Imaging of postoperative spine

Amit Herwadkar
Salford Royal Hospital
Introduction

• Spinal surgery is common and has extensively evolved into a complex, specialized field.

• Instrumentation is used to provide stability and restore anatomical alignment in the treatment of fractures, degenerative disease, infection, tumours, and congenital deformities.

• Various posterior and anterior surgical approaches may be used and instrumentation may involve a myriad of devices including screws, spinal wires, vertebral cages, and artificial ligaments and disks.
How to tackle this issue?

“The more I want something done the less I call it work”

Illusions
What does my request card say with post op imaging?

Indications:

- Assess complications
- Assess progression of fusion
- Confirm integrity of construct
- Detect new disease or disease progression
Points to share

• Understand the relevance of the imaging techniques and protocols used in the assessment of the postoperative spine.

• Normal imaging appearances of the postoperative status of the spine following various surgical procedures including stabilization, fusion, and disk replacement with various techniques and devices.

• To demonstrate possible complications following spinal operations.
Our tools

- Radiographs
- CT evaluation
- MR Imaging
- USS
- Nuclear medicine
- Myelography
Radiographs

- Fusion
- Hardware integrity
- Comparison x-rays
- Flexion-extension views? For stability
CT evaluation

- Osseous union
- Hardware assessment
- Starburst artefacts
- Titanium better than steel
- High Kv and mA
MR Imaging

- Intraspinal consequences
- Infection and collections
- Titanium is less ferromagnetic than steel and less susceptibility artefacts

- GRE inhomogeneity is worsened.
- Reduction in echo time
- Phased array coils with parallel imaging and increase in band width
Myelography

- Technical challenges after surgical scarring and instrumentation reducing window to the theca
- Consider when MR is non-diagnostic
- Supplemented with CT
Myelography

- Evaluation of the spine when MR is not useful – e.g. artefact from metal prostheses

Distortion of images on MR

Diagnosis achieved with CT myelography
Know your surgeon and the Surgical procedures

3 goals

• Decompression of neural elements
• Stabilisation and fusion
• Excision of tumour and debridement of infection
Surgical procedures

Decompressive-
To relieve pressure on neural structures
- Laminotomy
- Laminectomy
- Facetectomy
- Discectomy
- Vertebrectomy
Laminectomy and hemilaminectomy
Surgical Procedures - Instrumentation

Instrumented fusion -
Does not replace bony elements but stabilises them during fusion.

Instrumentation without osseous union will fail.

- To promote bone fusion and to prevent pseudoarthrosis
- To ensure spine stability
- Deformity correction
Surgical procedures-
General Principles

• Generally, two of three columns must be anatomically intact for functional stability. Instrumentation is therefore considered if more than one column is disrupted by trauma, infection, tumour etc.

• Recent advances have been prosthetic disc replacements and distraction devices that aim to improve symptoms without the complications of spinal fusion.
Surgical procedures - General Principles

Nomenclature of the instrumentation used in spinal fixation reflects the surgical approach used to access the spine rather than the final position of the hardware.

- Posterior and posterolateral approach is used to either decompress neural structures or to fuse two or more adjacent vertebrae – traverse the neural canal to reach the intervertebral disc.

- Anterior or anterolateral approach allows direct access to the intervertebral disc space, resulting in a much lower risk of damage to neural structures.
Surgical approach

(a) Posterior lumbar interbody fusion [PLIF], discectomy and fusion via a posterior surgical approach.

(b) Transforaminal lumbar interbody fusion [TLIF], procedure similar to posterior one but performed using a more lateral approach, sparing the posterior elements, but still crossing the spinal canal.

(c) Anterior lumbar interbody fusion / anterior cervical discectomy and fusion [ALIF/ACDF], allows direct access to the intervertebral space without crossing the spinal canal.

(d) Extreme lateral interbody fusion [XLIF] involves a retroperitoneal approach, through the psoas muscle and into the disc space.
Interbody spacers

- Function as a spacer to restore the disc height and to facilitate bony fusion between adjacent vertebrae.

- Inter-body cages should be sited within the disc space with no adjacent lucency or sclerosis.

- Most contain two radio-opaque markers.

- Posterior marker of at least 2 mm anterior to the posterior vertebral body margin provides reassurance that the spacer is not protruding into the spinal canal.

