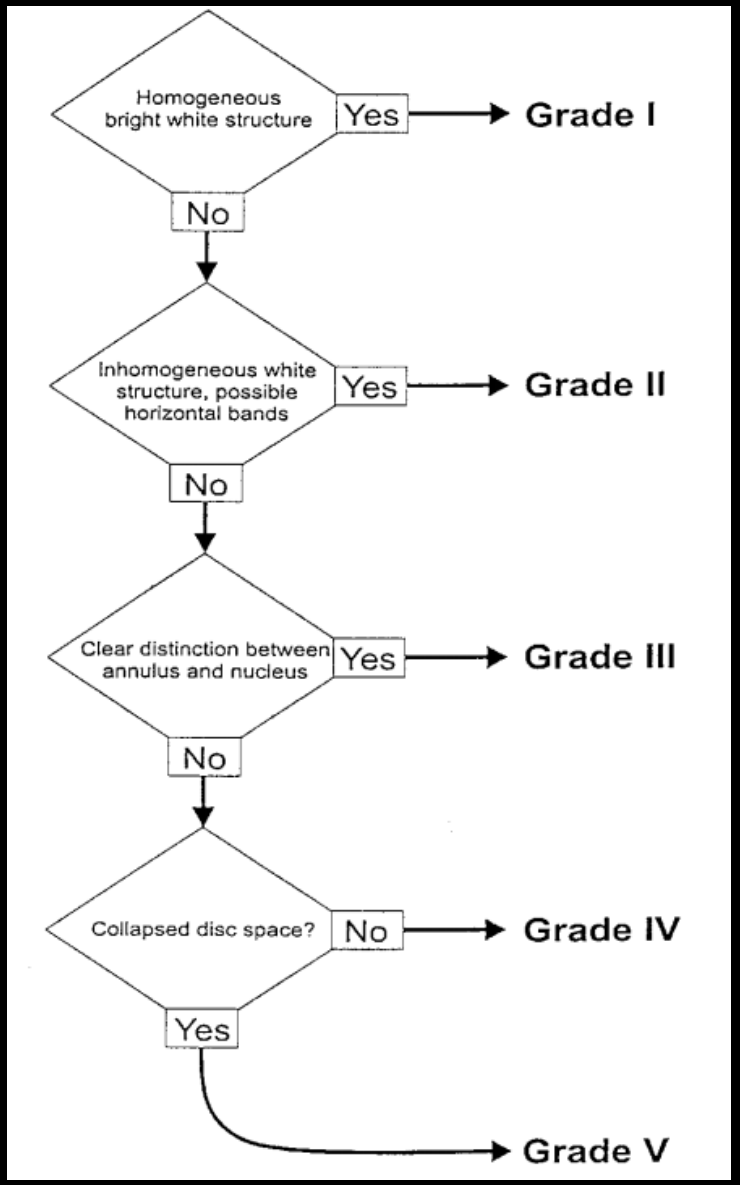
Intervertebral Disk Anatomy



Disk Degeneration

- Pfirrmann Grading System





SPINE Volume 26 (2001), Number 17, pp 1873–1878

Modified Pfirrmann Grading System

- Pfirmann grading system did not prove discriminatory when assessing elderly spine
- 5 level grading → 8 level grading

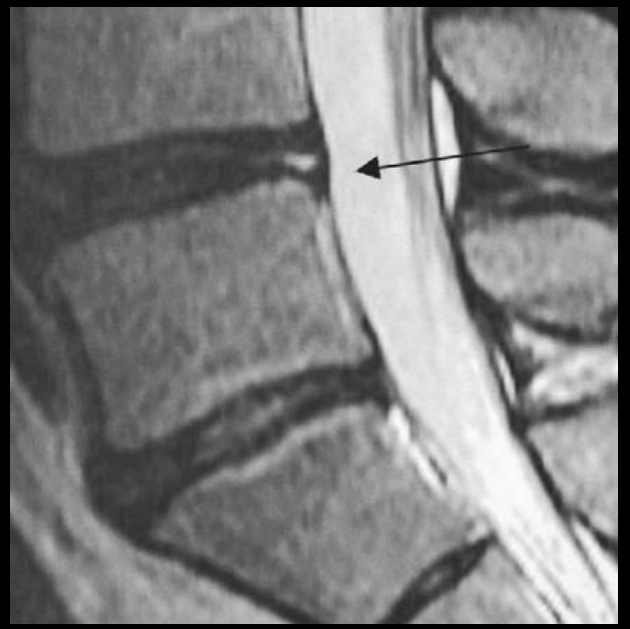
Table 1. Modified Grading System for Lumbar Disc Degeneration*

Grade	Signal From Nucleus and Inner Fibers of Anulus	Distinction Between Inner and Outer Fibers of Anulus at Posterior Aspect of Disc	Height of Disc
1	Uniformly hyperintense, equal to CSF	Distinct	Normal
2	Hyperintense (>presacral fat and <CSF) ± hypointense intranuclear cleft	Distinct	Normal
3	Hyperintense though <presacral fat	Distinct	Normal
4	Mildly hyperintense (slightly >outer fibers of anulus)	Indistinct	Normal
5	Hypointense (= outer fibers of anulus)	Indistinct	Normal
6	Hypointense	Indistinct	<30% reduction in disc height
7	Hypointense	Indistinct	30%–60% reduction in disc height
8	Hypointense	Indistinct	>60% reduction in disc height

SPINE Volume 32 (2007), Number 24, pp E708 –E712

Annular Tear/Fissure

- Tear of the anular fibrosus inner fibers +/- outer fibers
- Does not imply traumatic etiology
- Tear = Fissure ≠ Rupture



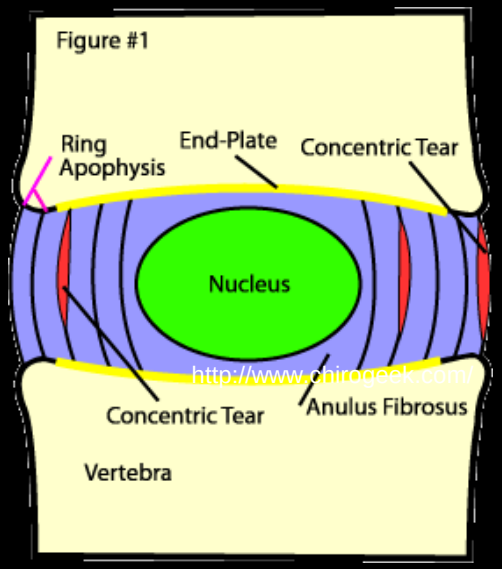
Anular Tear/Fissure

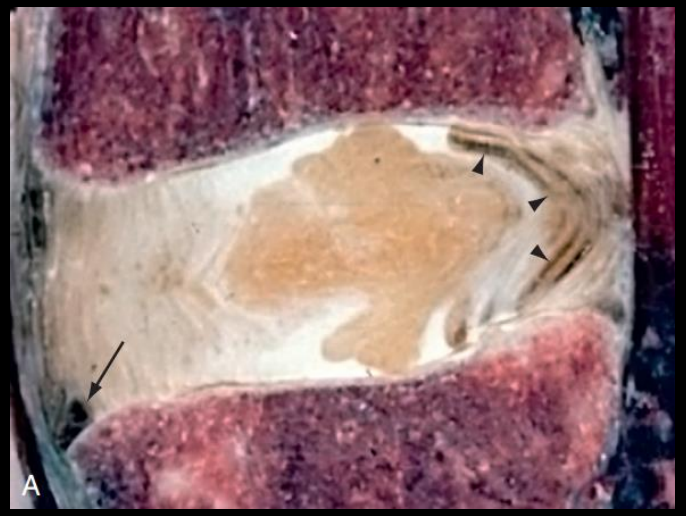
Type		
I	Concentric	Rupture of transverse fibers Ovoid/crescent shaped Not seen on MR
II	Radial	Rupture of longitudinal fibres Linear Shape
III	Transverse	Rupture of Sharpey's fibers Irregular fluid filled cavities at the periphery of annulus

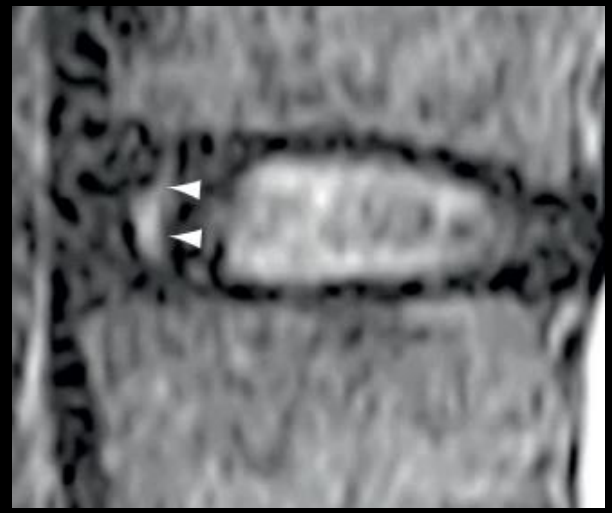
Bailey, W. M. (2006). A practical guide to the application of AJNR guidelines for nomenclature and classification of lumbar disc pathology in magnetic resonance imaging (MRI). Radiography, 12(2), 175-182.

Concentric Tear

- Delamination type tear between the adjacent lamellae.
- Craniocaudally oriented curvilinear high signal intensity

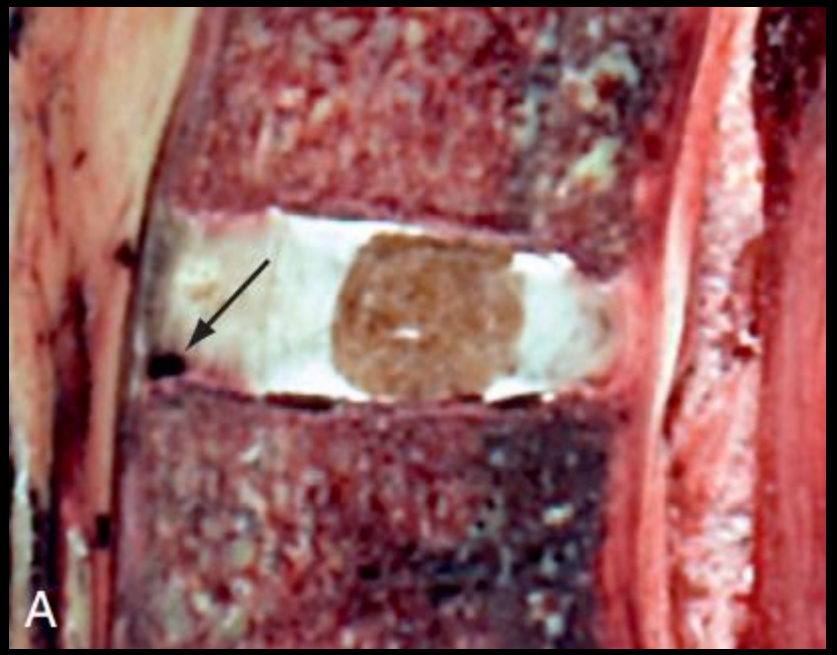


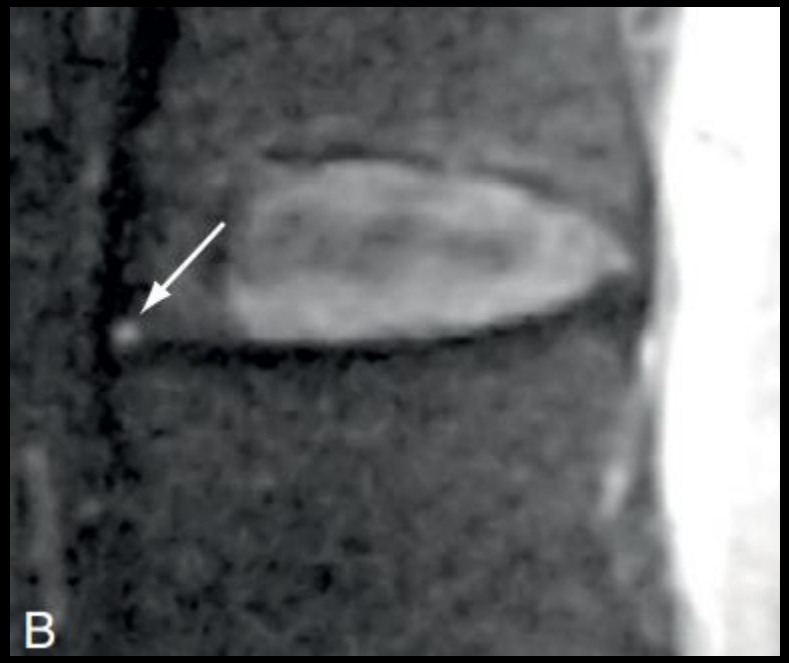




Transverse Tear

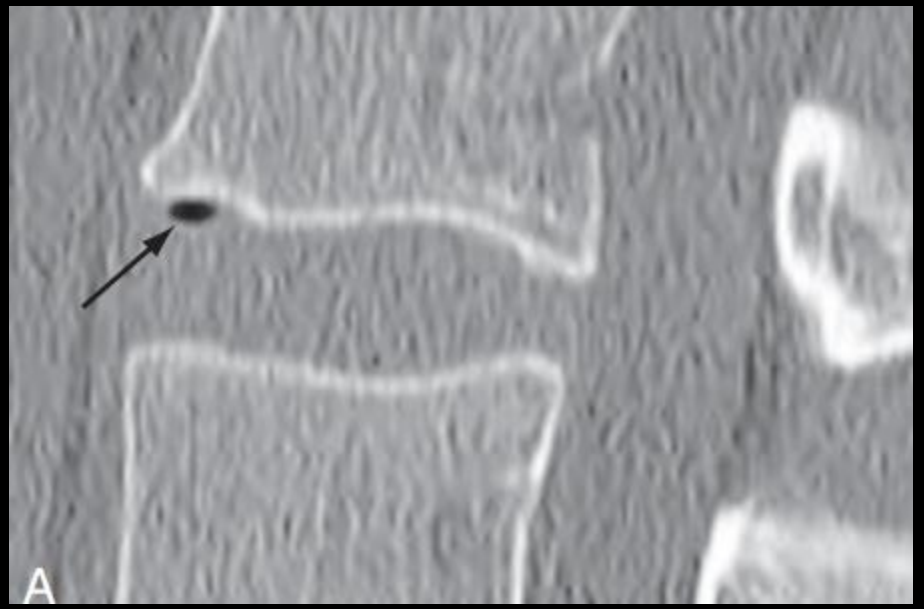
- Tear in one or more layers of the annulus fibrosus at the insertion into the ring apophysis
- Small focus of high signal intensity in the peripheral annulus fibrosus





Transverse Tear

- Gas may accumulate within the tear.



Asymptomatic Annular Tears

- Concentric tear
- Transverse tear

Radial Tear

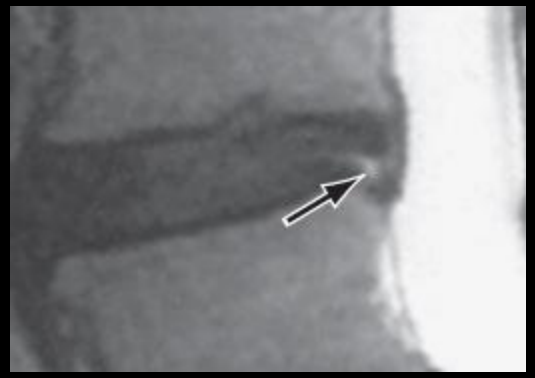
- Tear extending all layers of the annulus fibrosus from interior to the periphery
- Characteristic of all degenerative IVD
- Mother of all herniation

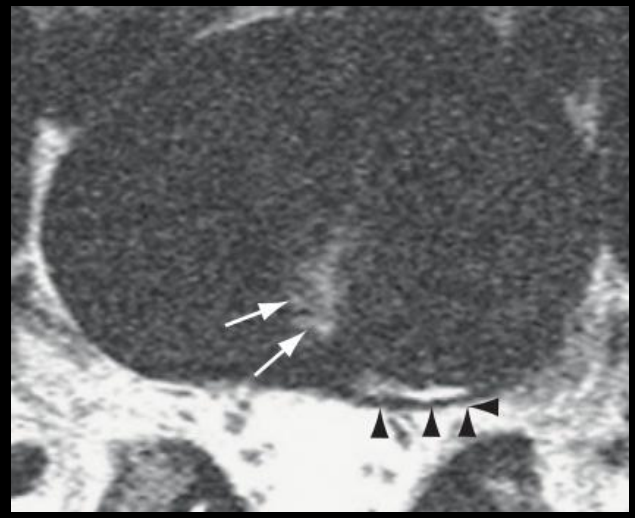
Symptomatic Radial Tear

- Disk Herniation
- Granulation Tissue Ingrowth
  - Clinically mimic radiculopathy of a herniated disk
- Adjacent inflammation
- Altered Biomechanics (hypothetical)
- Occult spinal stenosis

Radial Tear: Imaging Appearance

- Linear or irregular high signal intensity within annulus
- Dessication of Disc
- Herniation
- Disk height loss and collapse





T2 hyperintensity & Enhancement = Acute?

