Postoperative spine

And how to make it (slightly) less challenging

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Objectives

- History
- 3 main goals of spine surgery
  - Decompression
  - Stabilization/Fusion
  - Alignment
- Surgical techniques
- Hardware and materials
- Postoperative Imaging
- Complications

History

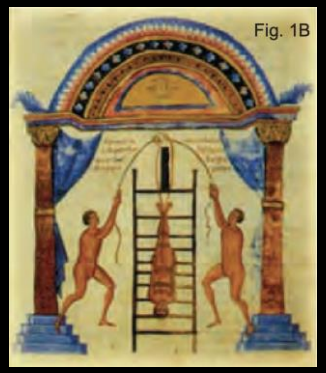
1550 B.C.

- Ancient Egyptians documented spine fractures causing paralysis

460-337 B.C.

- Hippocrates treated spine fractures using different patient positioning

Various physicians developed traction or spinal manipulation devices



Good. Journal of the Spinal Research Foundation. 2010; 5(1): 19-25.

History

1829 – 1888

- Dr. Alban Smith removed bone fragments and spinal tumors/TB for decompression

1940s

- Standard of care: posterior fusion and cast immobilization

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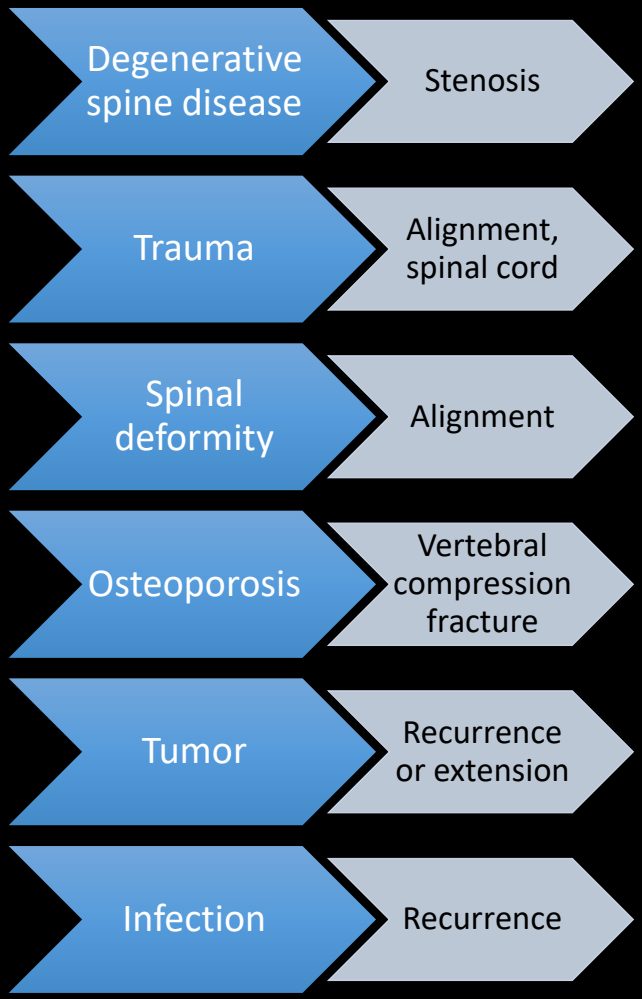
1914

- Dr. Russel Hibbs performed first spinal fusion for scoliosis

Indications for spine surgery



3 main objectives of spine surgery

- Surgical technique/approach and selection of hardware/graft depends on:
  - Objectives of surgery:

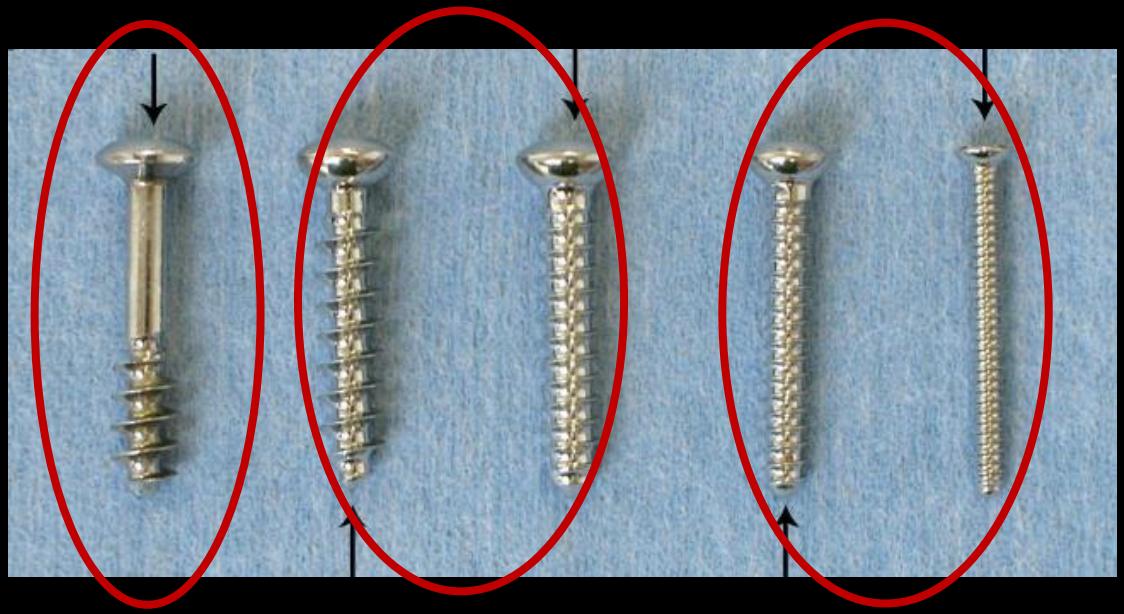
1. Decompression
2. Stabilization/fusion
3. Alignment

  - Site-specific considerations

Screws

- Functions:
  - Fix fractures
  - Attach fusion plates to bone
  - Connect with rods to form rod-screw constructs

Partially threaded screw



Cortical screw

Cancellous screw

cat.vet.upenn.edu

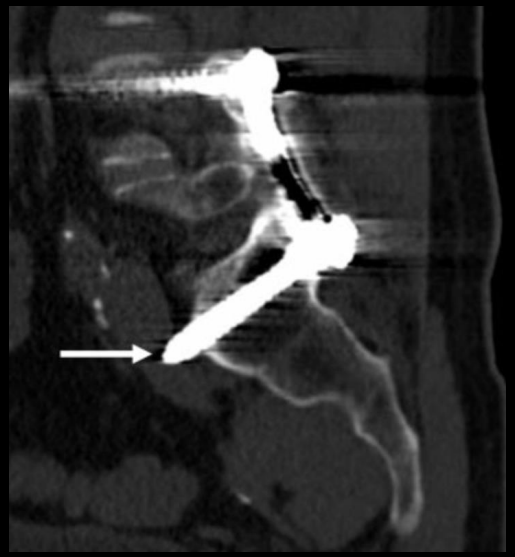
Types of screws

Classified by placement site or function

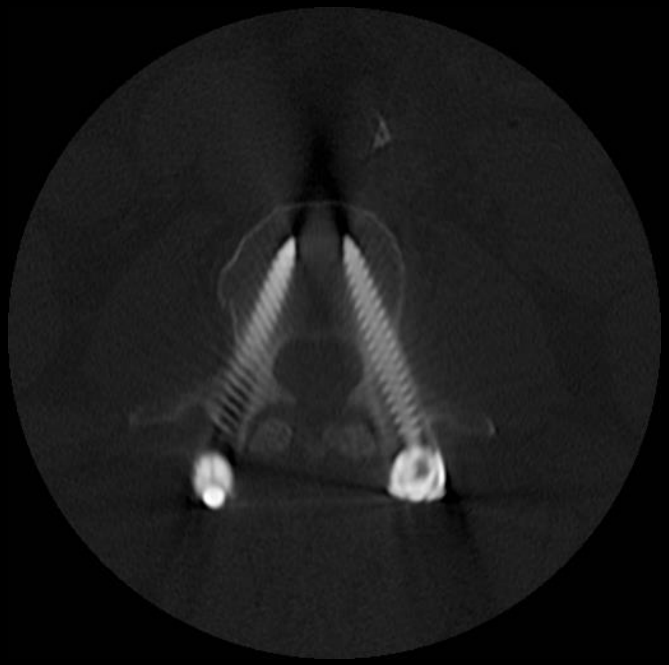
- Pedicle screw
- Laminar screw
- Lateral mass screw
- Facet screw
- Lag screw

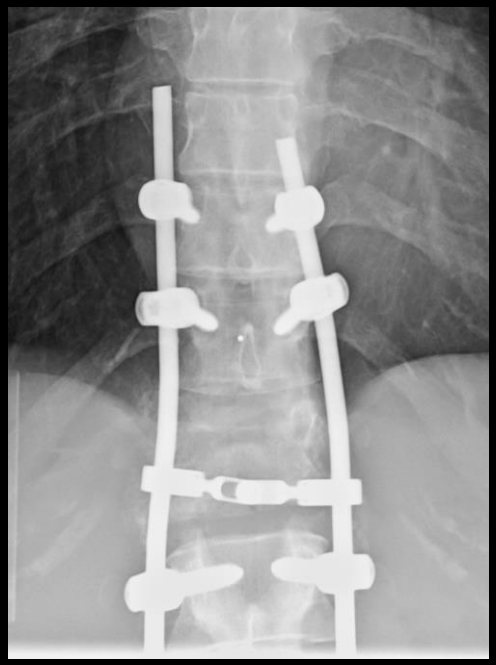
Screw placement guidelines

1. Should not breach medial cortex into neural foramen or spinal canal
2. Should not protrude anterior to vertebral body
3. Should not breach endplate



