Causes of failure of surgery on the lumbar spine.

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Learning objectives

1. To assess the complications of the lumbar spine surgery.
2. To show the most relevant radiological findings.
3. To evaluate the imagine technique most suitable in each case.
Background

INTRODUCTION

Due to the increase in the number and variety of techniques used in surgery of the lumbar spine, it is necessary for the radiologists to know the surgical complications and the imaging findings, as well as the indication of the most adequate imaging technique for each clinical situation.

For a better assessment of the spinal instrumentation and its complications is important that the radiologists recognize the normal appearance on imaging of the lumbar spine after stabilization, fusion and discectomy with various techniques.

The postoperative lumbar complications are important for their frequency (especially degenerative disease) and disability.

Complications after lumbar spine surgery are around 10-20%, mainly loosening and fracture of screws, accelerated degeneration of the disc / facets space, spondylolisthesis postlaminectomy, fibrosis, hematoma, pseudomeningocele, hernia recurrence and complications of spinal cord.

The most frequent reason for studying postoperative image column is the SYNDROME OF FAILURE OF THE SPINE SURGERY (SFCC). SFCC incidence varies from 10-40% (1). The causes are many, some are related to surgery and others not.
Findings and procedure details

We retrospectively reviewed the cases of lumbar spine surgery in our hospital from January-08 until 2014 and selected those with complications in image. In total 60 patients were evaluated. We collected general data such as age, sex and clinical information as well as the type of image technique performed and the findings of interest in each of them. We also collected the reason for the surgery and the surgical technique performed in each case.

The most frequent symptoms were severe low back pain with or without radiculopathy and second cause was cord compression.

The **indications of the surgical procedures** were:

a) **disc herniation**: Discectomy / microdiscectomy with a posterior approach.

b) **lumbar canal stenosis**: laminectomy with posterior flavectomy (laminectomy / foraminotomy), lumbar arthrodesis 360.

c) **spondylolisthesis**: a reduction and placement with or without osteosynthesis (cages, screws and plates or titanium bars) by anterior or posterior autologous bone graft.

d) **vertebral fracture**: vertebroplasty,

e) **tumors**: surgical excision of anterior, posterior or combined route.

This review has allowed us to assess the most common cause of post-surgery lumbar complications in our hospital, collect the most specific radiological findings with various imaging techniques and to determine the best imaging technique indicated in each case.

**A) SURGICAL APPROACH AND MATERIAL.**

The objective of the spinal fusion is the anatomic alignment and to restore the biomechanical function (2,3).

Preferences in the surgical approach and instrumentation material vary depending on the condition of the surgical indication.

- Several ACCESS ROADS (3):
  - Previous: Access anterolateral vertebral bodies.
  - Posterior.
  - Posterolateral: posterior arch, vertebral body and disc.

- **SURGICAL TECHNIQUES (3):**
  - Vertebroplasty.
- Discectomy (microdiscectomy): resection of the disc and release of nerve structures.
- Decompressive laminectomy: resection of posterior elements.
- Spinal fusion.

The aim of the use of surgical instrumentation is to provide stabilization long enough until bone fusion (3,4) occurs. The assessment of integrity and bone fusion is essential in the postoperative study and determines the success of long-term procedure.

The instrumentation associated with discectomy produces distraction in order to restore normal disc space, height and decompression of the neural foramina. The evacuated disc space can then be filled in with bone graft or block interbody fusion boxes containing fragmented bone graft.

Boxes or intervertebral spacers can be metallic or radiolucent with radiopaque marks delimiting their margins. The disc height can be also maintained using disc prostheses that are fitted in the intervertebral space (3,4,5). Bone grafts can be autografts or allografts and its location is after, or in the posterolateral disc space.

B) IMAGE LUMBAR SPINE POSTQUIRURGICAL.

The radiologist plays an important role in the evaluation of osteosynthesis material. They must have a basic knowledge of spinal biomechanics and therefore they have to ensure the integrity of bone, neural and vascular structures of the spine and adjacent structures in patients with spinal surgery.

B.1) IMAGING TECHNIQUES (Figure 1).