Radio-opaque markers of non-metallic cage in a patient who underwent an ACDF.
Instrumentation-ACDF plated fusion
ACDF changes
Anterior cervical discectomy fusion
Short segment fusion - Rods and plates with pedicle screws

- Pedicle screws connected by plates or rods that span single or multiple vertebrae
- Commonly used in lumbar spine.
- Tips of pedicle screws should be embedded in the vertebral body and should not breach the anterior cortex.
- The screws should traverse the pedicle and, in particular, should not breach the medial cortex of the pedicle.
- Metal work should be intact

Rod and screw construct spanning L1 to L3 to stabilise a burst fracture of L2. Note the normal positions of the pedicular screws and the intact metalwork.
Posterior fixation
Rod and screw device
PLIF
Posterior lumbar Interbody fusion
Degenerative scoliosis
PLIF
Vertebral body replacement

- Vertebral body replacement may be necessary after a resection (corpectomy) because of tumour, infection, or major trauma.

- Two main types, an expandable hollow cylinder packed with bone graft material or cement, or a device made of mesh.

- Rods and/or plates with lateral, anterior, or posterior screws are inserted for additional stability.
Disc prosthesis

Prerequisites

- Disc replacements overcome problems associated with pseudoarthrosis and reduce incidence of adjacent segment degeneration.
- Pain is believed to originate from disc degeneration
- No neural compression
- Residual 4mm disc height
- Absence of endplate degeneration
Disc replacements
Complications

Learning is not whether we lose a game,
But how we lose and how we have changed
because of it.
Losing, in a curious way, is winning

- The Bridge Across Forever
# Complications

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<th>Early</th>
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<td>Injury to adjacent structures</td>
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<td>Dural tears</td>
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<td>Post operative scarring</td>
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<td>Recurrence of disc prolapse</td>
<td>Loosening of prosthesis</td>
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Immediate-Post operative hematoma

Post operative **subdural haematoma** causing cauda equina compression following a posterior decompression.
Immediate-
Post operative haematoma

Postoperative epidural haematoma causing cauda equina compression following a posterior decompression and instrumentation (PLIF).
Immediate Vascular Injury

Tip of screw dissecting the left vertebral artery with embolic occlusion of basilar artery
Early CSF leaks and Pseudomeningoceles

• These result from dural breach during surgery
• These produce anterior or posterior clear fluid leaks
• They can produce intracranial hypotension manifesting with postural headaches.
• MR shows sagging of hind brain, subdural effusions and pachymeningel thickening
CSF leak

Anterior CSF leak that along the surgical tract into the subcutaneous tissues following a C5 corpectomy with cage insertion.

Pseudomeningocele following posterior decompression and instrumentation.
Early Intracranial Hypotension

Sagging hind brain, intracranial collections and pachymeningeal thickening
### 2013/14

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Accurate placement of spinal instrumentation is often a technical challenge.

Pedicle screws, in particular, deserve attention because of their frequent use and proximity to sensitive neural and vascular structures.

Optimal screw placement is close to the medial wall of the pedicle without breaching the cortex; the tip of the screw should approach but not breach the anterior cortex of the vertebral body.
Instrument malposition

a) Lateral malposition of the left pedicular screw.
b) Left pedicular screw in the left lateral recess.
c) Right pedicular screw in the right lateral recess.
d) Left pedicular screw in the spinal cord.
Misplaced screw in left lateral recess

Medially placed pedicular screw traversing the lateral recess and pressing the S1 root
Subacute-Infection

- Superficial or deep infections.
- Generally, superficial infections present earlier than deep infections and present clinically with pain, erythema, and swelling.
- Deeper infections involving the implant and/or intervertebral disc space(s); may be difficult to diagnose.
- Manifest as a collapsed intervertebral disc space, destruction of the adjacent endplates and occasionally a para-spinal collection.
Subacute Sacral osteomyelitis

- Foreign body
- Blood and csf culture medium
- Immunocompromised state

Infection along the S1 screws with collections and sacral osteomyelitis
Subacute Infection along screw

Deep Infection leading to discitis and spreading superficially to subcutaneous location
Pelvic Abscess due to infected construct

Deep infection with presacral abscess
Failure of surgical hardware

- Fracture, loosening or migration from mal-positioning, misconstruction, excessive stress, acute trauma, or metal fatigue.
- Transfacet, lateral mass, or transpedicular screws may fracture from metal fatigue, may cause fractures in vertebral body margins, or may enter neural foramen, the spinal canal, adjacent vertebral body levels, or soft tissues.
Chronic Failure of fusion and movement
Pedicular screw loosening

- Typically plain film and CT findings are of a lucent halo surrounding the implant (important differential is infection).