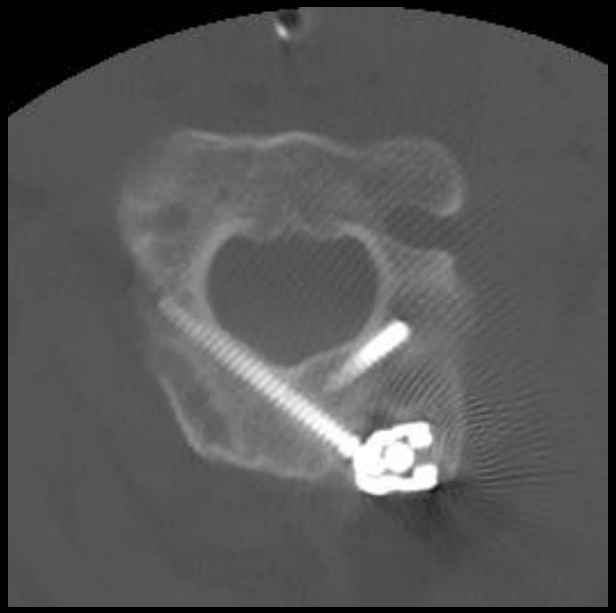
Pedicle screw



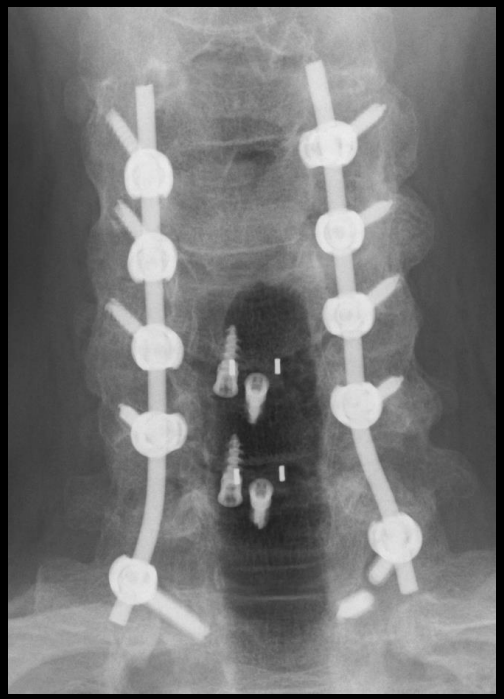


Indiamart.com

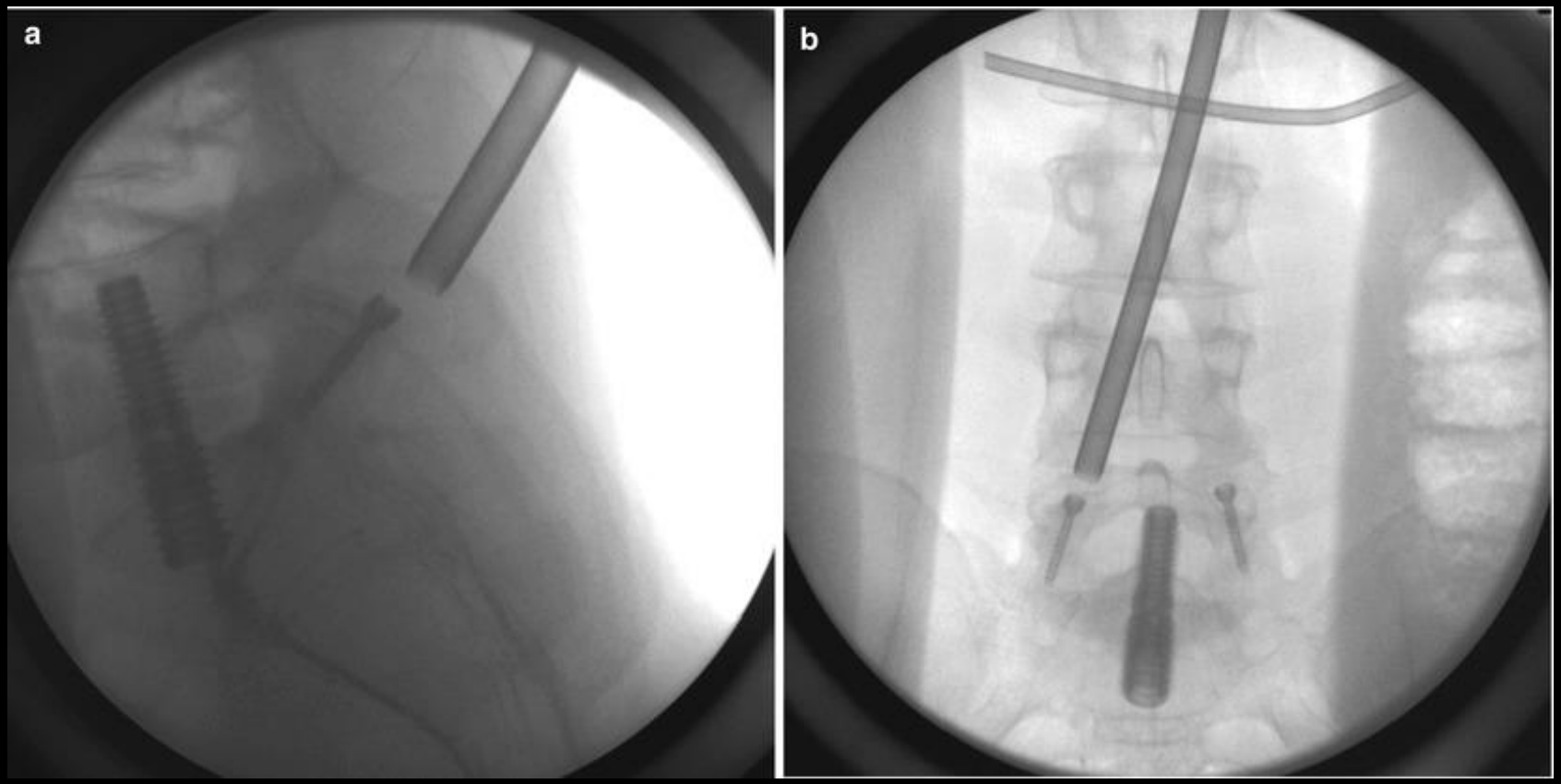
Laminar screw



Lateral mass screw

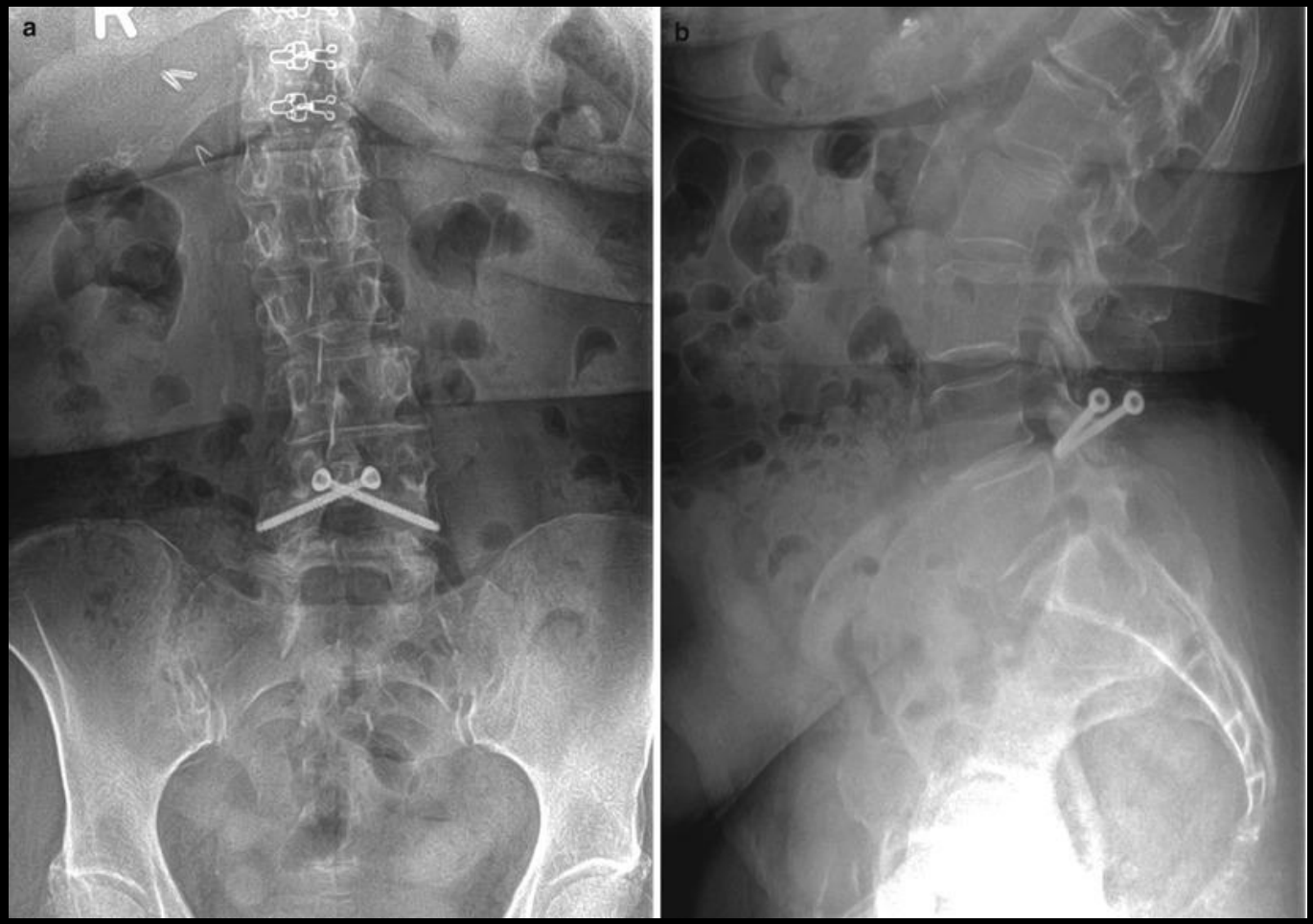


Facet screw



Lieberman I.H., Hu X. (2014) Minimally Invasive Facet Screw Fixation. Minimally Invasive Spine Surgery. Springer, New York, NY