RESULTS: **Annular tears were observed at 29 levels in 18 patients. Two tears developed during the follow-up interval. When contrast-enhanced images were obtained during serial examinations, 10 (100%) of 10 enhancing annular tears persisted on the follow-up contrast-enhanced T1-weighted images (mean interval, 17.2 months; SD, 12.3 months). High signal intensity on T2-weighted MR images was noted in 26 (96%) of 27 tears initially and persisted in 23 (88%) of 26 (mean interval, 21.9 months; SD, 15.0 months).**

CONCLUSION: **Hyperintensity on T2-weighted MR images and enhancement of annular tears could not be used to determine the tears' acuity over the range of follow-up provided in this study.**

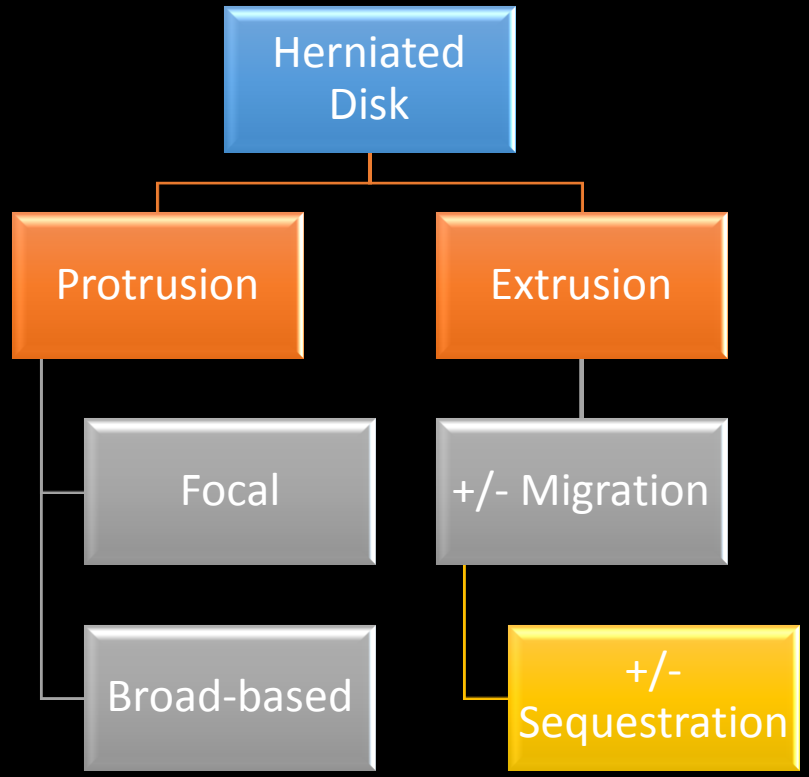
Munter, Fletcher M., Bruce A. Wasserman, Hsiu-Mei Wu, and David M. Yousem. 2002. "Serial MR Imaging of Annular Tears in Lumbar Intervertebral Disks." *American Journal of Neuroradiology* 23 (7) (8–1): 1105–1109. http://www.ajnr.org/content/23/7/1105.

Key Point

- Radial tear is pathologic i.e. intervertebral osteochondrosis.
- Other annular tears (transverse and circumferential) are age related i.e. spondylosis deformans.

Herniation

- General term refers to localized displacement (**<50%** of circumference) of disc material beyond the normal margins of the intervertebral disk space.



Protrusion

- “A herniated disc in which the greatest distance, in any plane, between the edges of the disc material beyond the disc space is less than the distance between the edges of the base in the same plane.”

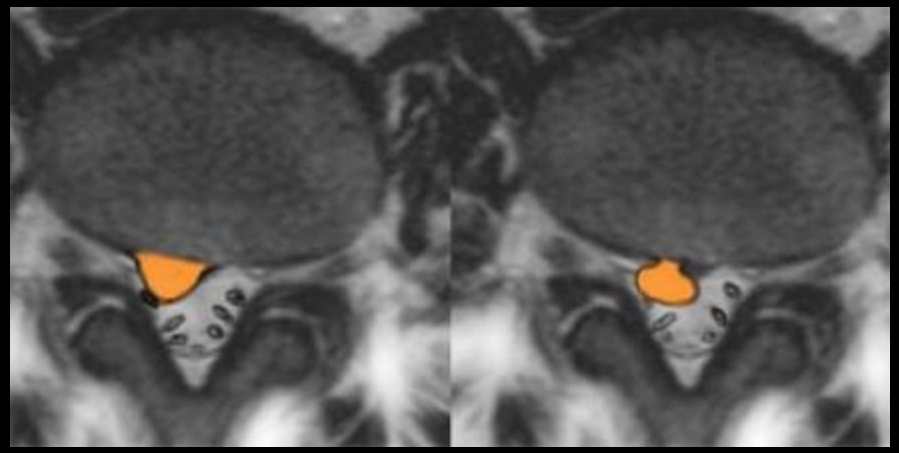
Protrusion

- Focal protrusion (< 25%)
- Broad based protrusion (25-50%)

http://www.radiologyassistant.nl/en/p423d18702d2bd/disc-nomenclature.html

Extrusion

- “ A herniated disc in which, in at least one plane, any one distance between the edges of the disc material beyond the disc space is greater than the distance between the edges of the base in the same plane, or when no continuity exists between the disc material beyond the disc space and that within the disc space.”



http://www.radiologyassistant.nl/en/p423d18702d2bd/disc-nomenclature.html

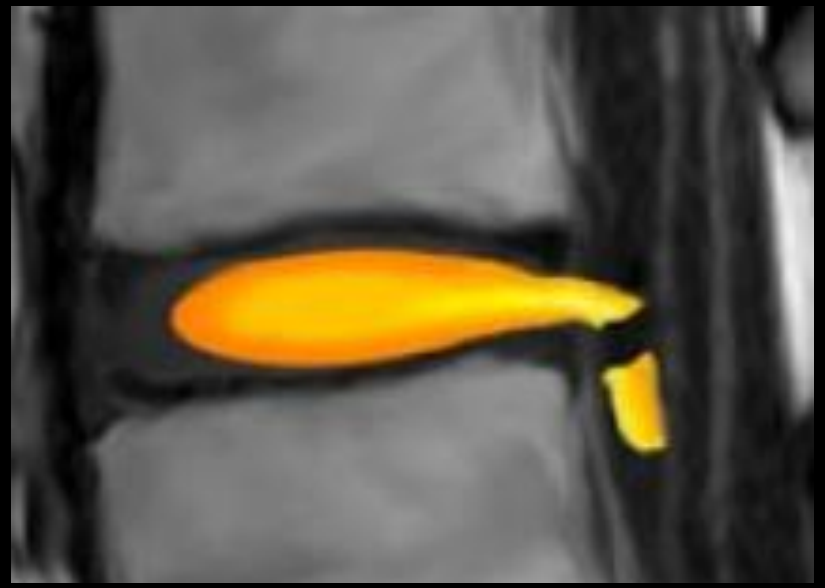
Migration

- “Herniated disc in which a portion of extruded disc material is **displaced away from the tear** in the outer annulus through which it has extruded.”

http://www.radiologyassistant.nl/en/p423d18702d2bd/disc-nomenclature.html

Sequestration

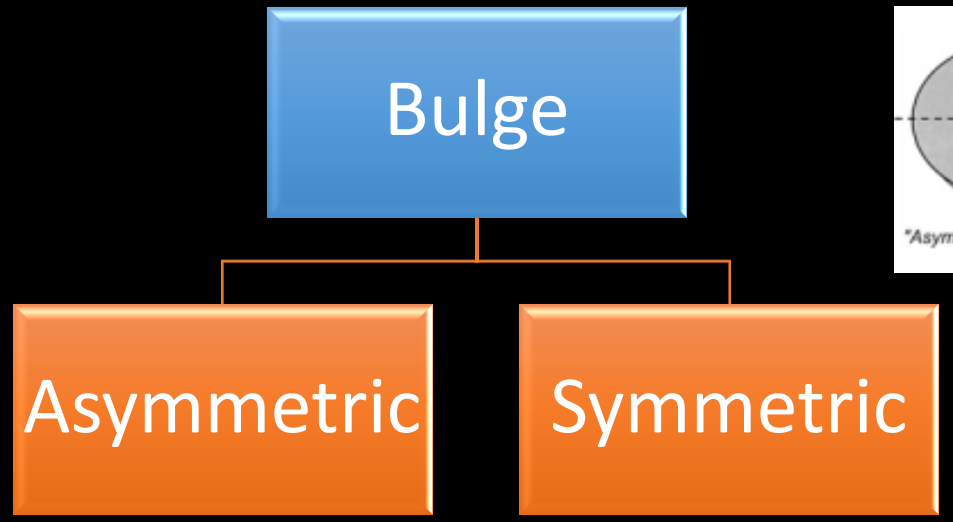
- “ An extruded disc in which a portion of the disc tissue is displaced beyond the outer anulus and maintains no connection by disc tissue with the disc of origin.”

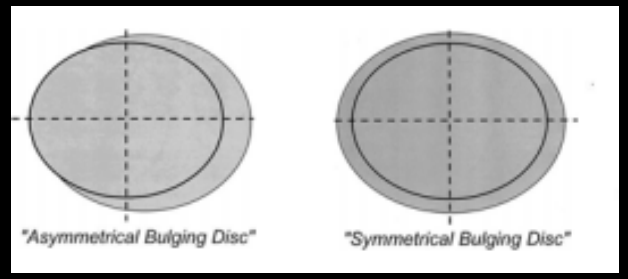


http://www.radiologyassistant.nl/en/p423d18702d2bd/disc-nomenclature.html

Bulge

- ”A disc in which the contour of the outer anulus extends, or appears to extend, in the horizontal (axial) plane beyond the edges of the disc space, over **greater than 50%** (180 degrees) of the circumference of the disc and usually less than 3mm beyond the edges of the vertebral body apophyses.”





Key Point

- ASNR Terminology for reporting consistency
- ASNR Terms does not imply symptoms

Preoperative Imaging

Vertebral Count

- Up to 50% of neurosurgeons may perform wrong-level spine surgery at some point in their career.

JBJS Reviews, 2014 Mar

- Counting from C2 is most reliable.
- Lumbar spine is most common site of anatomic variation.

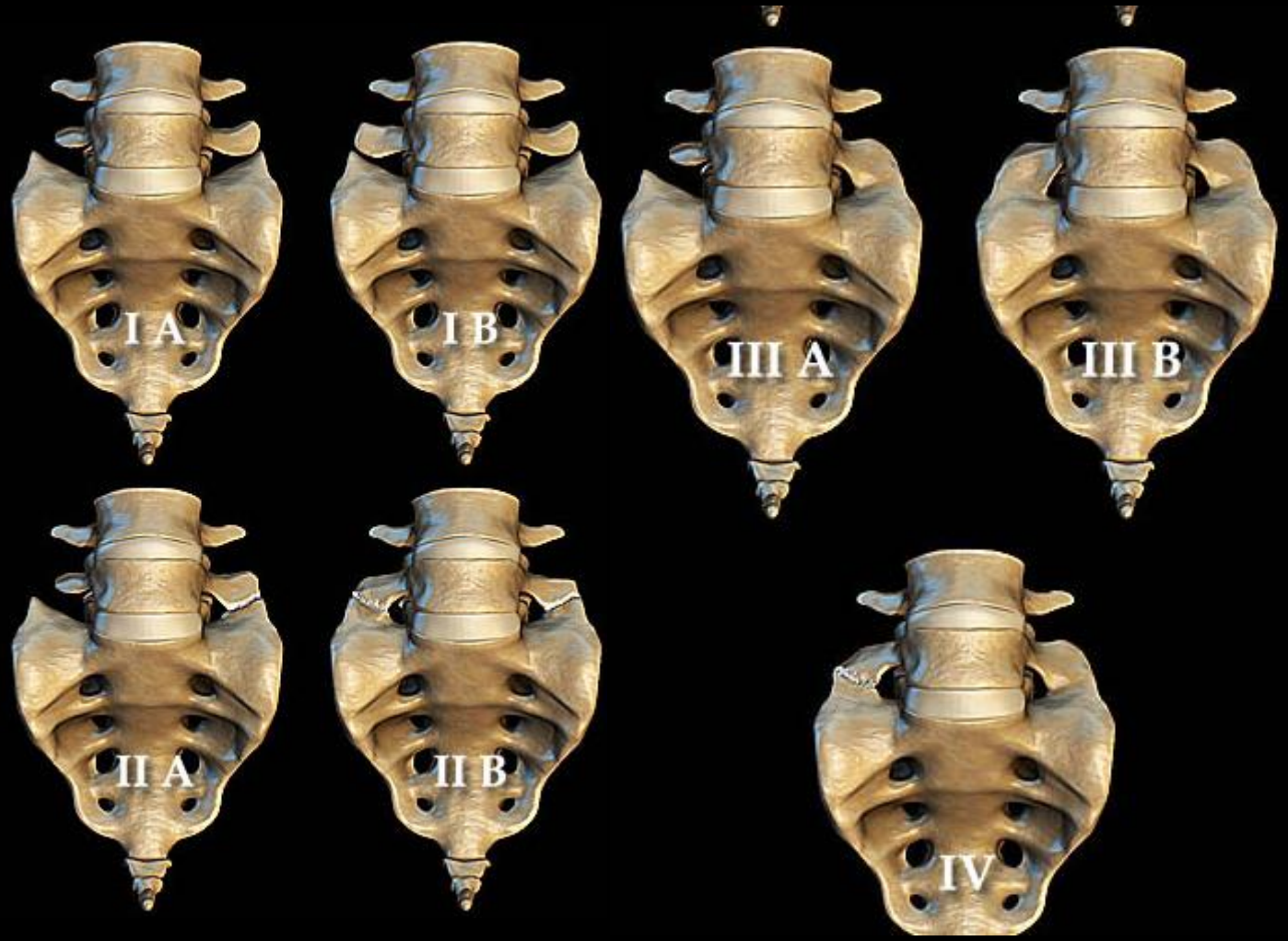
No. of Lumbar-Type Vertebrae	Total No. (%)	Male (%)	Female (%)
3	1 (0.13)	0 (0.00)	1 (0.13)
4	40 (5.33)	15 (2.00)	25 (3.33)
5	600 (80.00)	322 (42.93)	278 (37.07)
6	109 (14.53)	69 (9.20)	40 (5.33)
total	750 (100.00)	406 (54.13)	344 (45.87)

J Neurosurg: Spine / Volume 12 / January 2010

Lumbosacral Transitional Anatomy

- Common 5% to >35%
- Surgical planning
- Potential source of pain (?)

Castellvi Classification System



http://www.radsource.us/clinic/1312

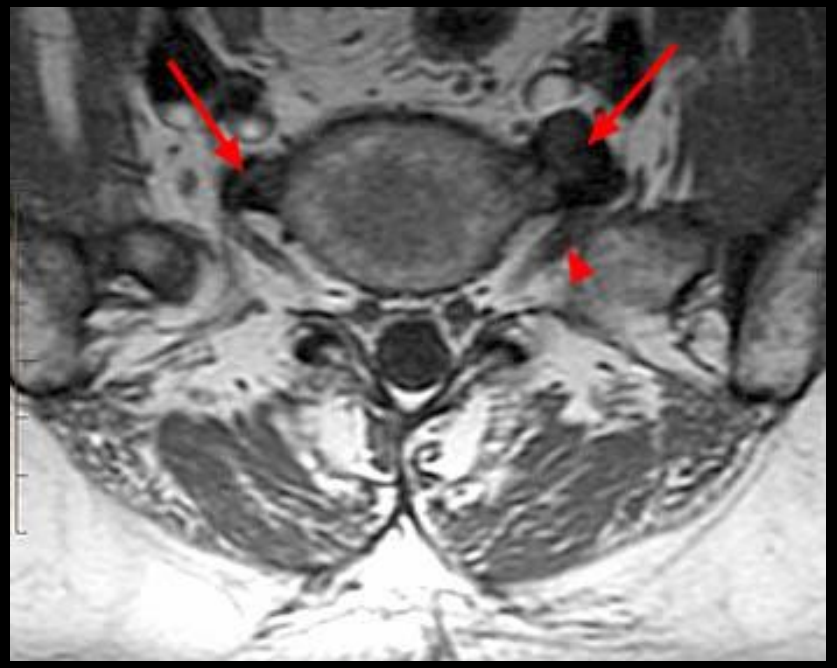
Type	Description
I	Enlarged L5 transverse process unilaterally (A) or bilaterally (B)
II	Diarthroidal joint between the enlarged transverse process and the sacrum i.e. pseudoarthrosis unilaterally (A) or bilaterally (B)
III	Solid fusion unilaterally (A) or bilaterally (B)
IV	Mixed fusion and pseudoarthrosis

L5 or S1?