For the evaluation of the operated lumbar spine, we have several imaging techniques (4-10), including:

1. **Plain radiograph** (Figure 2).
   - Routine screenings: anteroposterior, lateral and oblique.
   - Dynamic (flexion and extension) to assess stability in the bone fusion and the disc prostheses.
   - This is the noninvasive method most commonly used to assess the merger, although sometimes is limited to assess malposition, displacement or breakage of the material and bone fusion at 6-9 months post-surgery.
   - This technique does not have artifact instrumentation.
   - The x-ray is not able to assess the neural structures and the adjacent soft tissues properly.

2. **CT scan** (Figure 3).
   - MDCT provides a better assessment of the status and progression of bone fusion and the integrity and possible complications in the postoperative
evaluation. It allows a better assessment of bone fusion, position, alignment and about the strength of the material, occupation of the spinal canal, lateral recess and neural foramina as well as about the adjacent soft tissues.

- It provides high image quality and detail of the bone.
- It allows reconstructions in coronal planes, sagittal and 3D reconstructions with limitations due to the metallic artefacts.
- The use of intravenous contrast media distinguishes disk material from epidural fibrosis.

3. MRI (Figures 4,5)

- The MRI image quality is more compromised by the metalwork artefacts than the CT scan. The use of specific sequences (SE or ESF) decrease image disturbance allowing a better assessment in most of the cases.
- The MRI technique lets us a better characterization of the infection and of the degenerative disc disease.
- The use of intravenous contrast allows the diagnosis of infections and collections as well as may help us to distinguish collections from fibrosis.

B.2) ISSUES TO BE CONSIDERED by radiologists:

- Abnormal alignment: anterolisthesis or retrolisthesis, scoliosis and rectification.
- Disk space: assessing disc height, fused vertebral levels and possible disc disease.
- Correct placement of the osteosynthesis material: the pedicle screws should not have medial or lateral deviation across the cortical and medullary canal which may cause nerve root compression or irritation. They also do not have to come across the anterior wall of the vertebral body.
- Anterior or posterior surgical approach: see if the osteosynthesis material is located anterior or posterior in relation to the disc space.
- To check for migration of the material compared to the previous TC.

- RADIOLOGICAL CRITERIA OF BONE FUSION postsurgical (3)
  - Bridge bone fusion in 6-9 months after surgery.
  - Criteria (Ray) on the strength of fusion (without external validity and controversial):
    1. < 3 degrees of variation in intervertebral Rx lateral flexion and extension.
    2. No radiolucent areas around implants.
    4. Absence of vertebral fracture or graft.
    5. Absence of sclerotic changes in grafts or adjacent vertebrae.
    6. Visible bone formation in or around the graft.
• **Type of material** used.

• **Sinking**: if the material sinks in some of the adjacent vertebral bodies.

• **Radiolucent zone** around the screw or around the metallic material such as a halo-margin, indicating loosening.

• **Cystic changes** in the adjacent endplates material indicating failure of fusion although they can be solved by themselves and disappear.

• Bone formation within or adjacent to the osteosynthesis material: it can be seen in 3 months and progresses to 18-24 months.

• **Abnormalities in other levels** not fused.

• **Location and integrity of the material**.

**TIME CONTROL:**

- **3 months**: incipient bone formation. If there are radiolucent zones adjacent to the metalwork indicates loss of fixation. There will be crushing or implant migration and loss of structural stability.
- **6 months**: The fusion can be completed with formation of bony bridges that are usually seen lateral to the implant or within.

You can see cystic lesions adjacent to the implant or linear defects in bone bridges indicating a nonunion (broken line).

- **12 months**: Similar to above. The stranding is more mature, with obvious bony bridges.
- **24 months**: only performed if there is a solid arthrodesis at 12 months. The disc space should be consolidated and filled in with bone.

**B.3) FINDINGS IN NORMAL PICTURE.**

- Small fluid collections in soft tissues.

- Absence of yellow ligament.

- Subsequent disruption of fatty and muscular levels.

- Decreased signal intensity of the bone marrow in T1.

- Increase the signal strength of cortical bone.