Facet screw



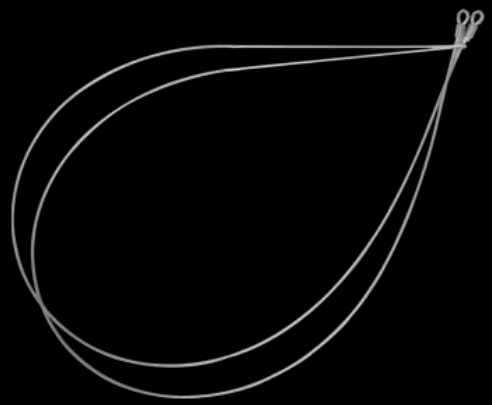
Lieberman I.H., Hu X. (2014) Minimally Invasive Facet Screw Fixation. Minimally Invasive Spine Surgery. Springer, New York, NY

Lag screw

Medicalexpo.com

Wires

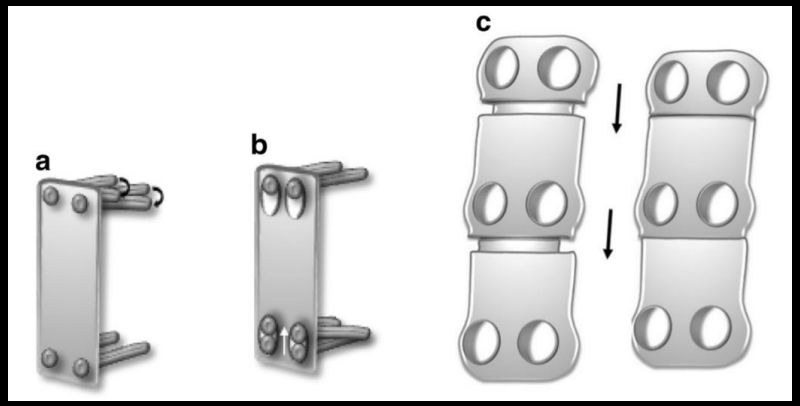
- Metallic wires traditionally used as primary or supplementary fixation
- Tension-band principle provide compressive force
- Mostly replaced by newer fusion techniques



Medapparatus.com
Globusmedical.com

Plates

- Allow fixation and are anchored to bone by screws
- Screws should be 2 mm from the endplate
- Site-specific:
  - Anterior cervical spine (most common)
  - Occipitocervical junction posteriorly
  - Less commonly, thoracolumbar spine



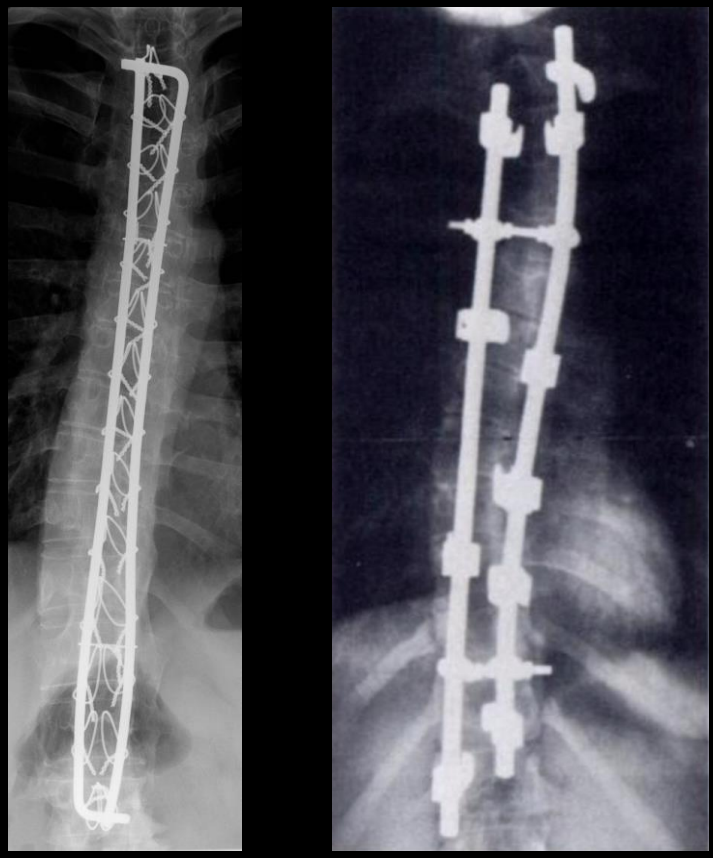
Kani et al. Skel Rad. 2018;47(1):7-17

Harrington rods

- 1950s Harrington hook and rod
  - Rod with hooks attached at top and bottom for distraction
  - Originally treating paralytic scoliosis from poliomyelitis
  - Shortcomings
    - Pull-out of hooks
    - Negative influence on sagittal contour of patient (“flat-back syndrome”)

Rods and rod-wire/screw constructs

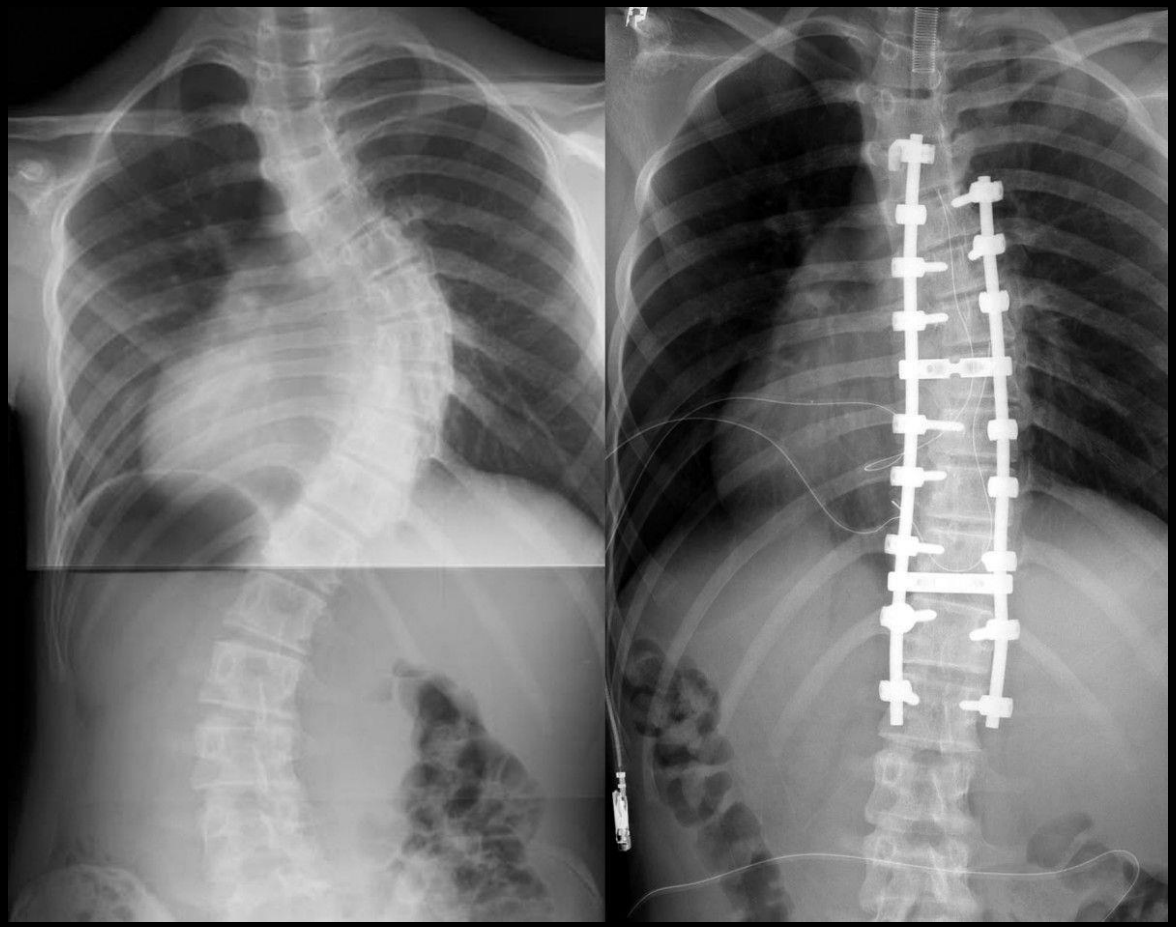
- 1973: First segmental instrumentation by Edwardo Luque
  - Two-rod system with sublaminar wires at each level
  - Did not address rotational component
- 1980: Subsequent systems allowed for correction for rotation and cross-linking for additional stability



Bonepit.com

Slone et al. Radiographics. 1993;13(3):521-543

Modern rod-screw constructs



Fusion cages/grafts

- Made of: various materials, including: polyetheretherketone (PEEK), titanium, carbon fiber, ceramics, etc.
- Interbody spacers
  - Ramps vs cages in C-spine (filled with bone graft)
  - Goals:
    - Promote fusion
    - Maintain alignment
    - Provide support and restore height
  - Placement: radiopaque marker should be 2 mm anterior to posterior cortex of adjacent vertebral body