- Functional L5 nerve root originates at the most caudal "mobile"
  - For type I and II (pseudoarthrosis), L5
  - For type III (fusion), S1

Bertolotti's Syndrome

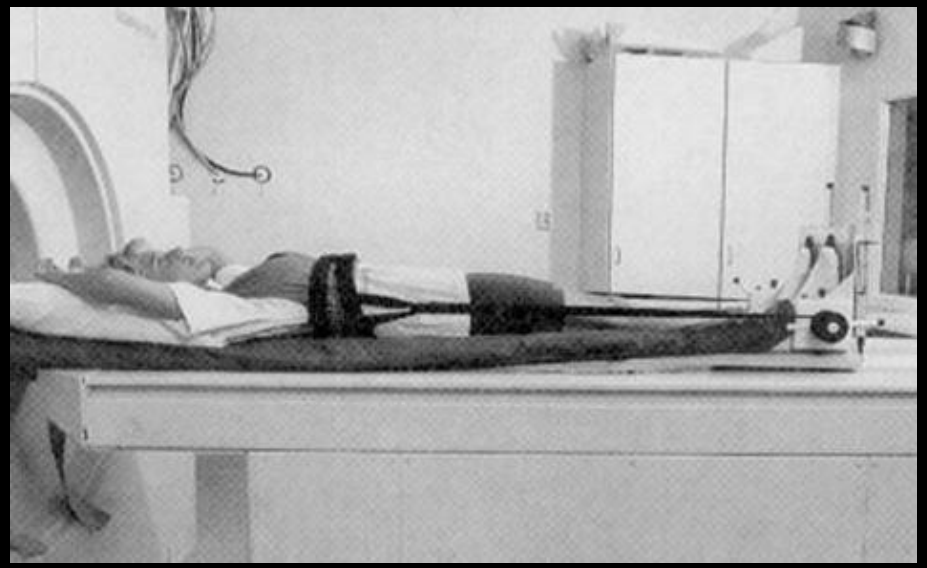
- Pain secondary to the arthritis of the "transverse-sacral pseudoarthrosis"



http://www.radsource.us/clinic/1312

Imaging Techniques

- Sagittal T2W FSE sequence – Central canal size
  - Cervical Spine
    - Normal: > 13 mm
    - Borderline: 10-13 mm
  - Lumbar spine
    - Normal > 1.5 cm^2 OR
    - AP diameter < 11.5 mm
- CT scan – Foraminal Stenosis
- Upright MRI/Axial loading CT/MR
  - Increased Axial loading to simulate patient's symptomatic condition



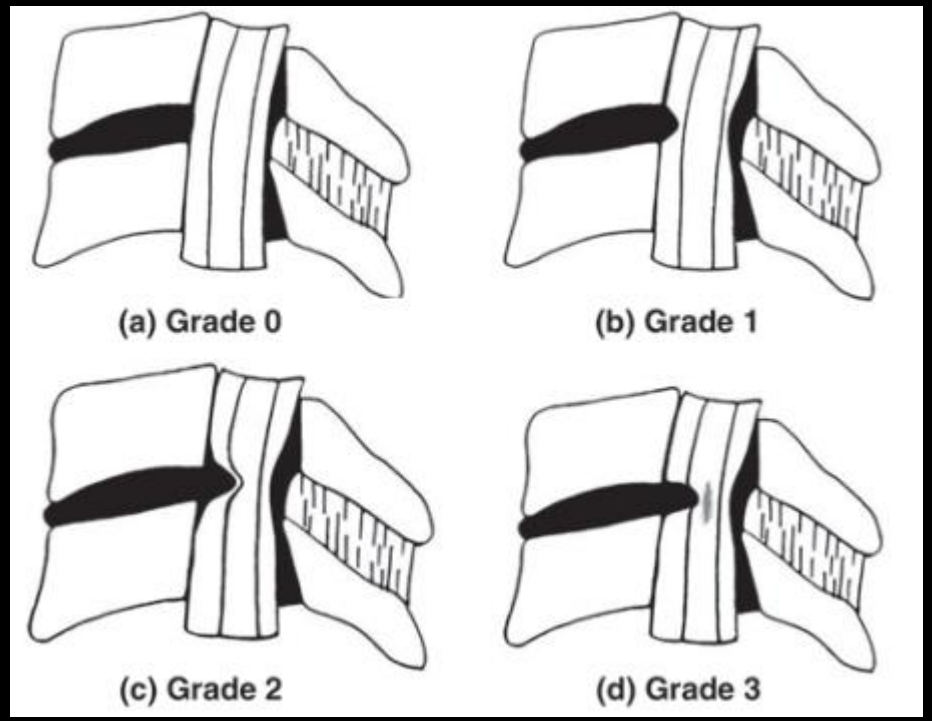
Spine (Phila Pa 1976). 2010 Apr 20;35(9):995-1001. doi:

Central Stenosis

- Osteophytes
- Facet arthropathy
- Thickening of the ligaments
- Bulging of the intervertebral discs

Cervical Canal Stenosis Grading System

Grade	
0	Normal
1	Arbitrary subarachnoid space loss exceeding 50%
2	Cord deformity
3	Cord signal abnormality

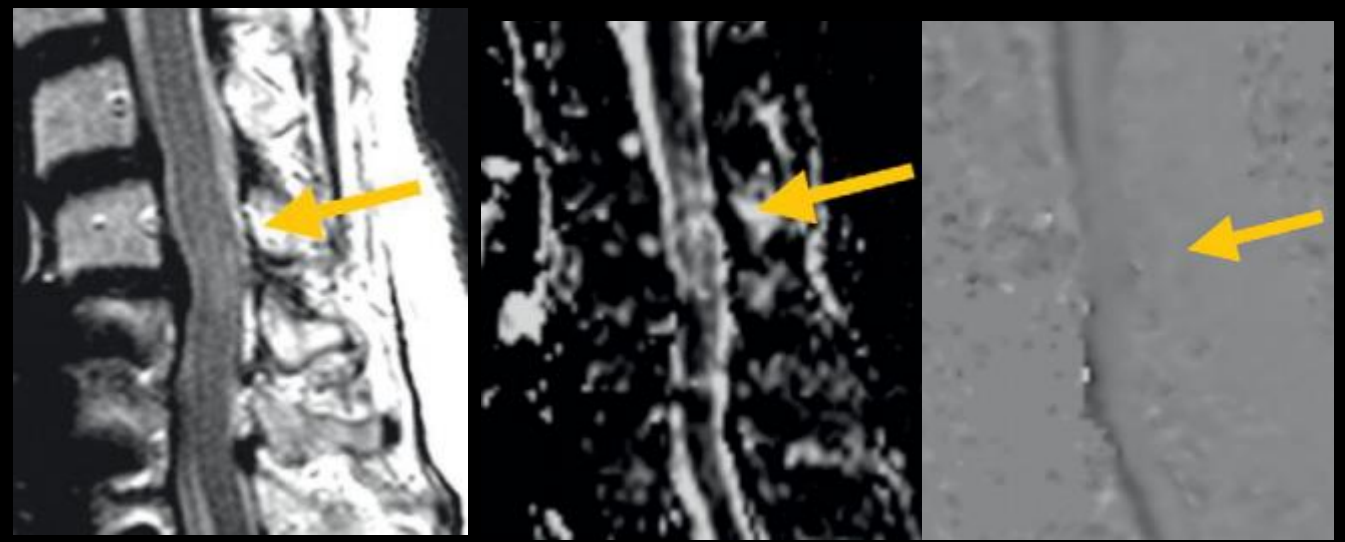


Kang, Y., Lee, J. W., Koh, Y. H., Hur, S., Kim, S. J., Chai, J. W., & Kang, H. S. (2011). New MRI Grading System for the Cervical Canal Stenosis.*American Journal of Roentgenology*, *197*(1), W134–W140.

Imaging Techniques

- DWI
- CSF Flow

T2 hyperintensity → Reversible
T1 hypointensity → Irreversible



T2W DWI CSF Flow

Peripheral Stenosis

- Lateral recess stenosis
  - Lumbar (sagittal)
    - Normal: > 5 mm
    - Borderline: 3-4 mm
    - Pathologic stenosis: <= 2 mm

Semin Ultrasound CT MR. 1993 Dec;14(6):404-13.

- Foraminal stenosis
  - Changes with body positions at each level (lumbar spine)
- Imaging sensitive but not specific

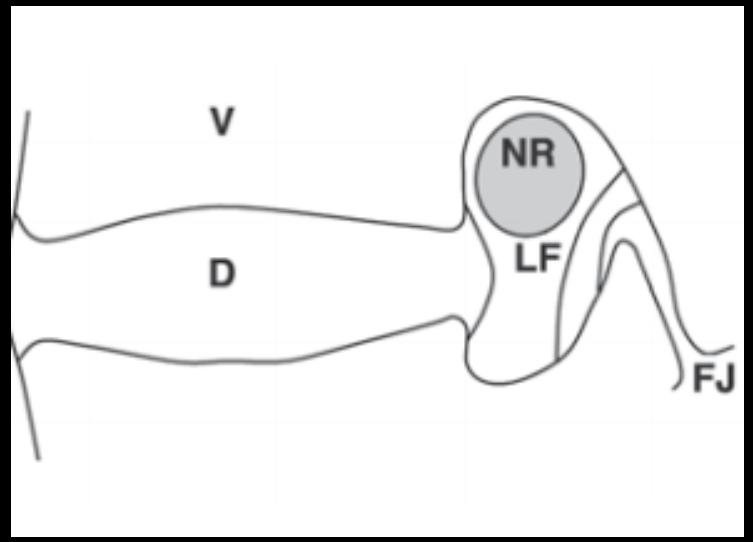
Lumbar Foraminal Stenosis Grading System

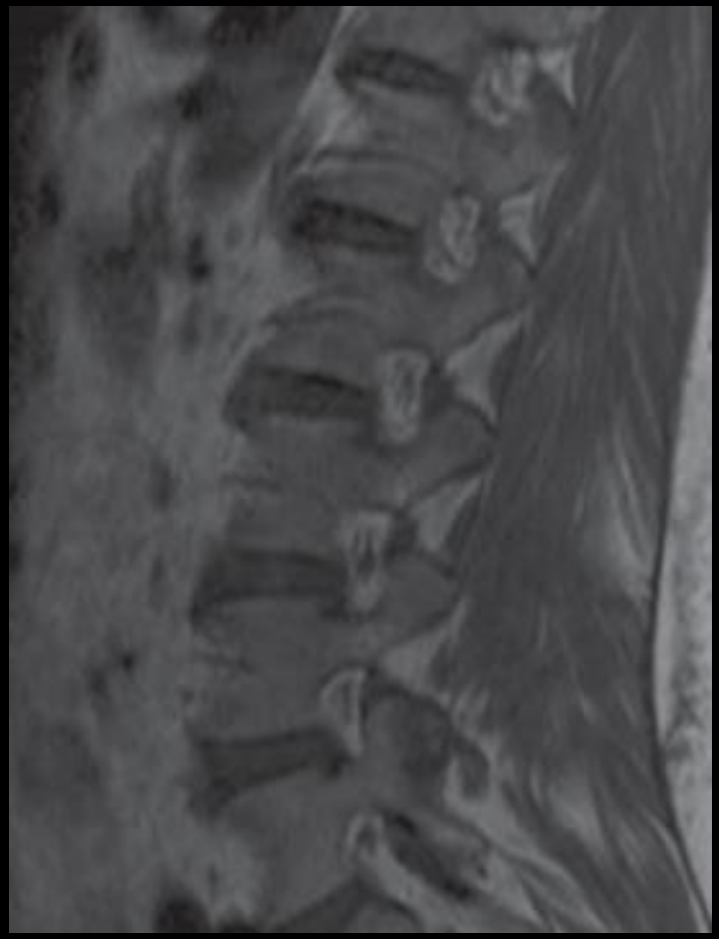
Grade	
0 (normal)	Normal
1 (Mild)	Perineural fat obliteration in two opposing directions, vertical or transverse direction
2 (Moderate)	Perineural fat obliteration in all four directions without morphologic change, both vertical and transverse directions
3 (Severe)	Nerve root collapse or morphologic change

Lee, Seunghun, Joon Woo Lee, Jin Sup Yeom, Ki-Jeong Kim, Hyun-Jib Kim, Soo Kyo Chung, and Heung Sik Kang. 2010. "A Practical MRI Grading System for Lumbar Foraminal Stenosis." *American Journal of Roentgenology* 194 (4) (April 1): 1095–1098. doi:10.2214/AJR.09.2772.http://www.ajronline.org/doi/abs/10.2214/AJR.09.2772.

Grade 0: Normal

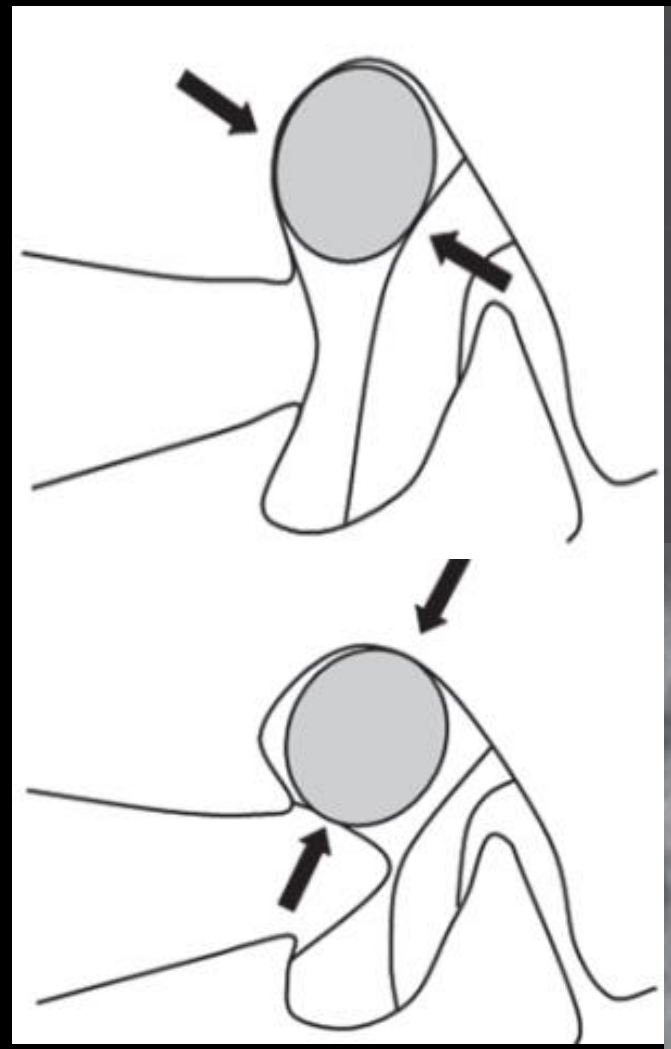
Grade	
0 (normal)	Normal
1 (Mild)	Perineural fat obliteration in two opposing directions, vertical or transverse direction
2 (Moderate)	Perineural fat obliteration in all four directions without morphologic change, both vertical and transverse directions
3 (Severe)	Nerve root collapse or morphologic change