- Helpful differentiator for a mechanical cause is a “windscreen wiper motion” pattern that is caused by a screw pivoting around a fixed point.
ACDF screw loosening
Loosening with non-healing
TLIF at L5/S1 for a recurrent disc prolapse. Migration of the cage into the left L5/S1 lateral recess.
Nerve root cut off

Prosthetic inter-vertebral disc

Poor contrast opacification of left L5 root sleeve due to proximal compression
Thoracic fusion surgery for thoracolumbar scoliosis. Radiograph and volume rendered 3D reformatted CT image demonstrate fracture of the interconnecting rod.
Fracture of screw
Pseudarthrosis / non-union

- Represents fibrous rather than osseous union of the fusion complex resulting in the adjacent bony vertebrae remaining mobile and creating a false joint or pseudarthrosis.
- Assessment of fusion can be difficult and it can take up to a year for evidence of bony fusion to be present after surgery.
- May develop in the presence of chronic low-grade instability and motion.
Chronic Non Fusion

Principles of fusion surgery
- Two of three columns must be anatomically intact for functional stability.
- Instrumentation is necessary if more than one column is disrupted.
- The development of an integrated osseous fusion complex is essential for long-term success,
- Implanted hardware exists to provide short-term stability while fusion develops.
- Inadequate fixation and subsequent motion may cause the bone graft to resorb rather than to be incorporated.
- This in turn puts hardware at risk of failure
Criteria for Non Fusion

- More than 3 degrees of intersegmental position change on lateral flexion and extension views.
- Fluid in the affected segment
- Lucency area around the implant.
- Fracture of the device, graft, or vertebra.
- Sclerotic changes in the graft or adjacent vertebra.
- Absent bone formation in or about the graft material.
Pseudarthrosis / non-union

Ankylosing spondylitis with a fracture through the T10/11 disc and posterior elements that was treated with a T10/11 decompression and T8/L1 pedicle screw fixation.

Sagittal T2-weighted MR image (a) performed at the time of injury demonstrates high signal in the disc space and injury of the posterior elements.

Subsequent STIR sequence (b) and CT (c) images performed 2 years after surgery demonstrates a pseudarthrosis at the T10/11 level (yellow arrows).
Assessment of fusion
AS with pseudoarthrosis

Nonunion with vacuum phenomenon and pseudoarthrosis post instrumentation
Chronic Translational Syndrome

- Loss of mobility of the fused segment places additional stresses on adjacent levels of the vertebral column.
- There is an increased likelihood of degenerative changes, ligamentous instability, and even fracture at levels adjacent to a successful fusion construct.
Interspinous bursitis-Bastruups disease

This can develop above the operated level and cause instability.
Chronic Adjacent level degeneration

Adjacent level degeneration above instrumented level and decompression
Adjacent segment degeneration
Post decompression listhesis
Junctional kyphosis
Chronic Arachnoiditis

Empty theca - Nerve tethered peripherally

Cord sign - Nerves clumped centrally
Chronic
Recurrent disc v/s postoperative scarring

• The hallmark sign distinguishing postoperative scar from recurrent or residual disc herniation is the pattern of enhancement.

• Scar tissue tends to enhance homogeneously, while disc herniation tends to enhance peripherally.

• In the early postoperative period (less than 3 to 6 months), it may be impossible to distinguish peripherally enhancing scar type changes from recurrent/residual disc herniation.
Chronic Recurrent Neuralgia
Disc prolapse and Scarring

Recurrent disc prolapse
Enhancing scar tissue
Conclusion

• Know your surgeon and the surgery

• Know your tools. As elsewhere in radiology, plain films, CT and MRI all are equally relevant.

• Know the disease. We need to be familiar with the normal imaging appearances of the spine following surgery with various techniques and devices and the possible complications that may arise.
Gratitude

- Patients
- Clinicians

- Dr Calvin Soh
- Dr Roger Laitt
- Dr David Hughes
- Dr Samantha Mills
- Dr Gillian Potter

- Dr Toby Williams
- Dr Hannah Stockley
- Dr Owen Thomas
- Dr Stavros Stivaros
- Dr Rekha Siripurapu

For enabling me to learn from my mistakes