Bone grafts

- Facilitate fusion
- Autograft
  - Sites include: Local, iliac crest, ribs/fibula
  - Complication: donor site morbidity, limited quantity
- Allograft: cadaveric donation
  - Drawback: infection transmission

Bone graft substitutes

- May be used alone or supplement bone grafts
- Recombinant bone morphogenic protein (r-BMP)
  - Supplemental use with bone graft improves fusion
  - Complications have tempered enthusiasm for its use
- Demineralized bone matrix (DBM)
  - Derived from demineralized cadaveric bone
  - Similar disease transmission as allograft
  - Demineralized technique not regulated -> variability

Google.com

Wright.com

Decompression surgery

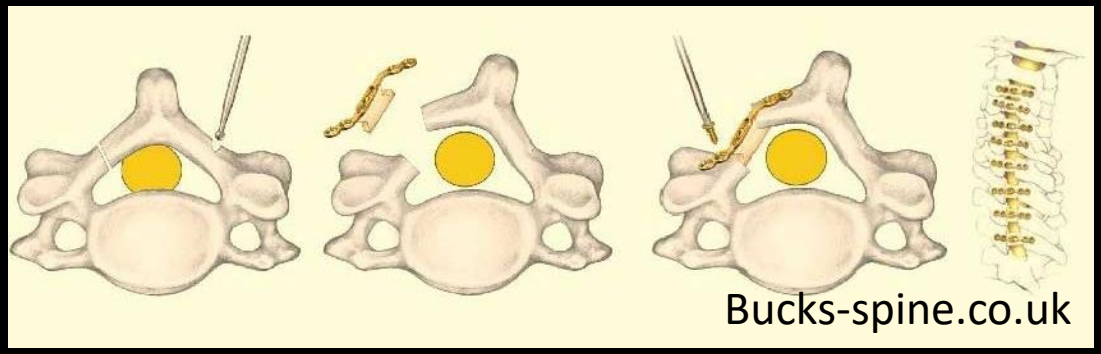
- Relieve mass effect on spinal cord and/or exiting nerve roots
  - Potential culprits: Bone, disc, ligaments, facet joints, cyst, epidural mass lesion
- Multiple techniques:
  - Laminotomy
  - Laminectomy
  - Facetectomy
  - Laminoplasty
  - Discectomy

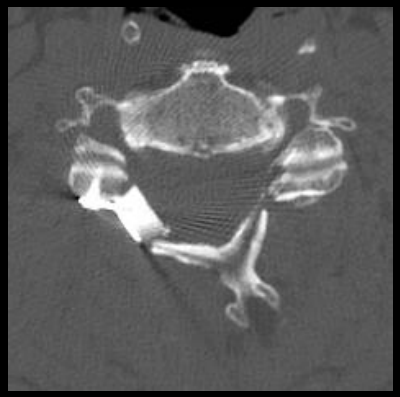
Laminotomy and Laminectomy

- Laminotomy = removal of part of lamina
- Laminectomy = complete removal of lamina and if bilateral, also of spinous process
- Facetectomy = removal of inferior facet and joint capsule
- Foraminotomy = removal of medial half of inferior facet
- Each of these can be used as access to remove offending structures (i.e. disc, cyst, facet capsule hypertrophy)

Laminoplasty

1. Cut one lamina, partially cut the other lamina
2. Elevate laminar fragment to widen spinal canal
3. Stabilize with a plate





Stabilization and Alignment surgery

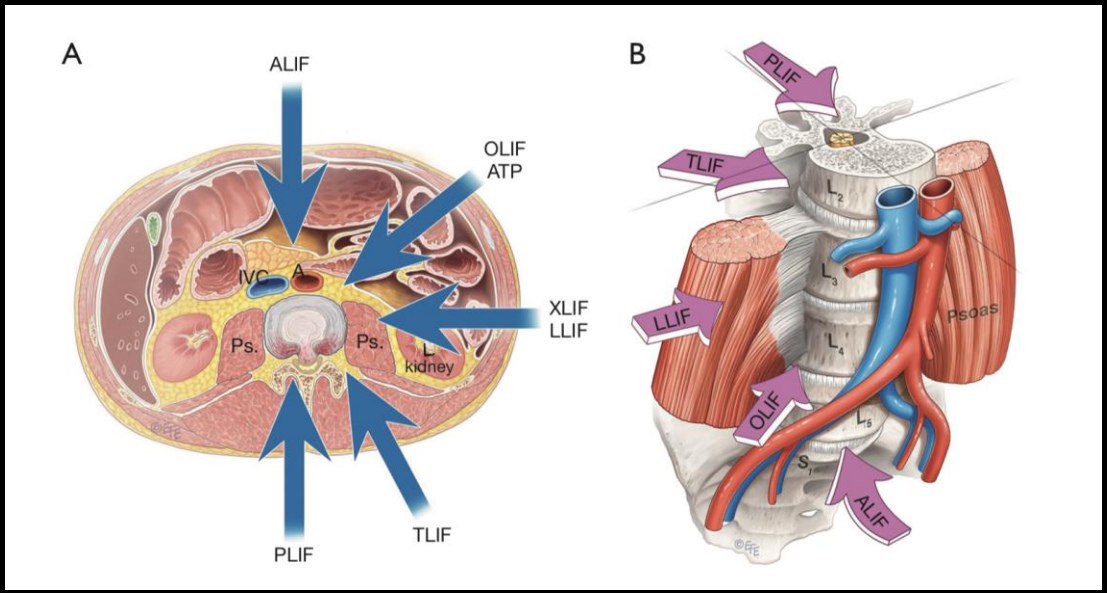
- Objectives:
  - Stabilization
  - Maintain/improve alignment
  - Replace removed structures
  - Eliminate pain
- Stabilization achieved by:
  - Rigid instrumentation
  - Interbody implants
  - Vertebral body implants
- Alignment achieved by:
  - Distraction and compression instrumentation
  - Segmental instrumentation

Posterior fusion

- Fusion of posterior elements
- Most commonly used in occipitocervical junction and thoracolumbar spine
- Often performed after posterior decompression to maintain stability
- Performed with:
  - Rod-screw constructs,
  - Posterolateral fusion with bone graft (between transverse processes or lamina)

Interbody fusion

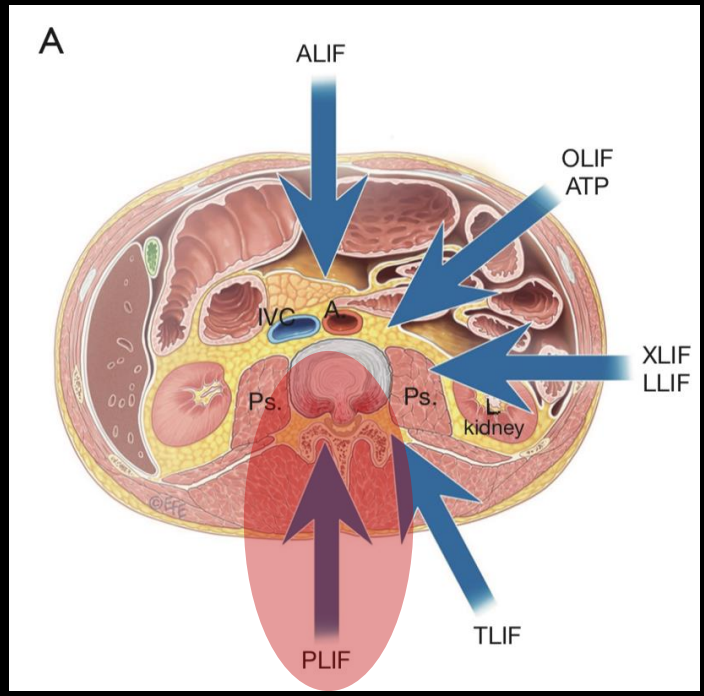
- Fusion of the anterior spinal column
- Nomenclature of interbody fusion is based on approach
  - Anterior approach in the cervical spine (ACDF)
  - 5 main approaches in the lumbar spine



Mobbs et al. Journal of Spine Surgery. 2015;1(1):2-18

Posterior lumbar interbody fusion (PLIF)

- Either midline or paramedian, followed by b/l laminectomy or laminotomy
- Usually 2 small grafts oriented sagittal
- Advantages:
  - surgeon comfort
  - convenient 360 degree fusion
- Disadvantages:
  - retraction of neural structures
  - damage to paraspinal and posterior ligamentous structures

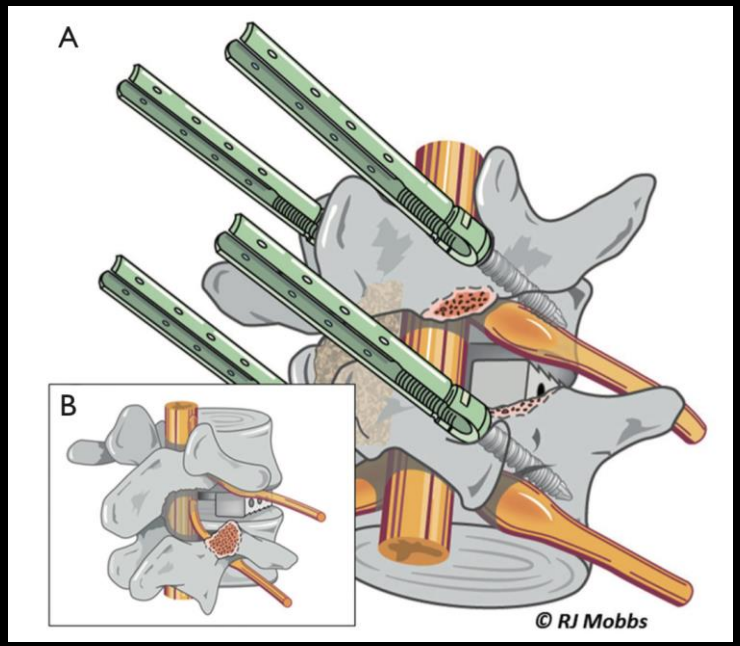


Mobbs et al. Journal of Spine Surgery. 2015;1(1):2-18

Posterior lumbar interbody fusion (PLIF)