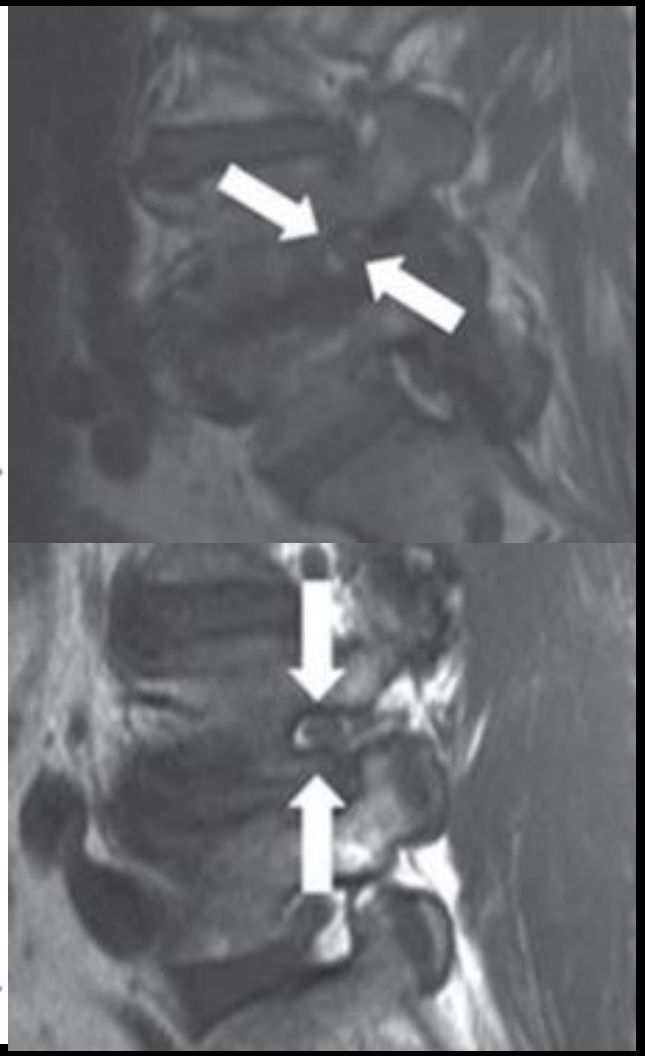




Grade 1: Mild

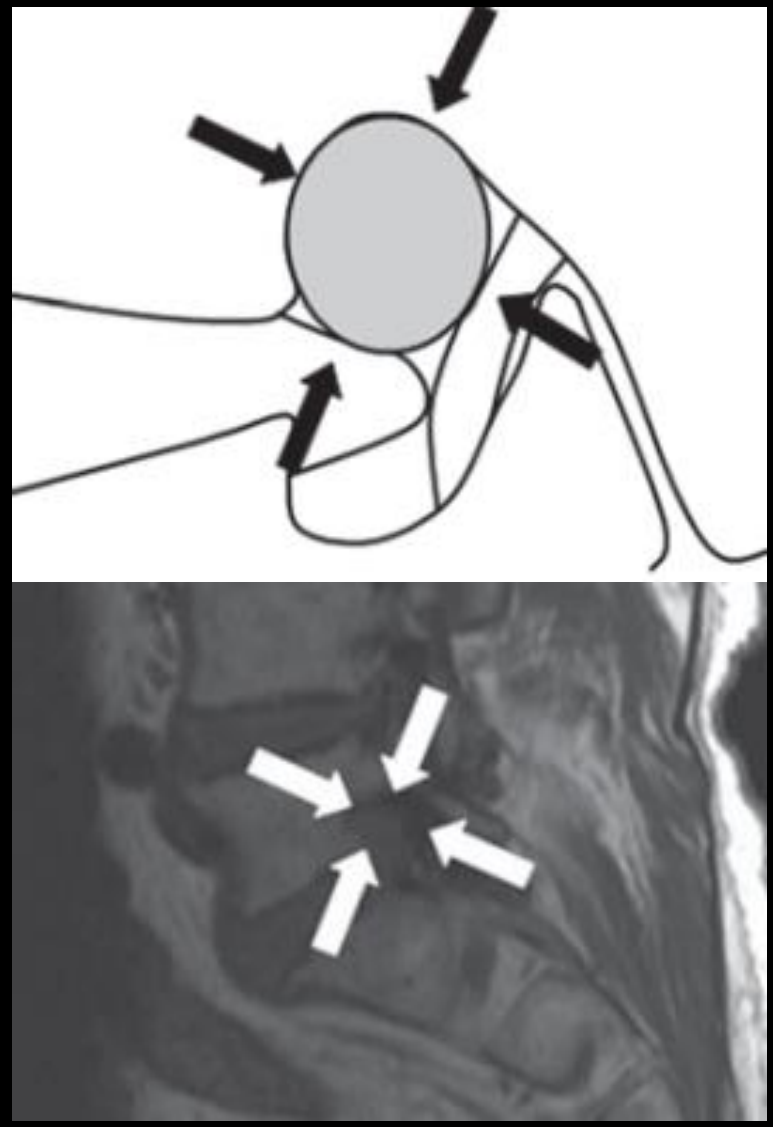
Grade	
0 (normal)	Normal
1 (Mild)	**Perineural fat obliteration in two opposing directions, vertical or transverse direction**
2 (Moderate)	Perineural fat obliteration in all four directions without morphologic change, both vertical and transverse directions
3 (Severe)	Nerve root collapse or morphologic change





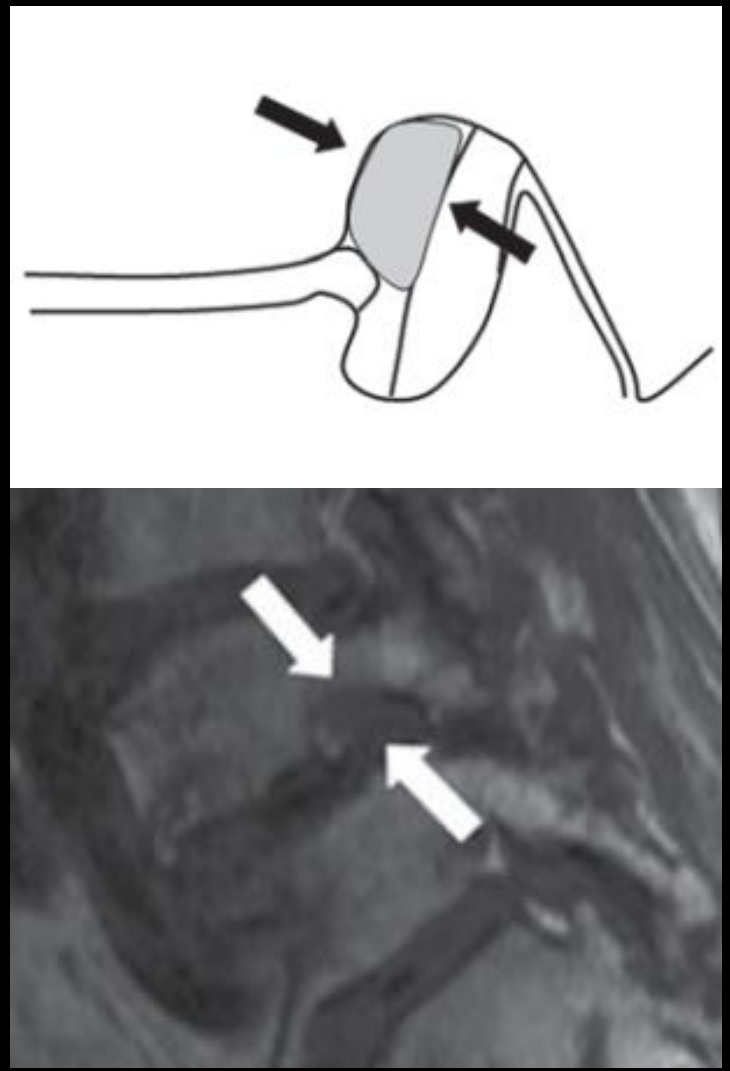
Grade 2: Moderate

Grade	
0 (normal)	Normal
1 (Mild)	**Perineural fat obliteration in two opposing directions, vertical or transverse direction**
2 (Moderate)	**Perineural fat obliteration in all four directions without morphologic change, both vertical and transverse directions**
3 (Severe)	Nerve root collapse or morphologic change



Grade 3: Moderate

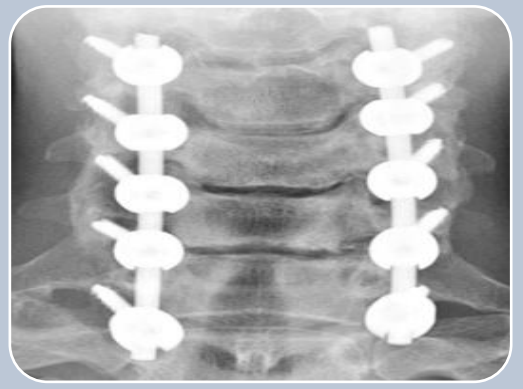
Grade	
0 (normal)	Normal
1 (Mild)	**Perineural fat obliteration in two opposing directions, vertical or transverse direction**
2 (Moderate)	Perineural fat obliteration in all four directions without morphologic change, both vertical and transverse directions
3 (Severe)	**Nerve root collapse or morphologic change**



Key Points

- Degree of imaging stenosis ≠ Clinical significance
- Grading Systems for consistent reporting

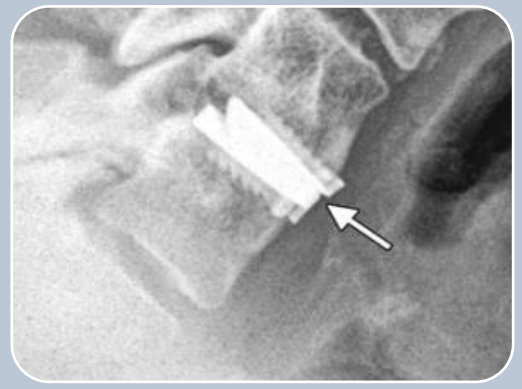
Types of Surgeries



Stabilization

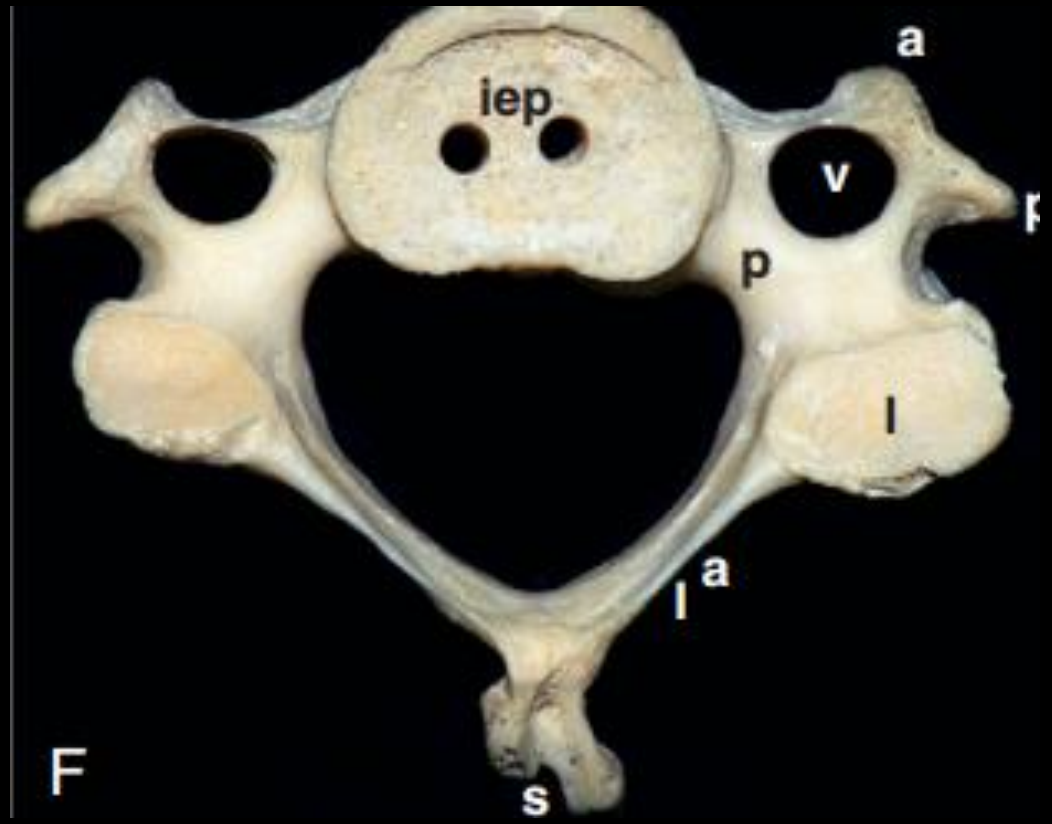
- Fusion
- Distraction

Decompression



Disc replacement

Decompression



Decompression	
Laminotomy	Partial removal of the lamina
Hemilaminectomy (unilateral laminectomy)	Removal of a single lamina with exposure limited to one side of the interspinous ligament
Total laminectomy	Removal of the bilateral lamina along with the spinous process
Laminoplasty	Expansion of the spinal canal while preserving the dorsal laminar arch
Pediculectomy	Removal of the pedicle, usually along with the facet as a transpedicular approach and often combined with laminectomy
Corpectomy	Complete or partial removal of the vertebral body
Vertebrectomy (spondylectomy)	Complete or partial removal of the vertebra
Foraminotomy	Expansion of the neural foramen, usually via resection of part or all of the facet
Facetectomy	Resection of part or all of the facet
Discectomy/ microdiscectomy	Removal of herniated disc material

Atlas of Postsurgical Neuroradiology - Imaging of the Brain, Spine, Head, and Neck.

Stabilization

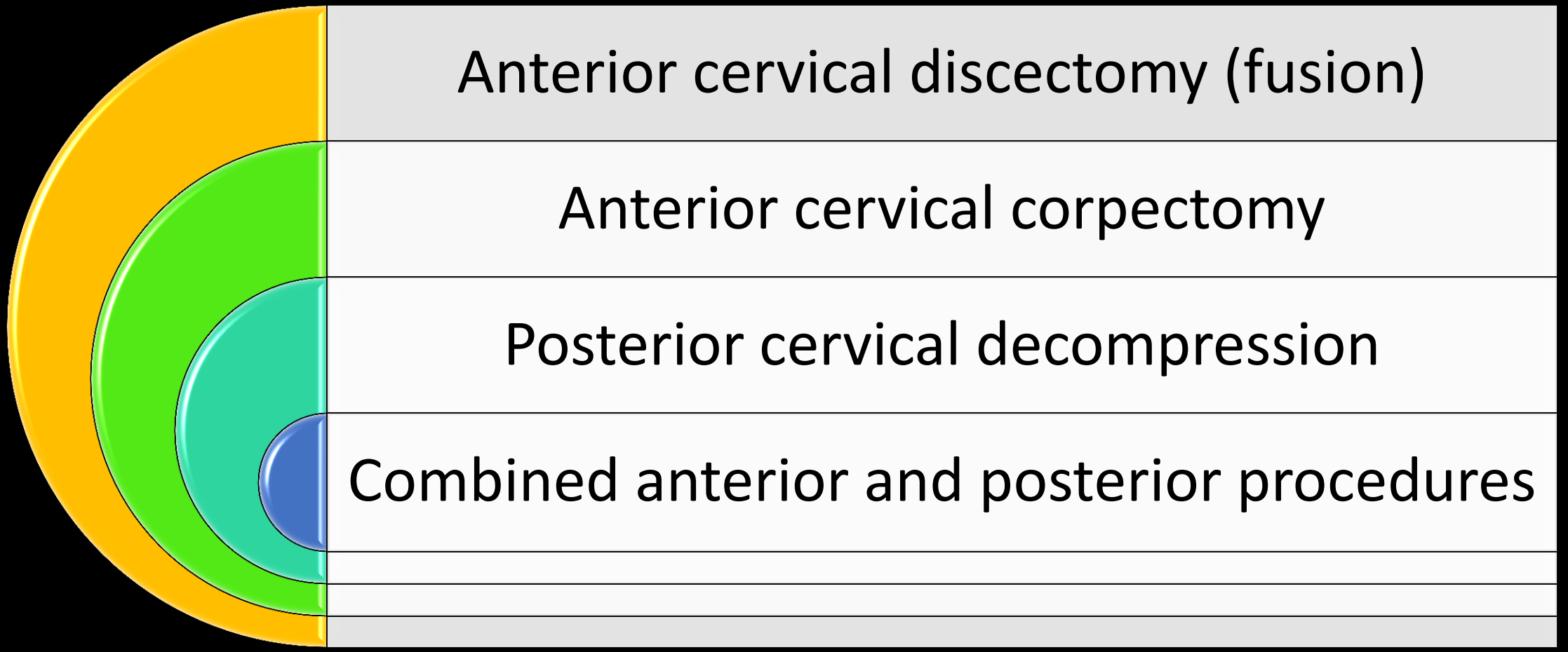
Stabilization	
Fusion (spondylodesis)	Uniting portions of the spine via instrumentation and/or graft materials. A variety of approaches can be implemented (anterior, posterior, etc.)
Distraction	Halo, traction, or interspinous process devices to provide distractive force to vertebral column

Disc Replacement

- Dynamic reconstruction of the intervertebral disc with artificial disc or nucleus pulposus

Cervical Spine

Types of Surgeries

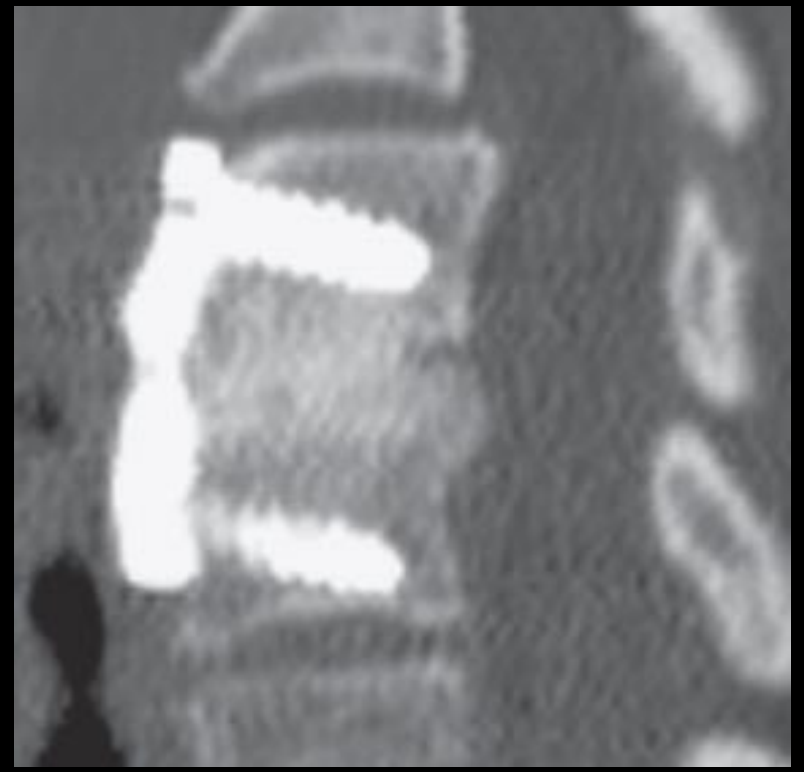


Anterior Cervical Discectomy (ACD)