- Subsequent elements:

- Immediate postoperative: irregular isoT1 and hiperT2 and soft tissue mass effect.
- Late postoperative: isoT1 and hypointense in T2. Mass effect is reduced and the thecal sac is subsequently displaced.

- Cuttings in spinal fusion:

- Autografts: hyperintense on T1 and isointense on T2.
- Allografts: hypointense on T1 and T2.

- Discectomy:

- Loss of posterior margin of the annulus.

- Increased T2 signal with mass effect. Lately a T2 hypointense ring.

**B.4) COMPLICATIONS: surgical and nonsurgical** *(Figure 6).*

The complications vary depending on the indication, the type of intervention, instrumentation, the type of patient and the surgical approach employed.

**1. Surgical Causes:**

- Epidural hematoma *(figures 7,8).*
- Pseudomeningocele *(figures 9,10,11,12).*
- Epidural scar *(figures 13,14,15).*
- Hernia Recurrence *(figures 16,17,18).*
- Infection *(figures 19,20,21).*
- Arachnoiditis *(figures 22,23,24).*
- Canal stenosis *(figure 25).*
- Complications of spinal fusion (*)
- CSF fistula.

**2. Nonsurgical causes:**

- Herniated disc in a different location.
- Facet joint osteoarthritis.
- Canal stenosis.
- Espondyloysis.
- Referred pain.

(*) FINDINGS OF FAILURE OF FUSION AND COMPLICATIONS (2-11) (figures 26,27,28,29,30,31,32,33,34,35,36,37,38)

- Radiolucent areas around screws or around the material representing mobilization secondary to osteolysis causing bone resorption.

- Linear defects (breakage) of the new bone formed within or adjacent to the material.

- Complication of the integrity of the material.

- Changes in position and sinking of the material.

- Postoperative hematoma.

- Pseudoarthrosis.

- Complication of vertebroplasty.
Images for this section:

Fig. 1

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Fig. 2

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Fig. 3

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Fig. 4

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Fig. 5

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Fig. 6

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Sagittal MRI images T1, T2 and STIR. Acute vertebral compression of D12 (arrows) with bone retropulsed into the spinal canal and small epidural hematoma associated, conditioned spinal canal stenosis of approximately 50%.

Fig. 7

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Fig. 8

Axial MRI images (T1, contrast-enhanced T1 and T2). Previous case, it is shown the epidural hematoma (arrows).
Fig. 9

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Axial MRI images (T1, contrast-enhanced T1 and T2) of previous patient. Posterior right lamina of L2 shown a liquid collection suggesting a small pseudomeningocele or seroma (*).

Fig. 10

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Axial MRI images (T1, contrast-enhanced T1, T2 and sagittal images contrast-enhanced T1) in other patient. L4-L5 level shown a liquid collection that extending from the posterolateral epidural space to left soft tissue suggesting pseudomeningocele (*).

**Fig. 11**

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Suspicion of CSF fistula, dural tear repaired with patch. Sagittal MRI images T1, T2 and T2 axial MRI. Collection posterior to the thecal sac from L3 to L5 / S1 (arrow), compatible with pseudomeningocele, exerting mass effect on the posterior aspect of the thecal sac (arrowhead) causing moderate stenosis of central canal, suggesting aracnoïdits.
Axial MRI images (T1 and contrast-enhanced T1). Occupation of the epidural fat and soft tissue L5 adjacent by a material isointense to muscle on T1 weighted images and intense contrast enhancement suggesting fibrosis (*).
Axial MRI images (T1 and contrast-enhanced T1).
Surrounding the left S1 nerve root shown a material isointense to muscle on T1 weighted images and intense contrast enhancement suggesting fibrosis.
Axial MRI images (T1 and contrast-enhanced T1): fibrosis in the front part of the epidural space and left lateral space (arrow) that displaces slightly the thecal sac to the right and envolves the left L5 nerve root (which presents a slightly enhancement in contrast with the contralateral one, which suggests radiculopathy).