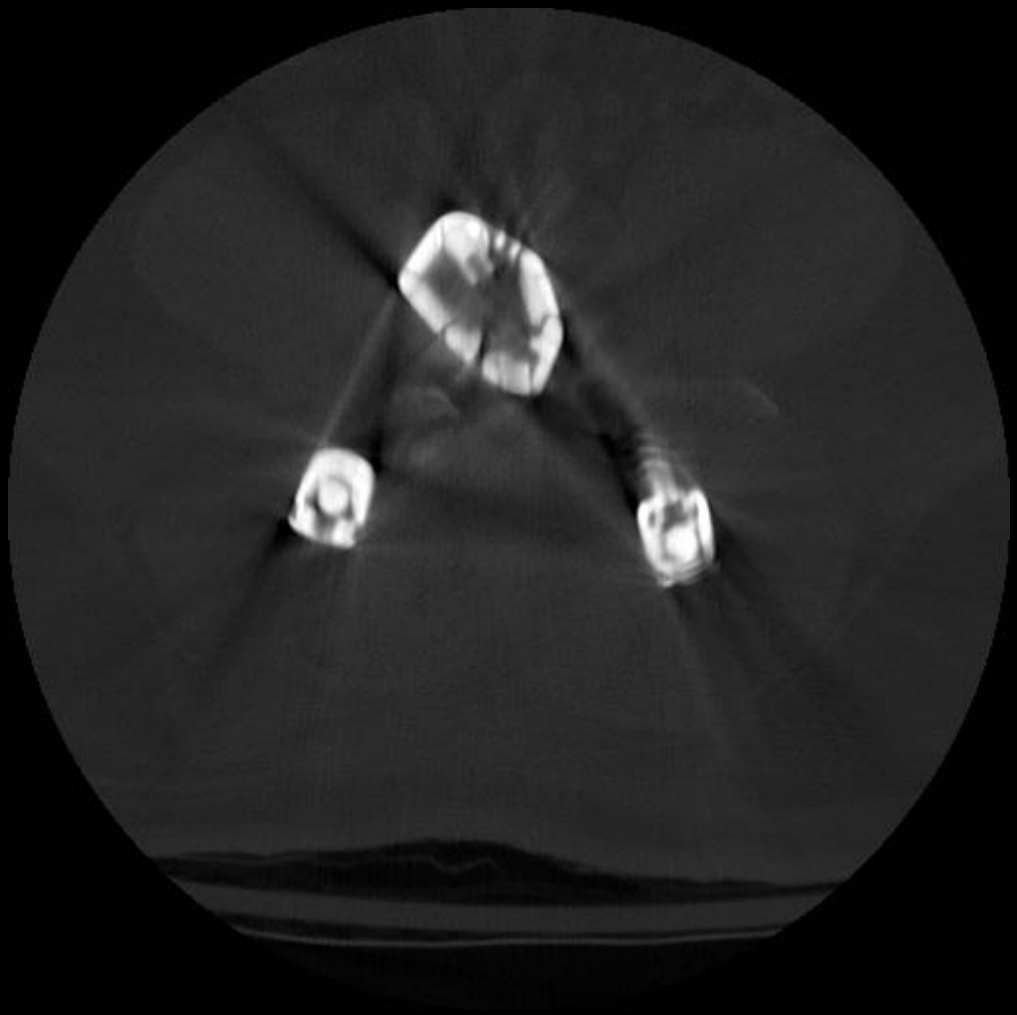
Transforaminal lumbar interbody fusion (TLIF)

- Either midline or paramedian approach, followed by u/l laminectomy and inferior facetectomy
- Oblique graft position, can be elongated
- Advantages:
  - preserve ligamentous structures
  - less retraction on neural structures
- Disadvantages:
  - paraspinal injury



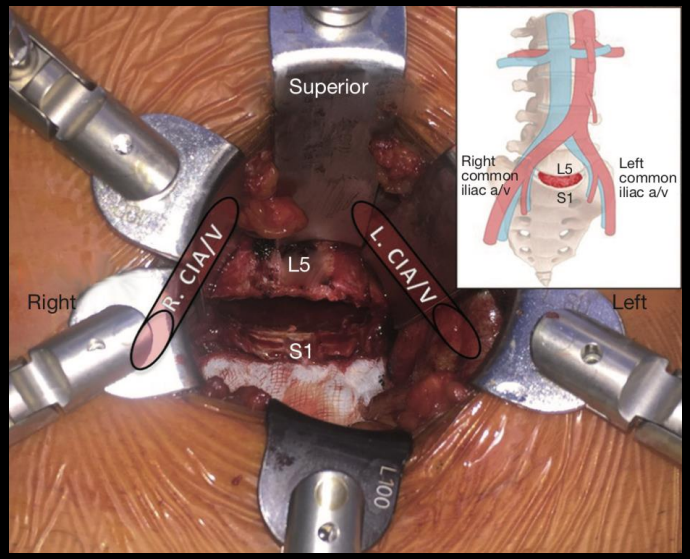
Mobbs et al. Journal of Spine Surgery. 2015;1(1):2-18

Transforaminal lumbar interbody fusion (TLIF)



Anterior lumbar interbody fusion (ALIF)

- Retroperitoneal approach
- Graft is round, usually anterior, and traditionally has interference screw
- Advantages:
  - direct visualization of disc to allow maximum implant size
  - Spares paraspinal muscles
- Disadvantages:
  - injury to vessels and anterior structures, limited at L2-L3 and L3-L4

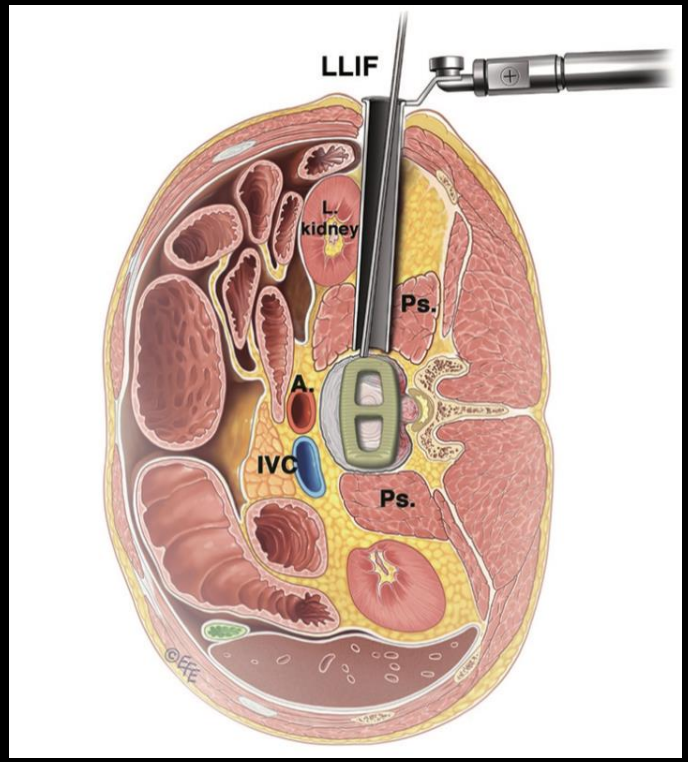


Mobbs et al. Journal of Spine Surgery. 2015;1(1):2-18

Anterior lumbar interbody fusion (ALIF)

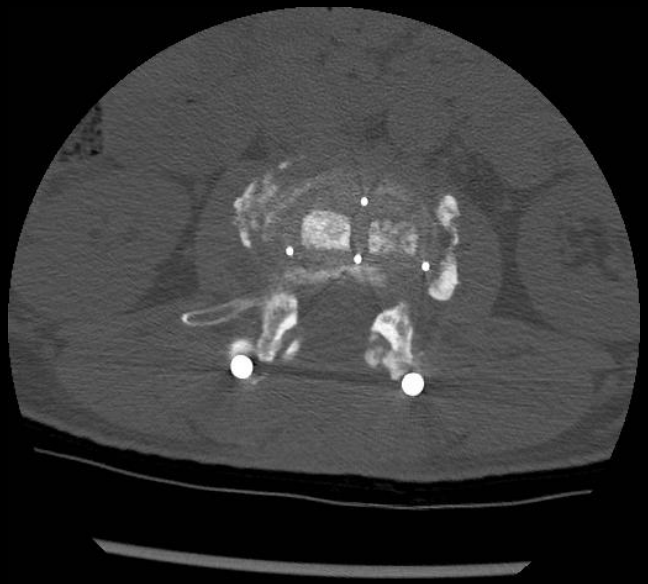
Lateral lumbar interbody fusion (XLIF)

- Transpsoas approach
- Rectangular graft, horizontal in position
- Advantages:
  - Quicker postop mobilization
  - Good disc clearance
  - High fusion rate
- Disadvantages:
  - Lumbar plexus injury
  - Psoas or visceral injury