- Single disc level
- Anterior approach
- Purpose: decompress the spinal canal or neuroforamen
- Techniques: Removal of compressive disk herniation and/or disc/osteophyte complex without placement of any interbody bone graft or instrumentation.
- Relatively uncommon now a days

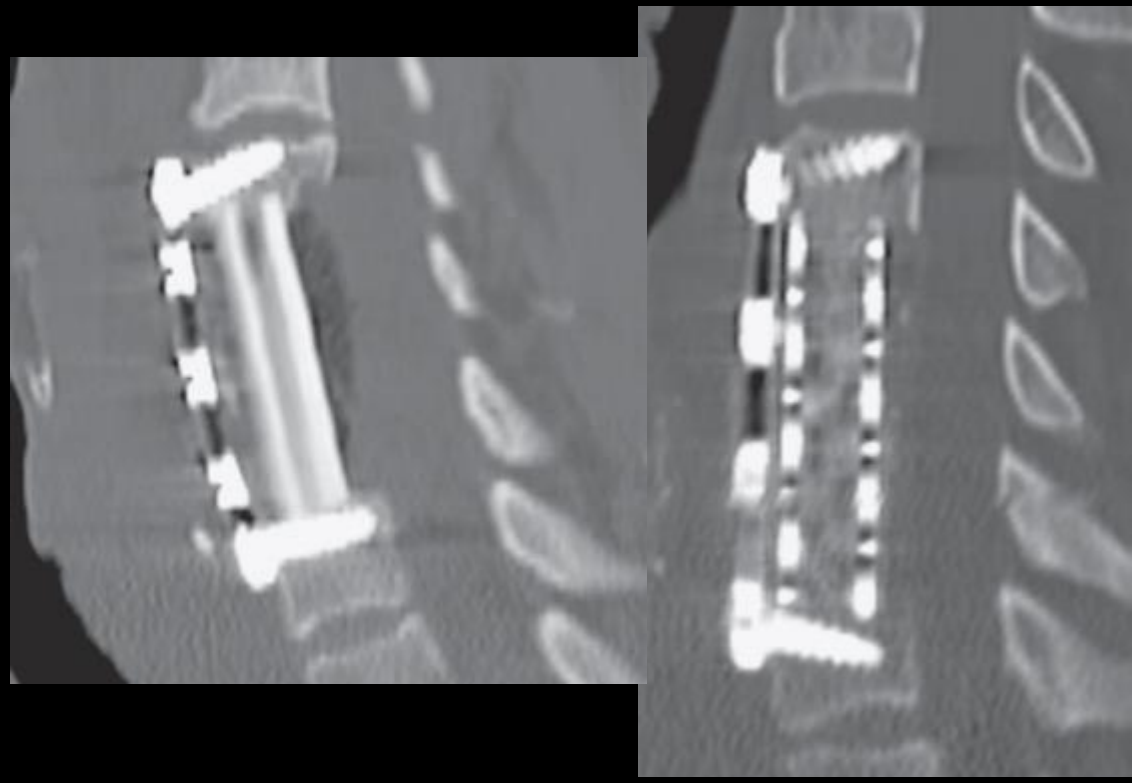
Anterior cervical discectomy and fusion (ACDF/P)

- >=1 levels
- ACD + interbody arthrodesis (fusion)
- Structural graft
  - Autograft
  - Allograft
- Additional plate and screw construct (P)
  - ACDFP



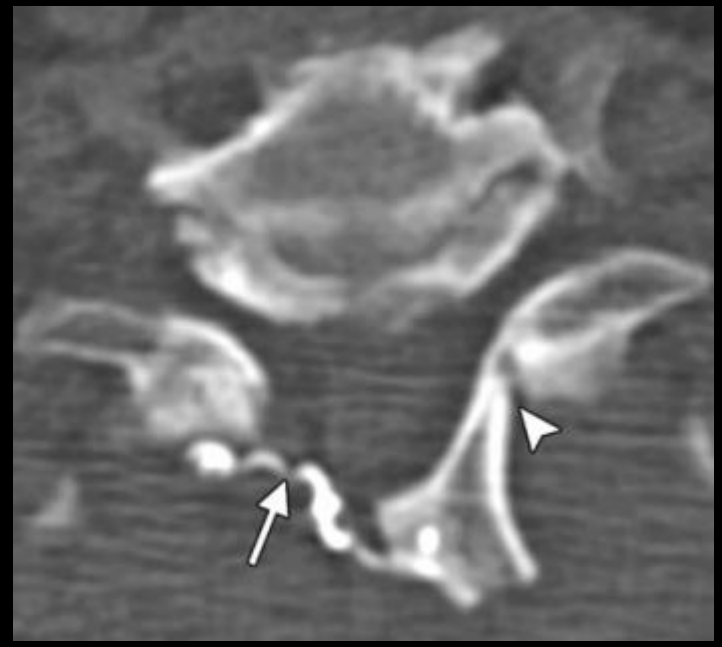
Anterior cervical corpectomy (ACC)

- >= 2 levels
- Purpose: Decompression of the spinal canal/neuroforamen
- Techniques:
  - Disectomy AND
  - Removal of most of the center of one or more vertebral bodies
  - Bone defect reconstruction
    - Fibular strut graft
    - Titanium mesh cage filled with autograft and/or allograft
  - Plate/screw construct



Posterior cervical decompression (PCD)

- >= 1 level
- Approach: Posterior
- Purpose: decompress central canal/neuroforamen
- Techniques
  - Laminectomy and/or foraminotomy
  - Laminoplasty
  - Lateral mass and/or pedicle screw instrumentation

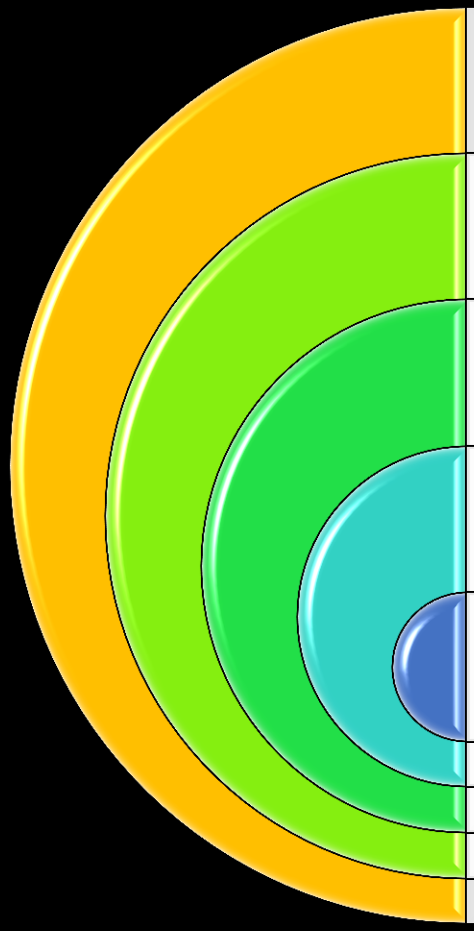


360-degrees/circumferential surgery

- Combined anterior and posterior procedures

Lumbar spine

Surgery Types



Posterior lumbar interbody fusion (PLIF)

Transforaminal lumbar interbody fusion (TLIF)

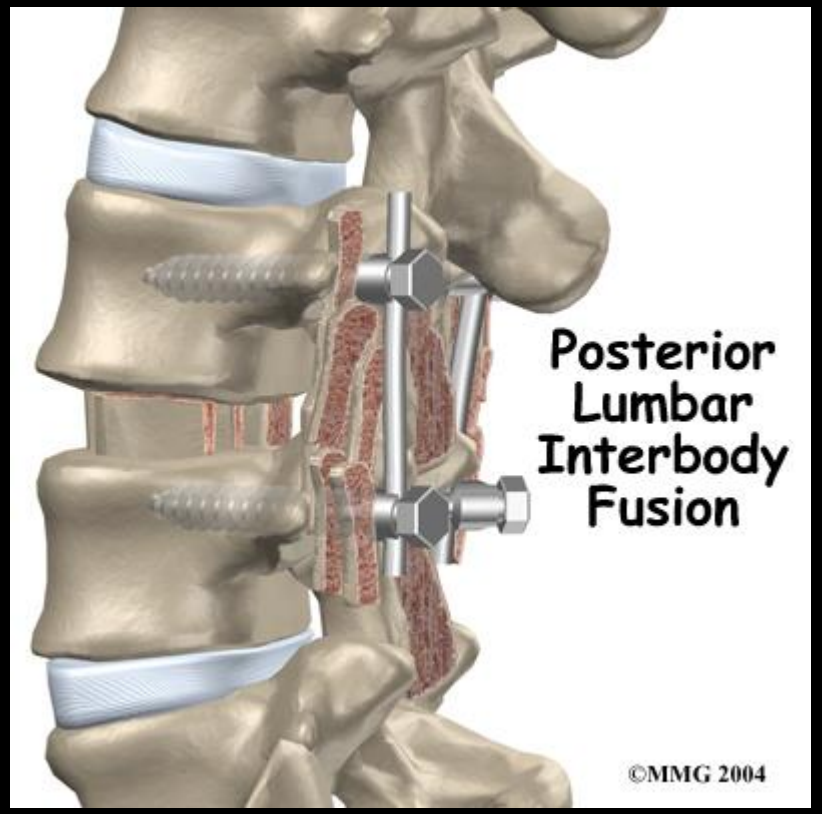
Anterior lumbar interbody fusion (ALIF)

Extreme lateral interbody fusion (XLIF)

Stand alone lumbar interbody fusion (Stalif)

PLIF

- Loss of posterior structural support → posterior fusion instrumentation
- **Thecal sacs and nerve roots retraction** → Risk of nerve injury



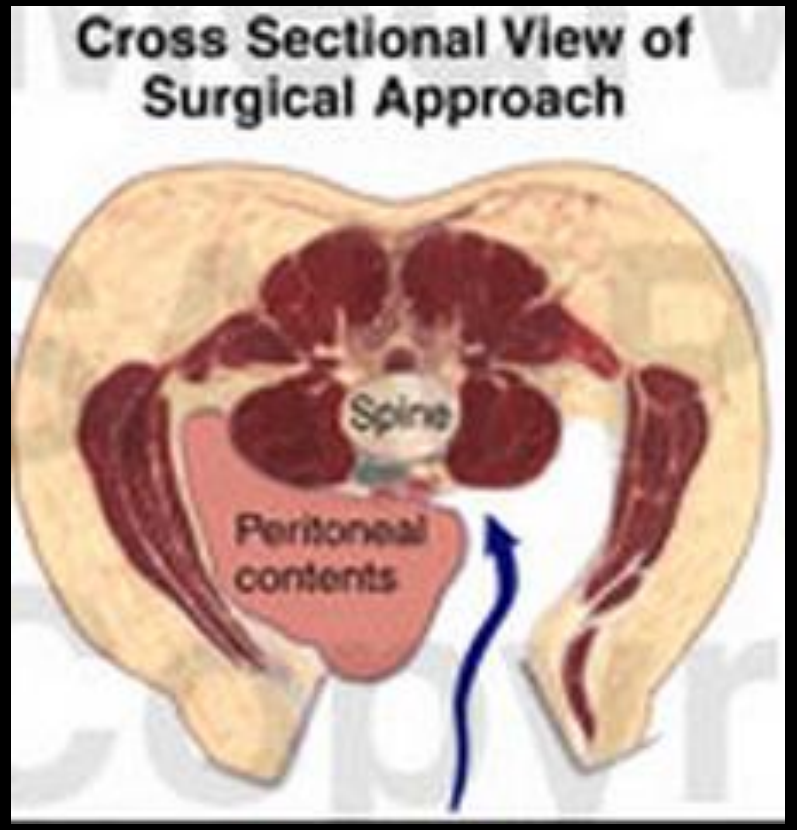
http://www.methodistorthopedics.com/

TLIF

- Reduces amount of surgical muscle resection
- **Minimizes nerve manipulation**
- Limited size of the interbody graft → posterior instrumentation

ALIF

- Through extraperitoneal space → extraperitoneal injury
- Sufficent size of disk access → No posterior instrumentation
  - No posterior paravertebral muscle damage
- No nerve root retraction
- No epidural scar



http://www.medivisuals.com/

XLIF

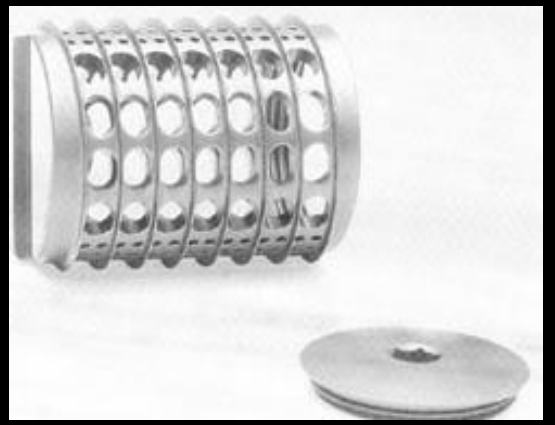
- Minimally invasive
- First described in 2006 by Drs. Ozgur, Aryan, Pimenta, Taylor from UC Irvine and UCSD
- Avoid incision that traverses through abdomen (vs. ALIF)
- Avoid cutting or disrupting the muscles of the back

Ozgur, Burak M., Henry E. Aryan, Luiz Pimenta, and William R. Taylor. 2006. "Extreme Lateral Interbody Fusion (XLIF): a Novel Surgical Technique for Anterior Lumbar Interbody Fusion." *The Spine Journal* 6 (4) (July): 435–443. doi:10.1016/j.spinee.2005.08.012.

XLIF

Interbody graft Types

- Bone graft
  - Bone graft site pain
  - High nonunion rate
- Titanium cage
  - Not fixate the spine well:
    - > L4/L5
    - Spondylolisthesis
    - Multilevel fusion
  - Obscure postoperative imaging
- Carbon fiber or PEEK cage
  - Requires posterior pedicle screws
- Bioabsorbable interbody cage



Titanium Cage

PEEK Cage

Postoperative Imaging

Interbody Graft Incorporation

- Radiologic fusion ≠ Clinical Success
- Techniques:
  - Radiography (standard vs. dynamic)
  - CT
  - MRI
- Minimum 6-12 months
  - Up to 24 months

Imaging Finding for fusion

- **Continuity of bone density and bony trabeculae across the interspace**
- Minimal loss of the operated disc space
- < 2-5 degrees of movement at operative site on flexion-extension series
- Presence of sclerotic line between the graft and vertebral bone
  - Remodelling with new bone formation at the junction
- Integrity of the construct with no screw fracture, pullout, or plate buckling

Standard Radiography

- Trabecular bone across the segment
  - Sentinel sign
- Overestimate fusion rate

Radiologic assessment of spinal fusion J Am Acad Orthop Surg. 2012 Nov;20(11):694-703

Dynamic Radiography

- > 1 or >2 mm between spinous processes across the fused segment (C spine)
  - Specificity 89%
  - Sensitivity 91%
- Change in Cobb's a[illegible] extension (C-spine)
  - Specificity 39%
  - Sensitivity 82%
  - 4 degrees cut off, 100% PPV but very low sensitivity
- USFDA: < 5 degrees of movement (L-spine)
- Significant observer bias → QMA
  - PPV 100%
  - NPV 73%

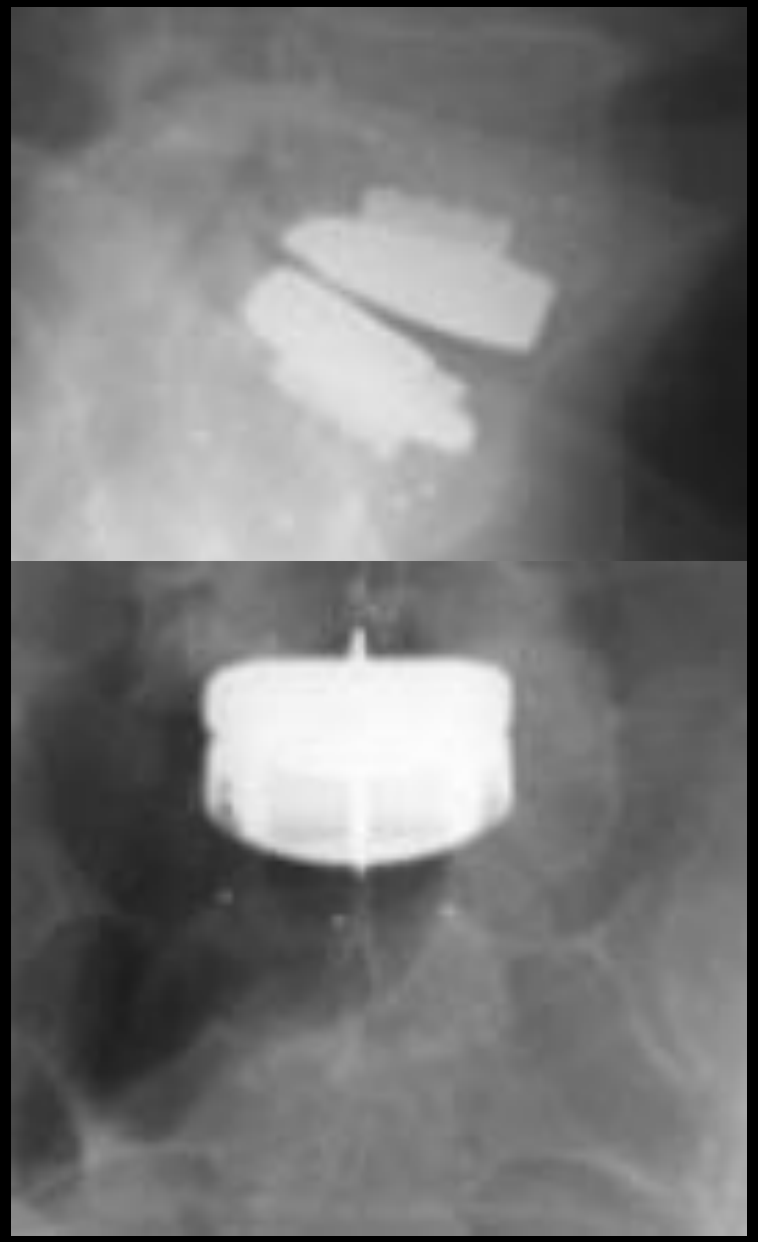
Overestimate solid fusion

Radiologic assessment of spinal fusion J Am Acad Orthop Surg. 2012 Nov;20(11):694-703

Ghiselli G et al: Prospective analysis of imaging prediction of pseudarthrosis after anterior cervical discectomy and fusion: Computed tomography versus flexion-extension motion analysis with intraoperative correlation.Spine 2011;36(6):463-468

Radiostereometric Analysis

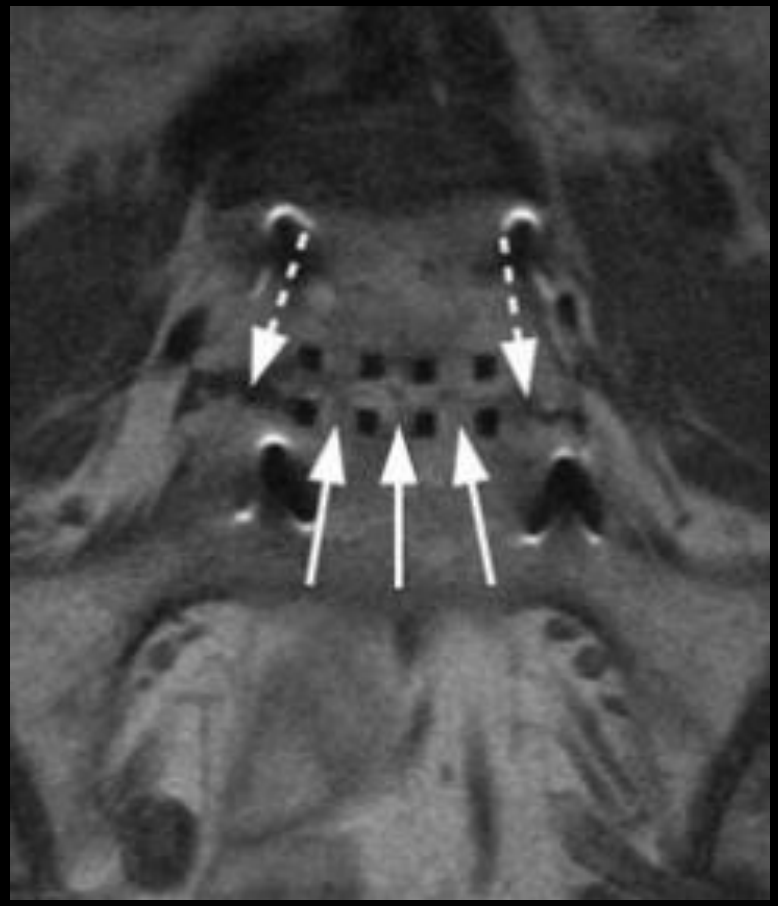
- 0.8 mm tantalum beads implanted into bone at the time of original surgery
- Biplanar dynamic radiographs
- Using computer, 3D data is calculated



http://ijssurgery.com/10.1016/S1935-9810(08)70012-4

MRI

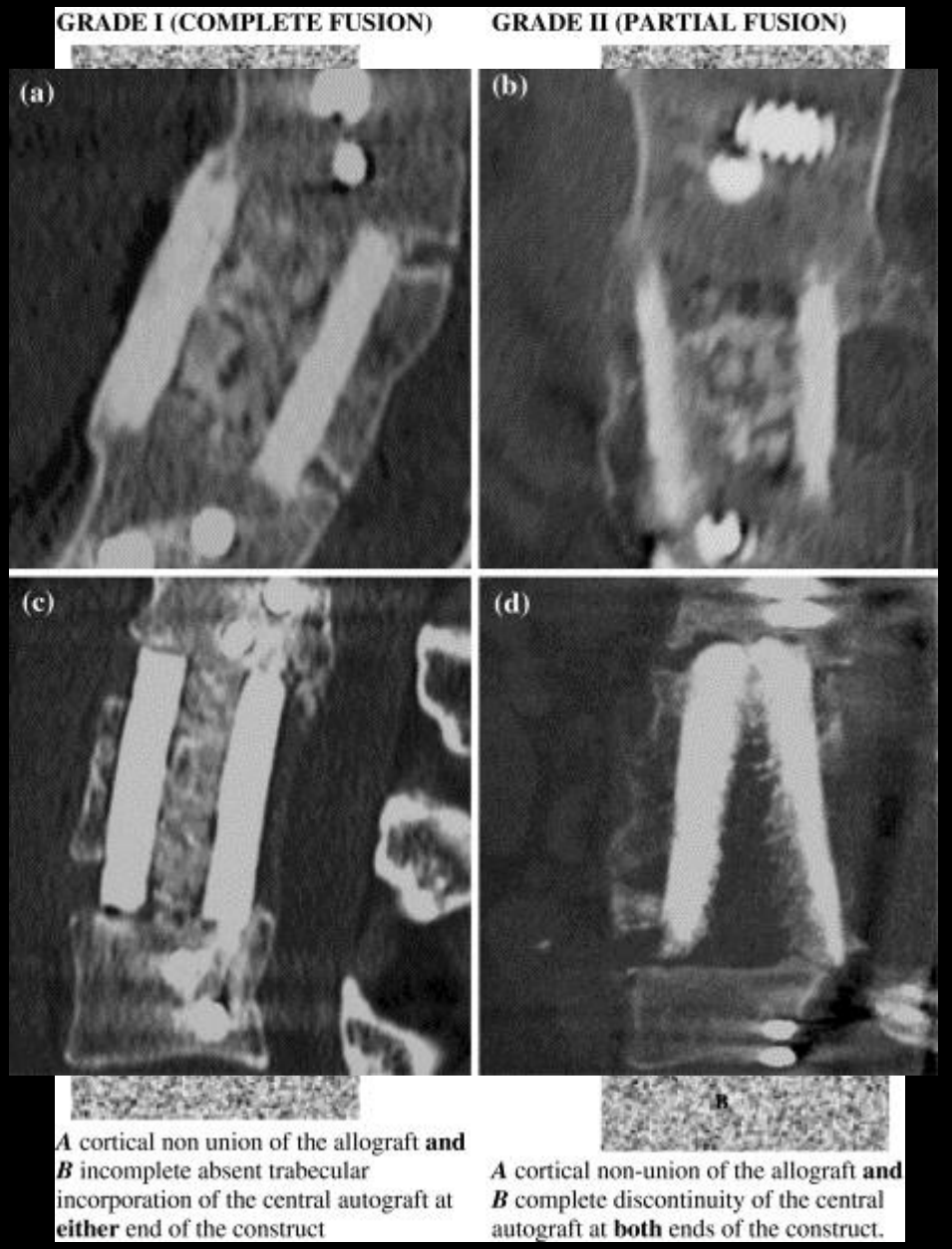
- No radiation
- Paradoxial effect of high field magnet



CT

- Higher sensitivity than radiographs
- Trabecular continuity
- Classification
  - Grade I: Complete
  - Grade II: Partial fusion
  - Grade III: Unipolar pseudarthrosis
  - Grade IV: Bipolar pseudoarthrosis
- Radiation Dose

Eur Spine J. Nov 2007; 16(11): 1875–1881.



Locked Pseudoarthrosis

- Nonunion within an interbody cage on CT but no radiographic evidence of osteolysis around the implant and no appreciable movement on flexion-extension.

Key Points

- Fusion can take up to 24 months
- CT is the imaging modality of choice for assessing interbody fusion.

Postoperative Complications

Autograft donor site pain

- Iliac crest donor site pain (> 30%)
  - Unicortical = Bicortical
  - Right = left
  - Anterior = posterior
- Infection (0.9%)

Non-union/pseudoarthrosis

Non-union/Pseudoarthrosis

- Single level discectomy alone has shorter postoperative course
- More structural support, better fusion rate, less nonunion
- More levels, higher nonunion rate.

Type of Surgery	Total No. of Procedures	Outcome	
		Fusion Rates (%)	Pseudarthrosis Rates (%)
One Disc Level			
ACD	73	84.9	15.1
1-level ACDF	1231	92.1	7.9
1-level ACDFP	339	97.1	2.9
Two Disc Levels			
2-level ACDF	422	79.9	20.1
2-level ACDFP	184	94.6	5.4
1-level corpectomy	73	95.9	4.1
1-level corpectomy with plating	56	92.9	7.1
Three Disc Levels			
3-level ACDF	123	65.0	35.0
3-level ACDFP	40	82.5	17.4
2-level corpectomy	88	89.8	10.2
2-level corpectomy with plating	53	96.2	3.8
Total	2,682	89.5	10.5

ACD, Anterior cervical discectomy; ACDF, ACD with fusion; ACDFP, ACDF with plating.
From Fraser JF, Härtl R. Anterior approaches to fusion of the cervical spine: A meta-analysis of fusion rates. J Neurosurg Spine 2007; 6:298-303.

Allograft vs Autograft vs Cage

- Allograft = Autograft

Samartzis D, et al. Is autograft the gold standard in achieving radiographic fusion in one-level anterior cervical discectomy and fusion with rigid anterior plate fi xation? Spine 2005; 30:1756-1761.

- Autograft > Cage

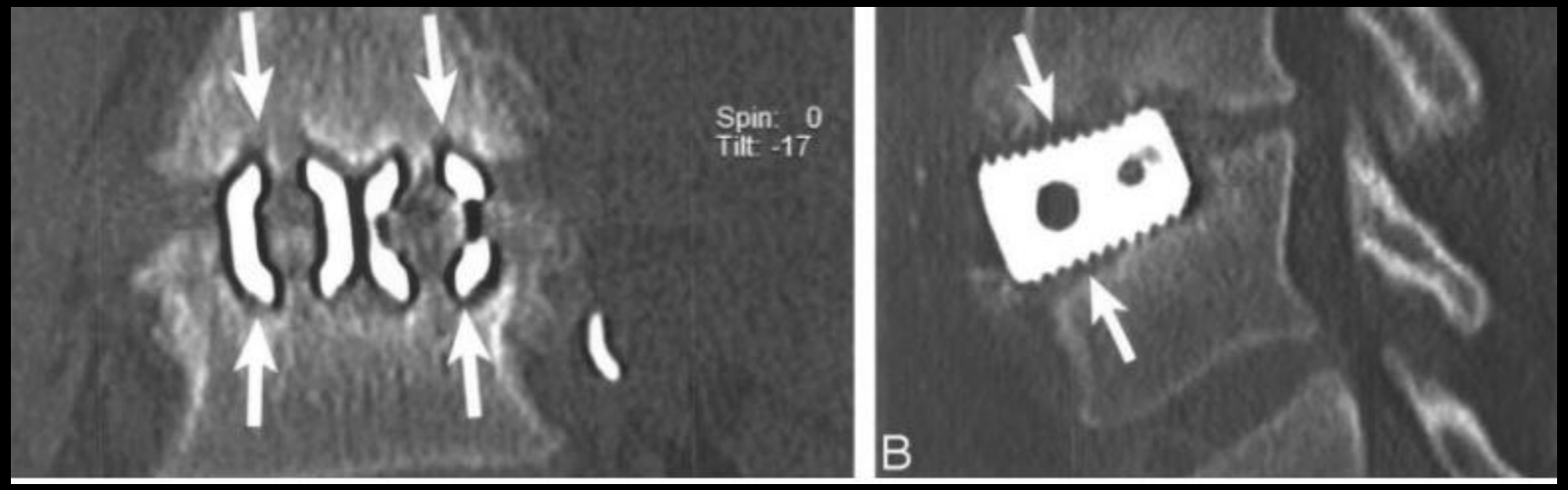
Jacobs WC, et al. Single or double-level anterior interbody fusion techniques for cervical degenerative disc disease. Cochrane Database Syst Rev 2004

CT Features of Delayed or Failed Fusion

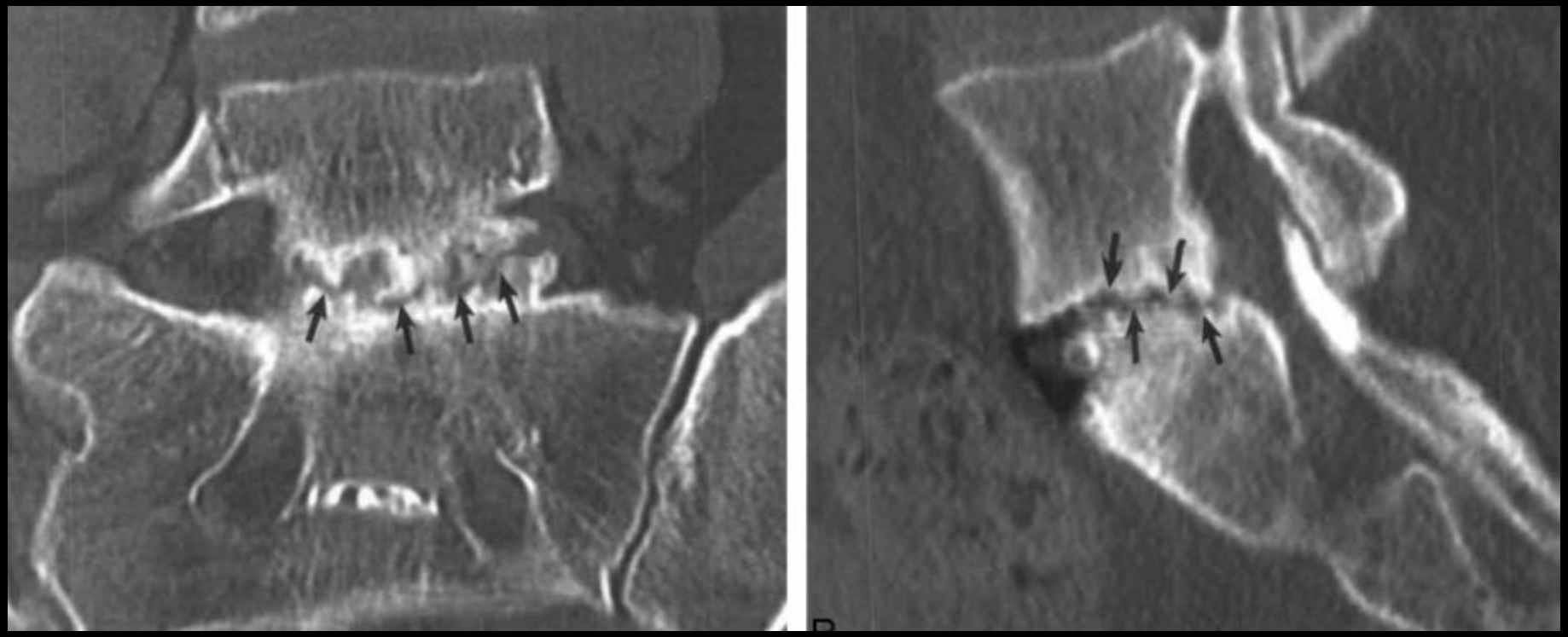
- Lucency around the device margin
- Cystic changes within the endplate
- Linear defects/fracture
- Change in device position
- Subsidence