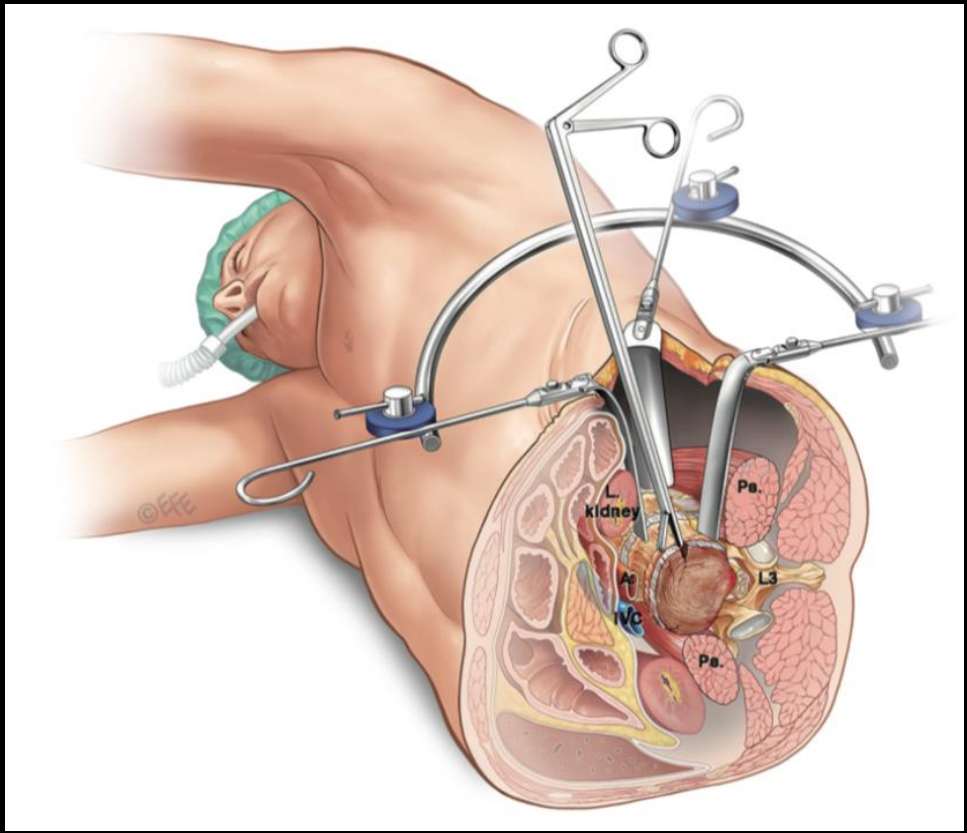
Mobbs et al. Journal of Spine Surgery. 2015;1(1):2-18

Lateral lumbar interbody fusion (XLIF)



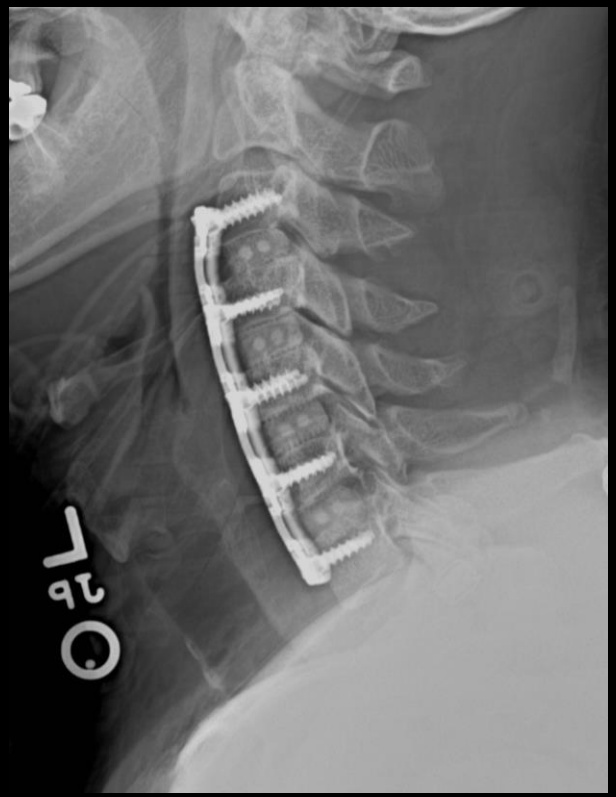
Oblique lumbar interbody fusion (OLIF)

- Anterior to psoas approach
- Otherwise similar to XLIF



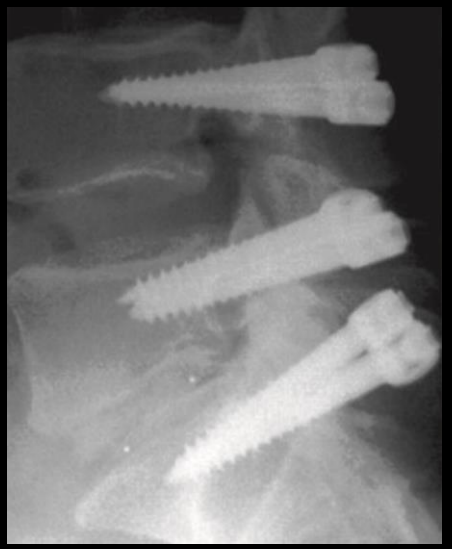
Anterior cervical discectomy and fusion (ACDF)

- Most commonly performed procedure for degenerative cervical disease
- Transoral-transpharyngeal, retropharyngeal techniques
- Discectomy, then fusion with interbody spacer
  - Spacer may be a ramp (solid) or cage (filled with bone graft)
  - May be augmented with plating system
- Corpectomy may be necessary



Dynamic posterior stabilization

- Provide stabilization but distribute stress throughout segments to lower risk of adjacent segment degeneration
- Pedicle screws connected by various materials, many which are not radiopaque, that still allow some motion



Rutherford et al. Radiographics. 2007;27(6):1737-1749

Motion-preserving instrumentation

Total disc arthroplasty

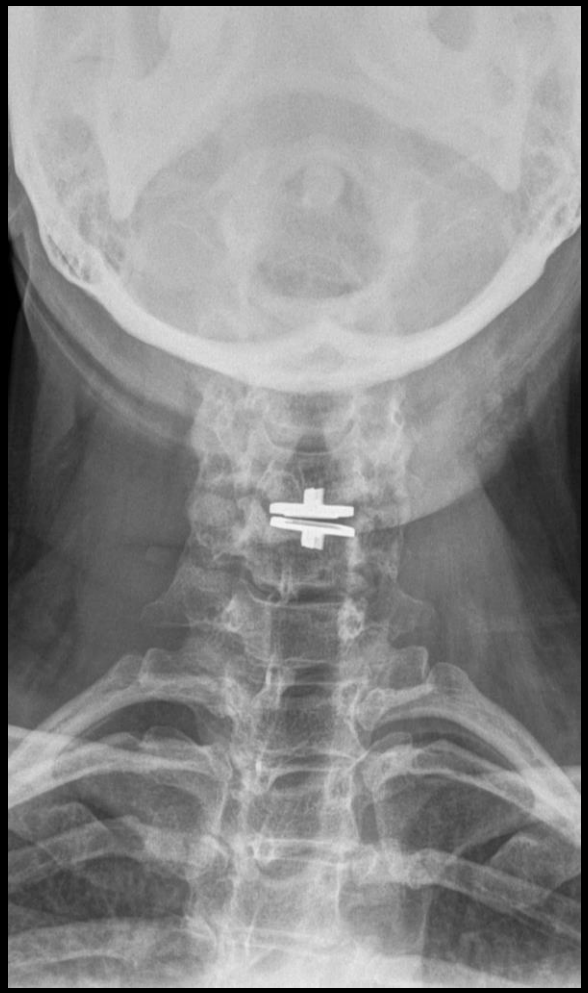
- Indications (Charité):
  - Degenerative disease at one level
  - Spondylolisthesis of 3 mm or less
- Contraindications
  - Demineralized bones
  - Lumbar vertebral stenosis
  - Isolated radicular syndrome