Non-union

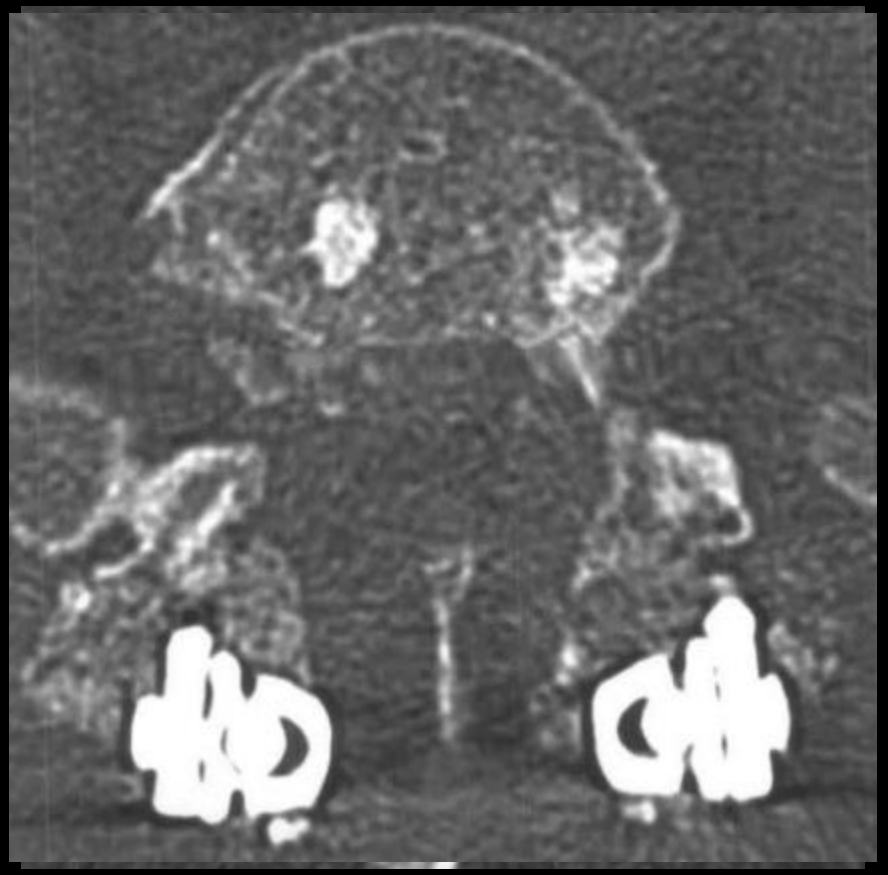
Nonunion



Linear lucency

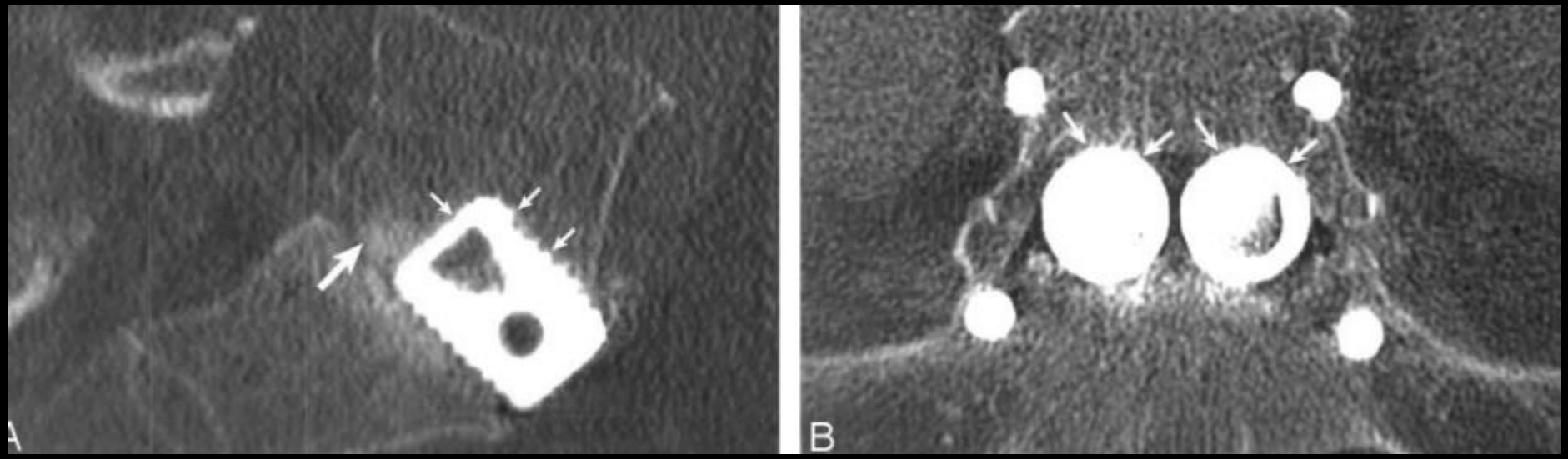


Cystic change in the endplate

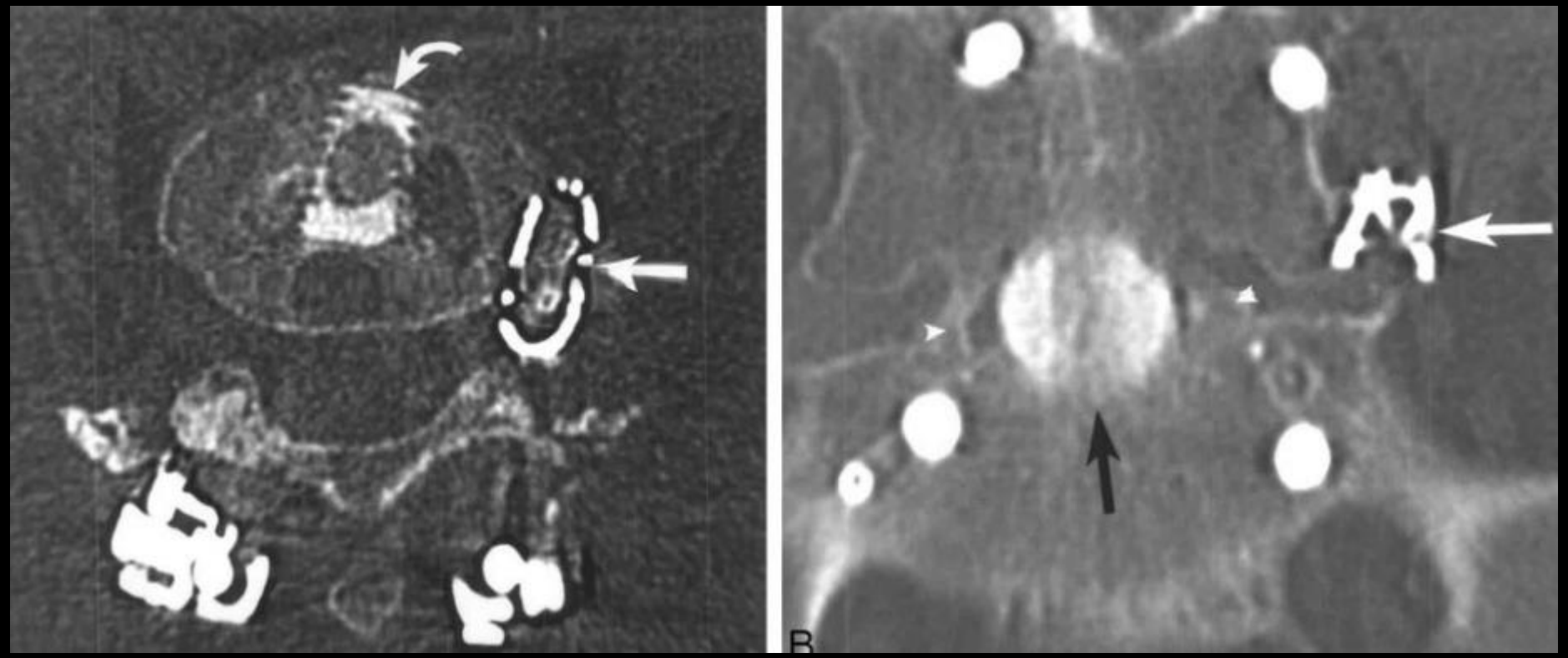


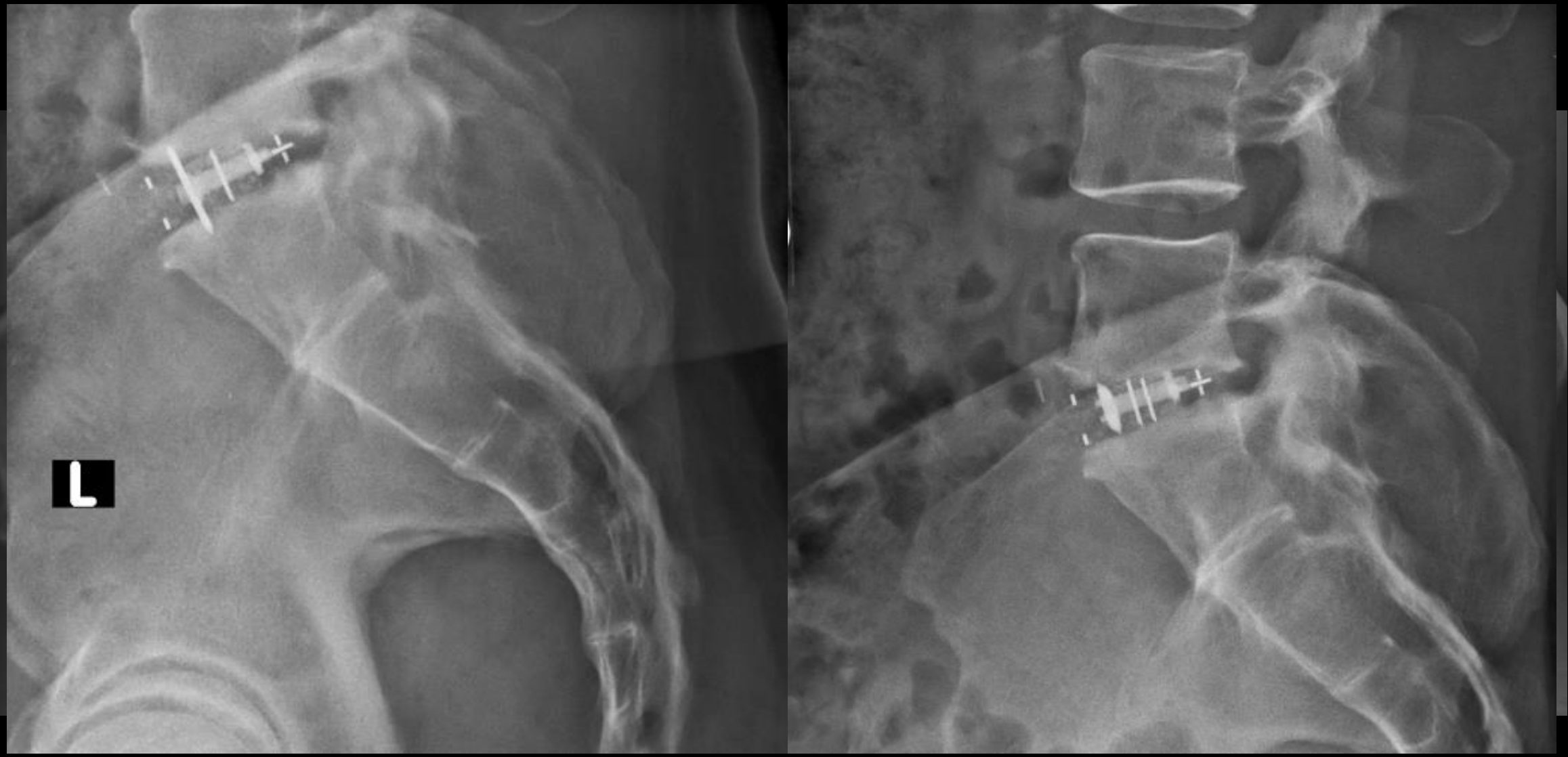
Subsidence

- Fusion device sinking into one or both end of the adjacent vertebral bodies.

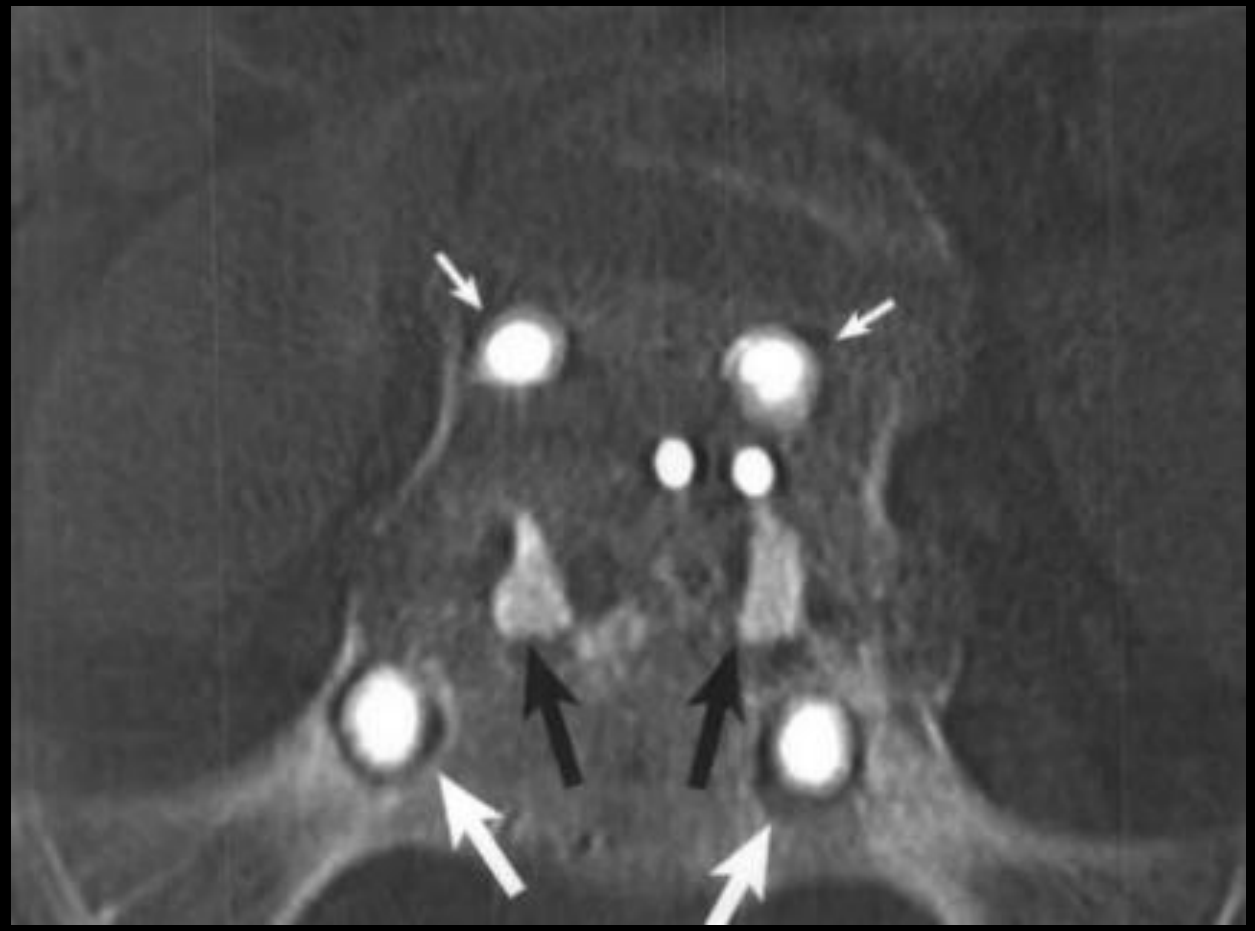


Change in position




L

Periscrew lucency

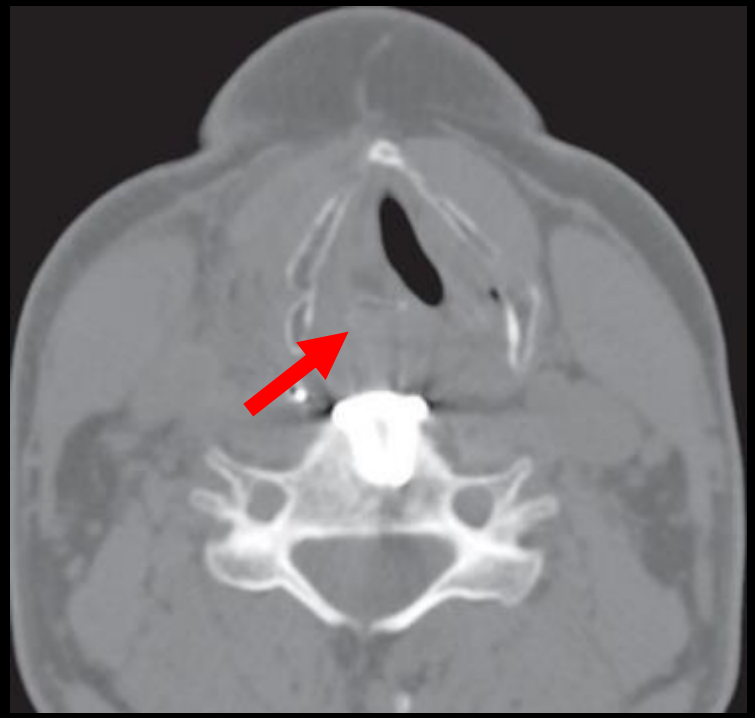


Screw Fracture

Adjacent Structure Injuries

Vocal Cord Dysfunction

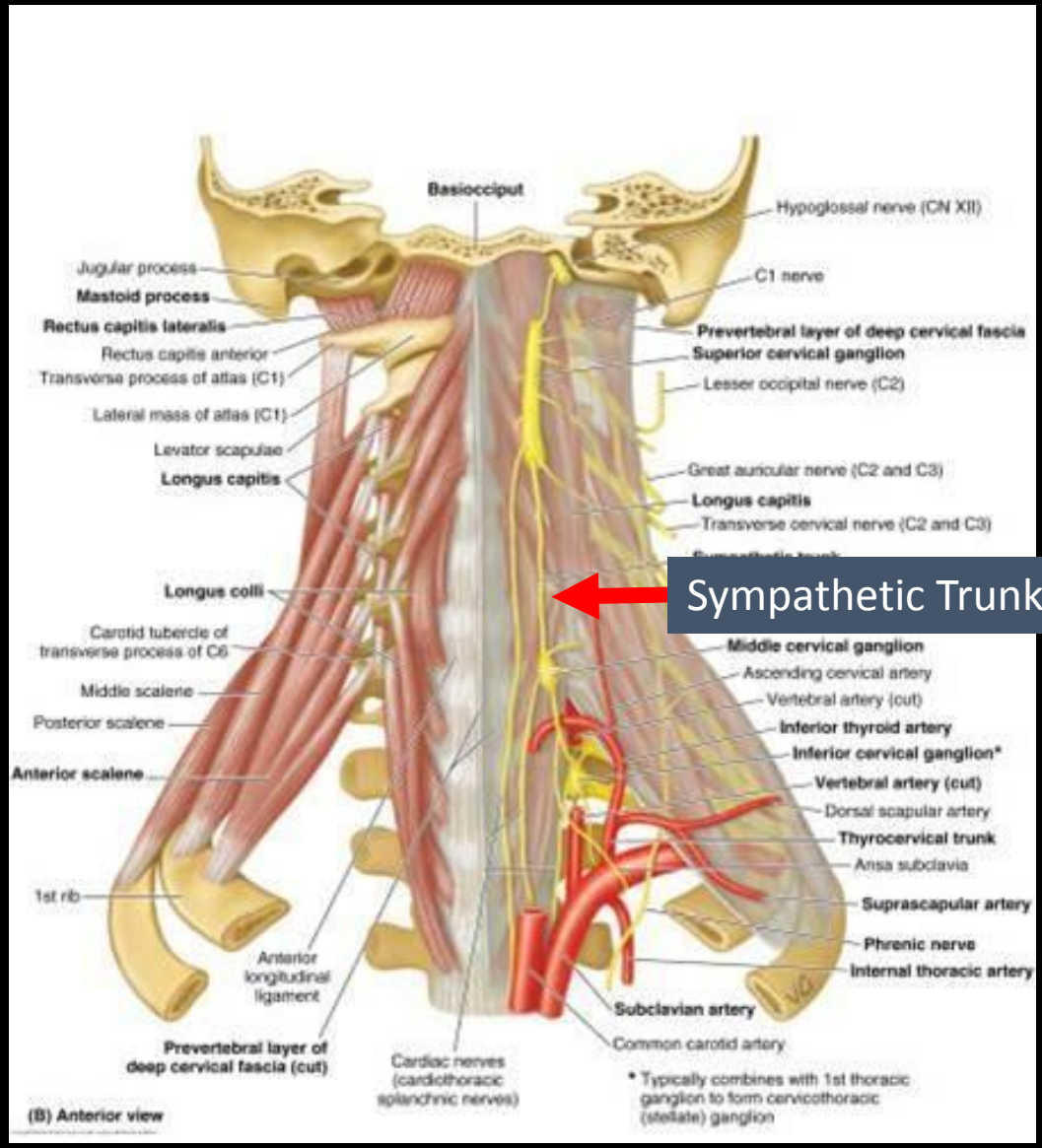
- Vocal cord dysfunction
  - Transient (80-90%)
  - Permanent (10-20%)



Naidich TP. Cervical spine decompression for spinal stenosis and disk disease: Complications of surgery. In Castillo M, Koeller KK, Mukherji SK. Neuroradiology Categorical Course Syllabus, pp 289-296. American Roentgen Ray Society, 107th Annual Meeting, Orlando, FL, 2007.

Horner's syndrome

- 0.1 – 4% risk of sympathetic trunk injury
- Risk higher for lower cervical spine surgery
  - Sympathetic trunk lies closer to the medial border of the longus coli at C6 than C3



http://www.studyblue.com/notes/note/n/neck/deck/4588539

Vascular Injury

- Narrowing
- Occlusion
- Intravascular clot
  - Embolization
- Dissection
- Pseudoaneurysm
- Rupture

www.refindia.net

Vascular Injury with ALIF

- Aorta
- Inferior vena cava
- Iliac arteries/veins
  - Left common iliac artery

Incidental durotomy

- Unintended tear or injury to the dura during surgery or other invasive procedure
- ~10% of lumbar spine decompression
- Symptoms
  - Postural headache
  - Neurological deficit
- Image Findings
  - Nuclear scintigraphy
  - CT myelography

Structural Complication

Spinal Instability

- Inability to withstand normal movements without development of abnormal subluxation, neurologic dysfunction and/or pain.
- Pathophysiology
  - Loss of posterior tension band

Adjacent level degenerative disc disease

- Definition
  - New or accelerated degeneration of the disc and development or exaggeration of spondylosis at the levels adjacent to the operated level.
- 17% in single level surgery

  Xie JC, Hurlbert RJ. Discectomy versus discectomy with fusion versus discectomy with fusion and instrumentation: a prospective randomized study. Neurosurgery 2007; 61:107-116; discussion 116-117

- 73% in long (4 or 5 level) anterior cervical construct.

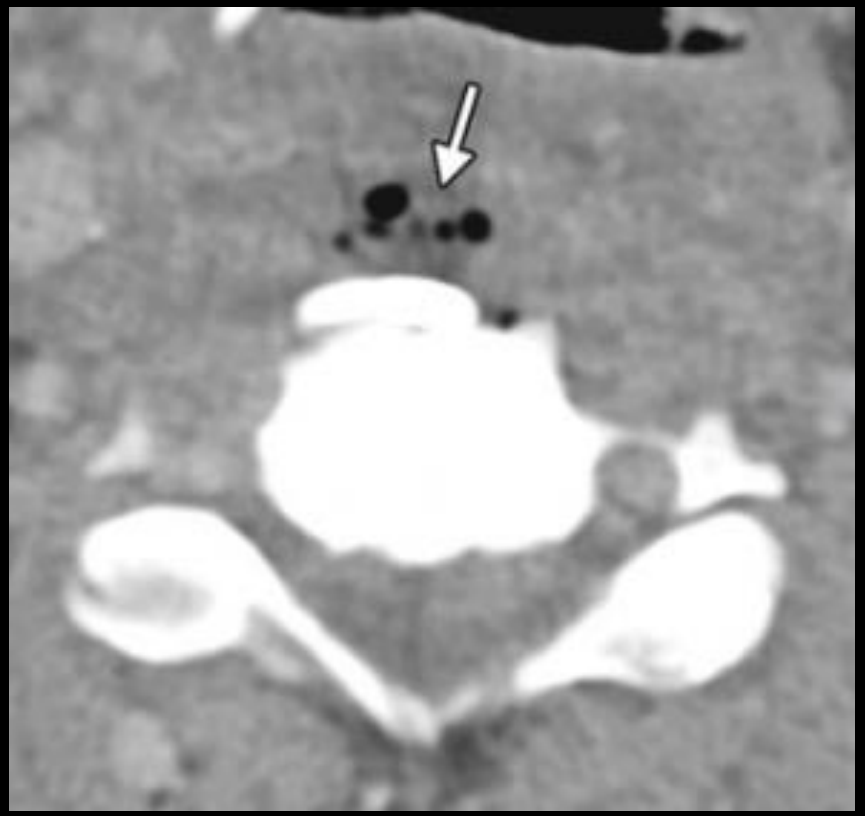
  Koller H, et al. 4- and 5-level anterior fusions of the cervical spine: review of literature and clinical results. Eur Spine J 2007; 16:2055-2071.

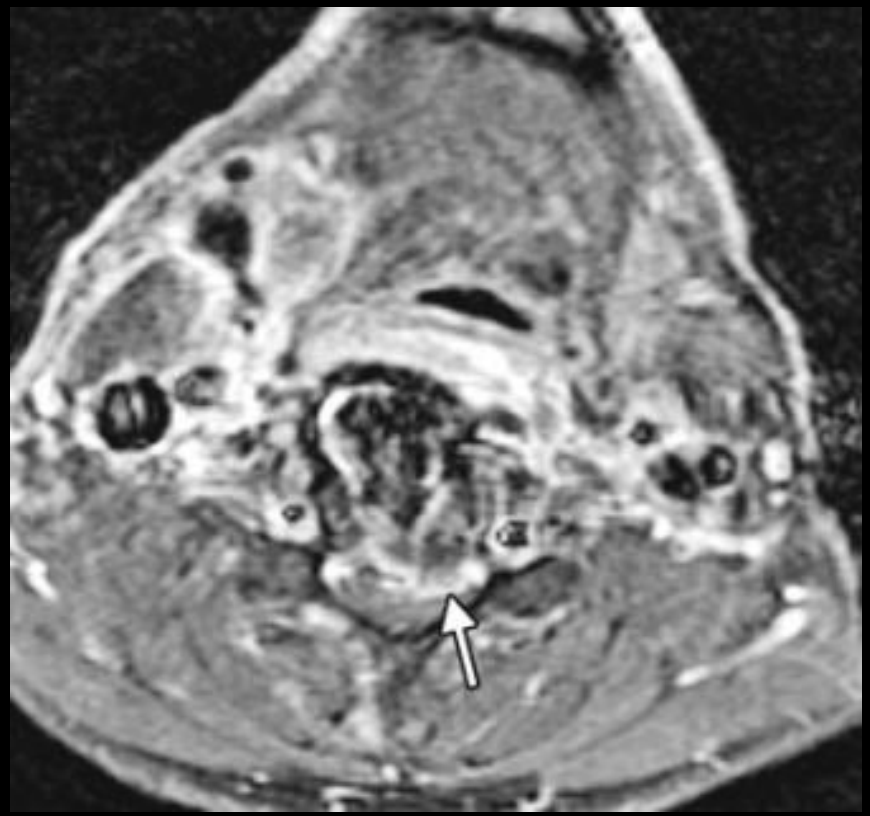
Infection

Surgical site infection

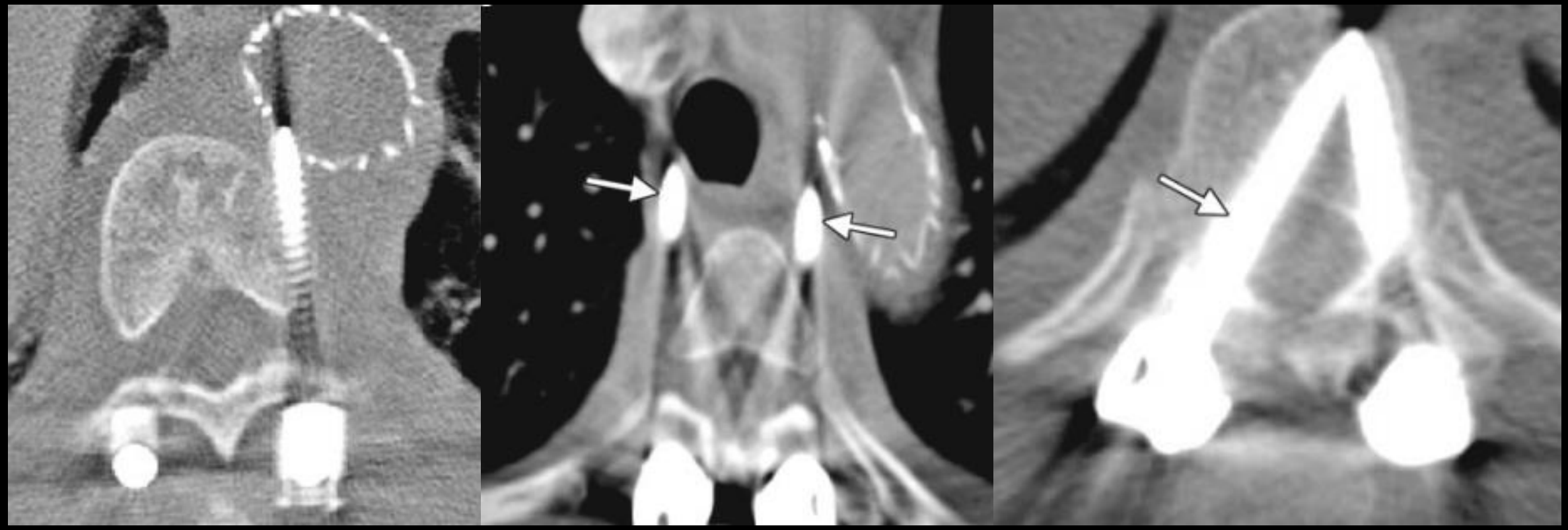
- Superficial surgical site infection
  - Infection isolated superficial to the dorsal fascia
  - Purulent discharge or cutaneous dehiscence with positive microbiologic testing
- Deep surgical site infection
  - Imaging evidence of infection deep to the dorsla fascia +/- positive microbial testing
- Acute infection
  - < 30 days of the surgical procedure
- Delayed (late) infection
  - > 10-12 months after surgery (average 27 months)

Infection





Mechanical Complication



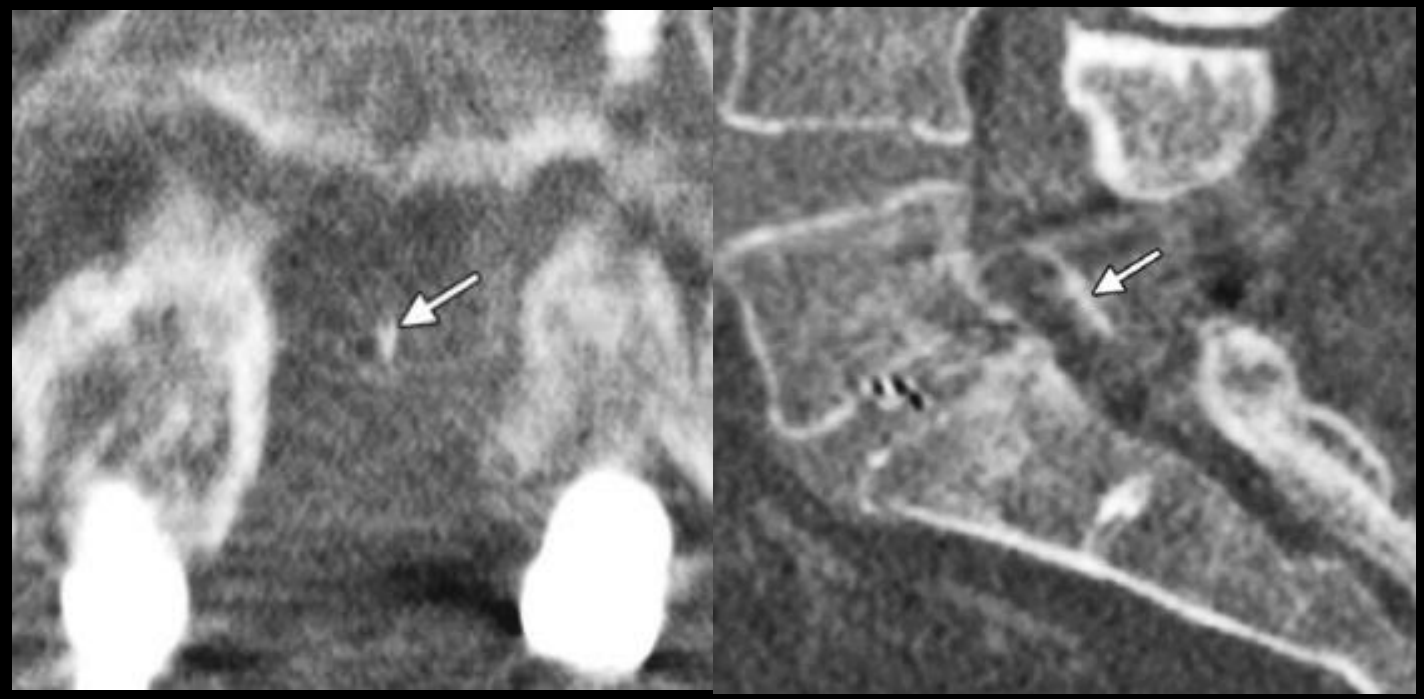
Other complications

Epidural hematoma

- Postoperative epidural hematoma is common (58%)
  - Symptomatic postoperative epidural hemorrhage is rare (0.1-0.22%)
- Most prominent in the thoracic spine

Arachnoditis

- Cause of postoperative symptoms in 6-16%
- Image Findings
  - Empty sac
  - Clumped nerves
  - Mass
  - Arachnoditis ossificans



Radiculopathy

- Typically starts 4 hours to 6 days
- C5 and C6 motor roots (most common)
- Back to baseline 2 weeks to 3 years (mean, 5.3 months)
- Pathophysiology
  - Unknown

Other complications

- Spinal cord injury (0.2%)
- Dysphagia
  - Temporary (60%)
  - More common in revision surgery (28% vs. 11%)
  - More common in multilevel surgery (18% vs. 10%)
- Esophageal perforation (0.1-0.4%)
- Airway complication (6%)
- Postoperative synovial cyst (1% cause of FBS)
- Postoperative intradural inclusion cyst

Summary

- Increasing numbers of spine surgery.
- Use standard terminologies
- Consider grading system for consistency
- CT is the best imaging modality.
- Type surgery → complication

Thank you