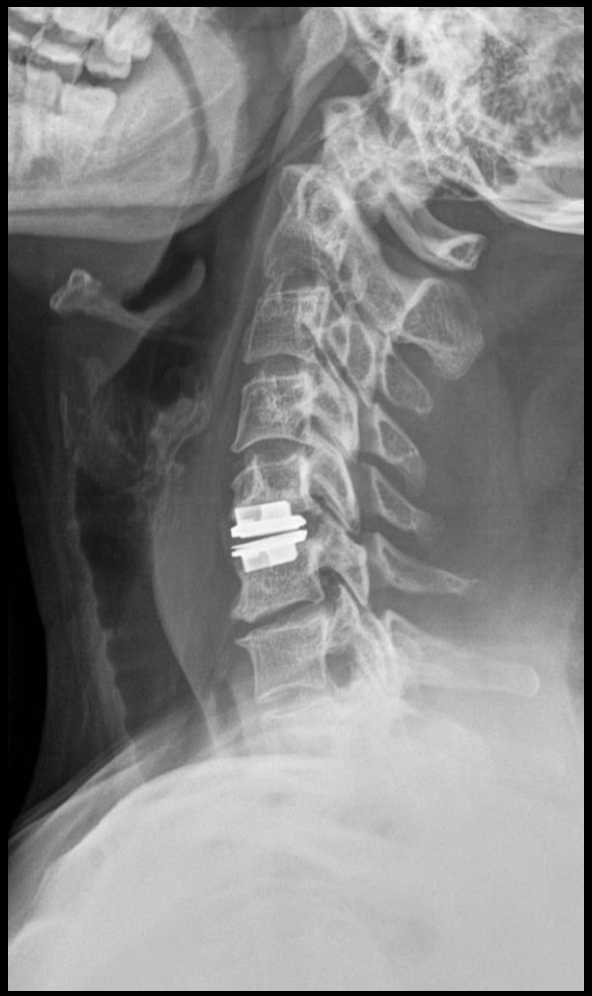
Motion-preserving instrumentation

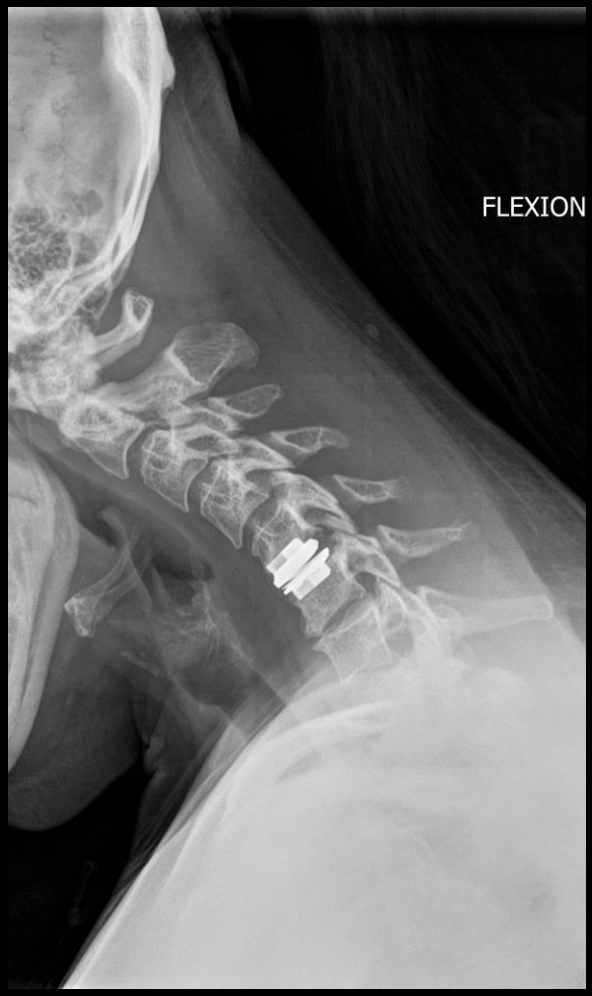
Total disc arthroplasty

- Design consists of 2 metallic plates attached to vertebral bodies with a central inlay, either by ball-socket mechanism or held by compression (Charité)
- Requires anterior approach
- Advantages:
  - decreased hospitalization, OR time and blood loss
  - Preserves flexion and extension to decrease adjacent segment disease

Total disc arthroplasty

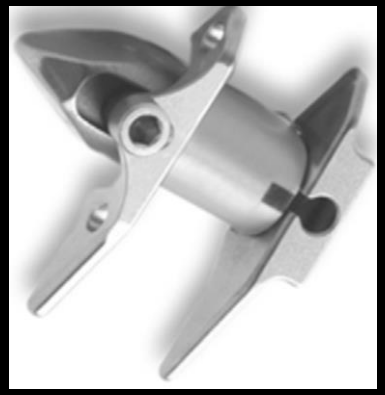






Interspinous distraction devices

- Indication: position-dependent intermittent claudication from spinal stenosis
- Keep spine in flexed position
- Decreases complications but increases revision rates



Murtagh et al. Radiology. 2011;260(2):317-330.

Radiographs

- Alignment
- Hardware position and fracture
- Bone-implant interface
- Dynamic imaging for instability

CT

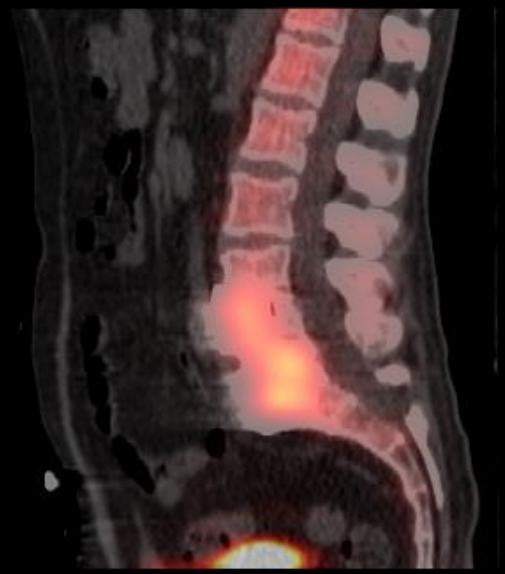
- Targeted exam, not recommended for routine follow-up
- Assess hardware, fusion, degenerative disease, recurrent disease
- Metal suppression
  - High-peak voltage
  - High-tube current
  - Narrow collimation
  - Thin sections during acquisition

MRI

- Assess for complications:
  - Infection
  - Dural tear
  - Compressive lesion
  - Postoperative collection
  - Fibrosis (with contrast)
- Metal suppression
  - STIR
  - Swap phase and frequency encoding directions
  - Increase bandwidth
  - decrease voxel size

Additional modalities

- Ultrasound: postoperative collections
- Nuclear medicine
  - Pseudarthrosis
  - infection



Immediate/early complications

- Wrong level
- Improper implant placement
- Dural tear
- Hematoma/postoperative collection
- Injury to adjacent structures
- Infection
- Hardware-related fracture

Immediate/early complications

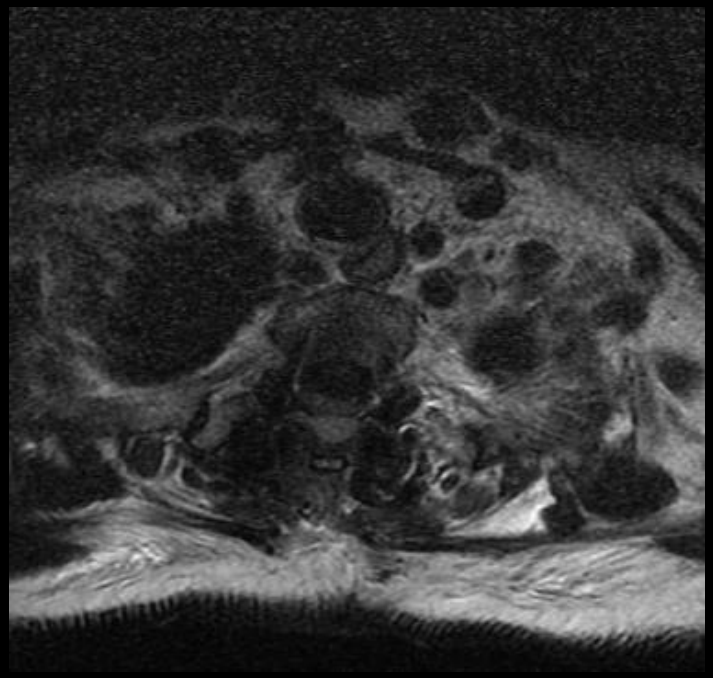
Rutherford et al. Radiographics. 2007;27(6):1737-1749

L4 burst fx

Wrong level

Immediate/early complications

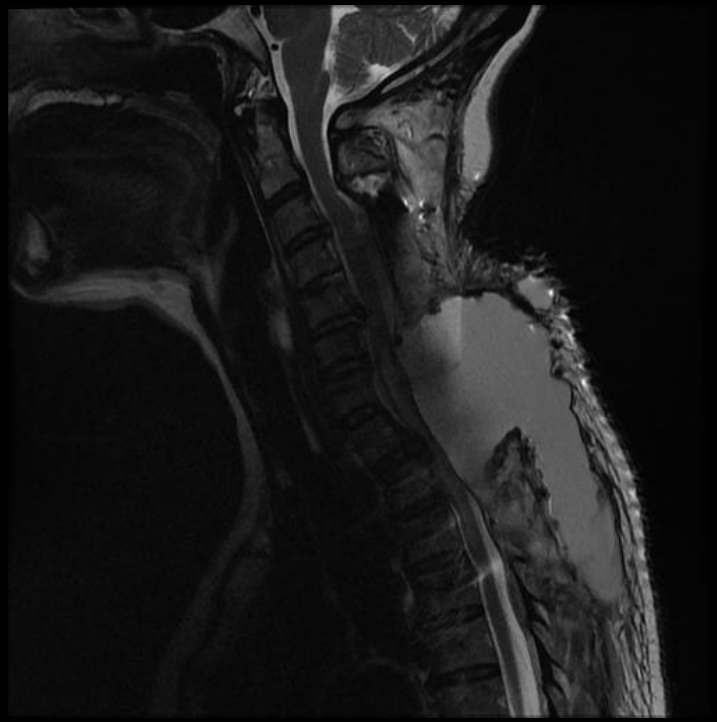
Several days s/p resection of OPLL



Epidural hematoma

Immediate/early complications

5 days after evacuation of epidural hematoma



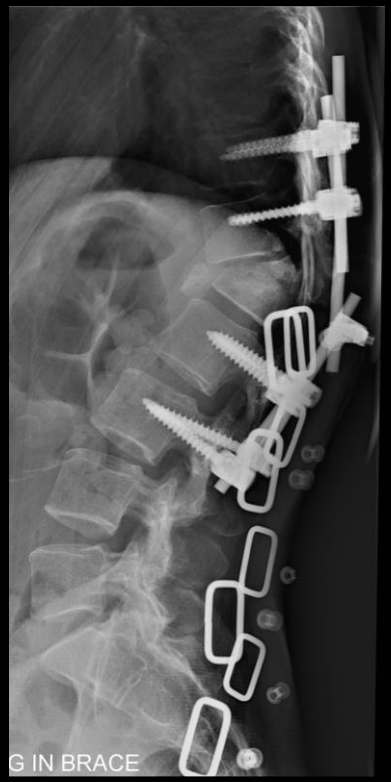
Dural tear/postoperative collection

Immediate/early complications

Injury to adjacent structures (internal iliac artery)

Immediate/early complications

Baseline

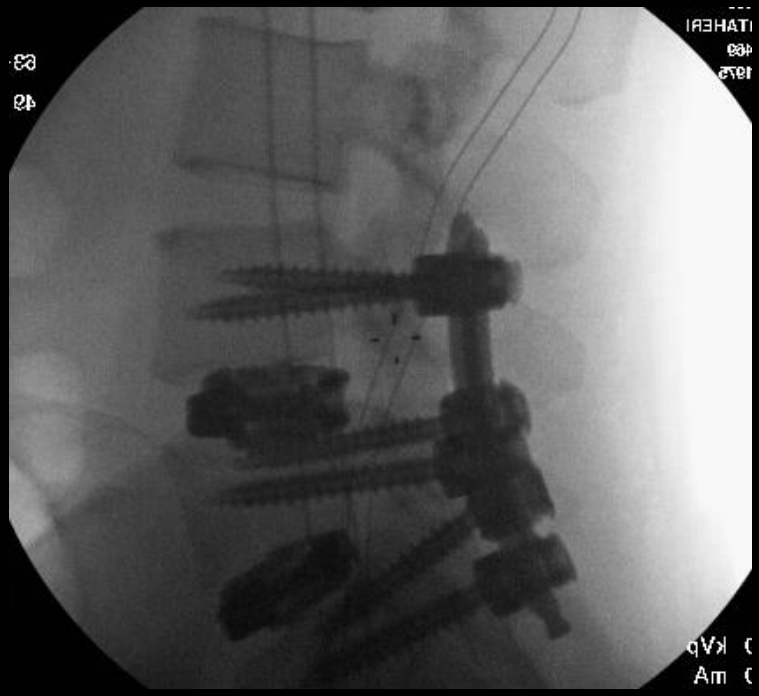


Few months later

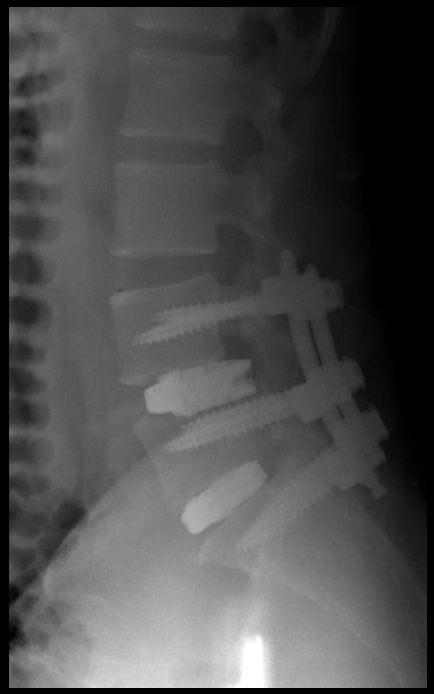
Hardware failure

Early complications

S/p TLIF



Baseline



3 days later

Migration

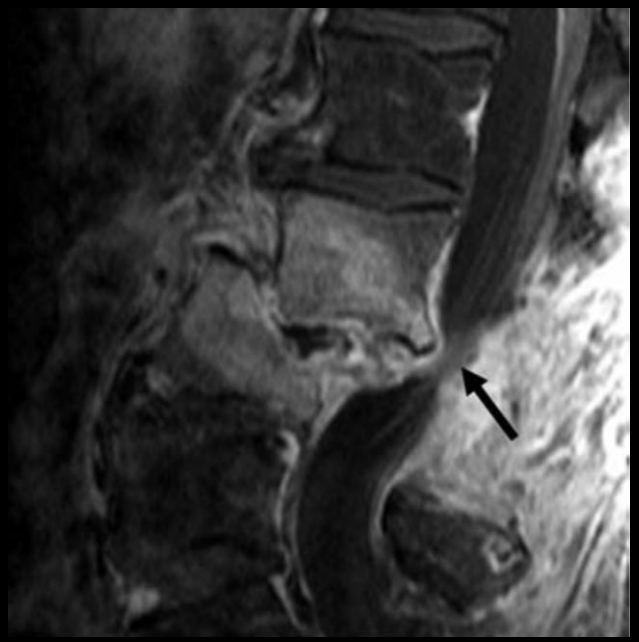
Late complications

- Infection
- Pseudoarthrosis
- Hardware loosening, migration, or failure
- Adjacent segment degeneration
- Failed back surgery syndrome
  - Peridural fibrosis
  - Arachnoiditis
  - Recurrent disc pathology

Late complications

S/p microdiscectomy

Young et al. RadioGraphics 2007; 27:775–789



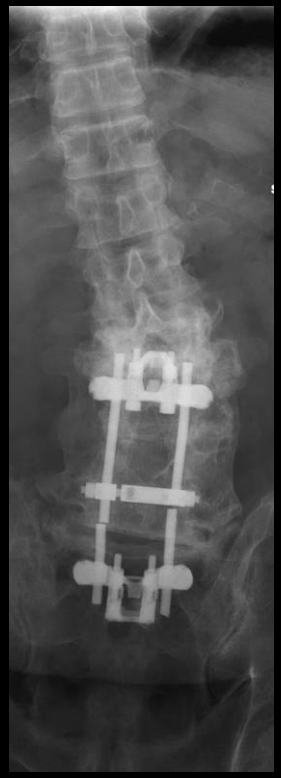
Baseline

6 month follow-up

Infection

Late complications

2 years after lumbosacral fusion



Pseudoarthrosis

Late complications

Postop

6 months later

Loosening

Late complications

Immediate postop

9 months later

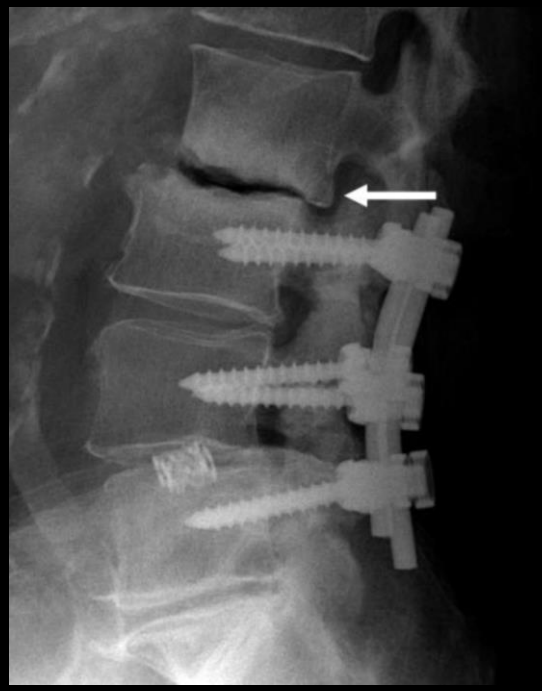
Subsidence

Late complications

S/p PLIF

Rutherford et al. Radiographics. 2007;27(6):1737-1749

Immediate postop

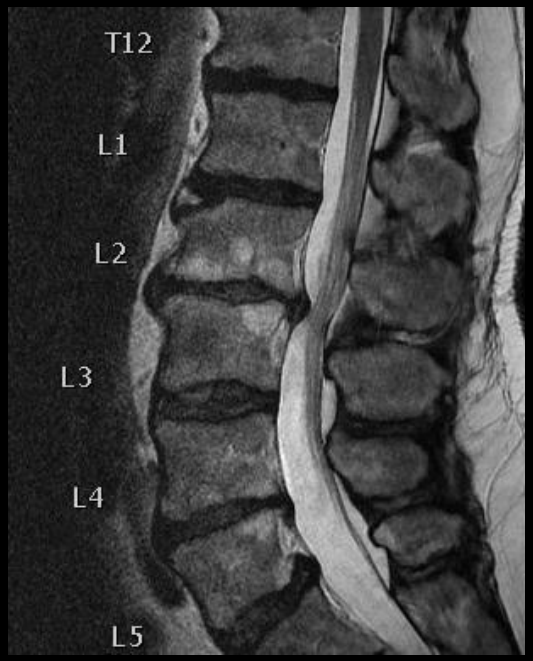


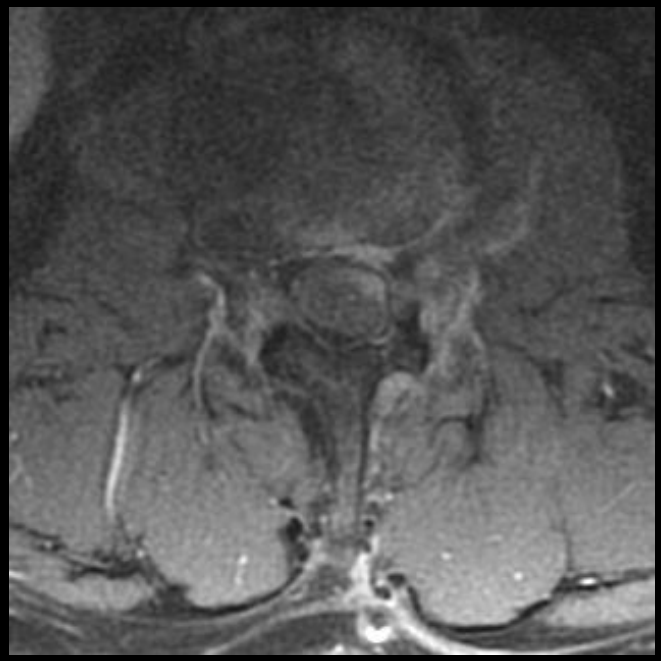
2.5 years later

Adjacent level degeneration

Late complications

S/p L2 laminectomy and microdiscectomy





Preop

7 months postop

Recurrent disc herniation

Summary

- Understand 3 objectives of spinal surgery
  - Decompression
  - Fusion
  - Alignment
- Reviewed current hardware and basic surgical approaches
- Familiarized with early and late complications of spine surgery

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