Fig. 15

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Fig. 16

Hernia recurrence at L4-L5 level, showing a small discal fragment in T2 (arrow).
Axial MRI images (T1 and contrast-enhanced T1). It is shown occupation of the right lateral recess by hypointense material in every sequence, which doesn’t present contrast enhancement, which suggests discal fragment (arrow). Defect in the right lamina between L4-L5. T1 Hypointense right paravertebral musculature with contrast enhancement suggesting inflammatory changes/fibrosis.

Fig. 17

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Fig. 18

Axial MRI images (T1, contrast-enhancement T1 and T2) Disc herniation extrusion at the level L4-L5 which cause severe stenosis of the left lateral recess (arrows)
Fig. 19

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Sagittal MRI images (T1 and T2) previous patient Bilateral laminectomy in en L5. Posterior collection to the thecal sac, at L4 and L5, suggesting an abscess (arrows).

Fig. 20

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Fig. 21

Axial MRI images (T2 and contrast-enhanced T1) Previous patient Posterior collection and inflammatory changes/fibrosis of the surrounding soft tissues, which present contrast enhancement (*).
Fig. 22

Sagittal MRI images (T1 contrast-enhanced and T2 (left) and axial image T1 contrast-enhanced (right). It is shown contrast enhancement and association of the cauda equina roots.
Fig. 23

Axial MRI images (T1, T2 and T1 contrast - enhanced) It is shown the "empty thecal sac" image, caused by association of the peripheral roots which present contrast enhancement (arrows).
Axial MRI images (T2 and contrast-enhanced T1) It is shown cauda equina roots, associated in peripheria, which present contrast enhancement e (arrow head).

Fig. 24

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Fig. 25

Axial MRI image (right): Central canal stenosis (anteroposterior diameter of 7.4 mm) as a consequence of a right paracentral disc extrusion L4/L5 (arrow).

Sagittal T2 MRI image (left): Moderate stenosis of the central canal at the right lateral recess caused by a disc herniation extrusion L1/L2.
Fig. 26

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Anteroposterior lumbar radiograph: Hernia repair surgery with articulated arthrodesis (no metal bars) with bilateral pedicle screws in L4-L5 and boxes fixation intersomatic in L4-L5.

Fig. 27

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CT axial obtained with soft-tissue. In the right lateral recess and foramen left of L4-L5 are observed minimums bony fragments (arrows). Between the psoas muscle and left transverse muscle (Level L3-L4) shown a ill-defined area and lower attenuation with small bubbles of gas which produce mass effect on adjacent structures, suggesting small residual hematoma (*).

CT axial obtained with soft-tissue (Level L4). Slight medial desviation of the left transpedicular screw L4 (arrow).
Anteroposterior lumbar radiograph (left) and TC (right). Emergency surgery for spinal stenosis. Posterior approach, spinal descompression and lateral recess descompression, pedicle screw placement (L3- S1). Halo of low attenuation around the sacral screws (arrows), suggesting weakening. Fissure of right screw L3 (red arrow).

Fig. 29

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Fig. 30

Anteroposterior and lateral lumbar radiographs. Posterior approach, spinal decompression, laminectomy, arthrodesis 360° with pedicle screw L1-L2, interbody cage and bone graft.
Fig. 31

TC axial scan (bone windowing) Medial deviation of right transpedicular screw (arrow)
Anteroposterior and lateral radiographs (Previous patient after intervention). Posterior approach, bilateral laminectomy, discectomy L5-S1, autologous and heterologous bone graft and circumferential arthrodesis (L5-S1) It is shown the fracture of the sacral screws (arrows)

Fig. 32

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**Fig. 33**

TC- VR reconstruction with bone suppression. It is clearly shown the fracture of the sacral screws (arrows).
Fig. 34

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Arthrodesis with transpedicular screws and interbody cage (CT scan lumbar). Posterior displacement of the L4-L5 cage marker with mass effect on the epidural space and potential injury to the right L5 root.

Fig. 35

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Patient operated of adult scoliosis with clinical discomfort at the S1 right level. Internal displacement of the rights screw at D12/L1 level (arrowhead), with obliteration of the ipsilateral recess (arrowhead) and damage of the neural roots at this level.

Fig. 36

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CT axial scan (soft-tissue and bone windowing). Sagittal MPR. Cement material leaks of vertebroplasty (arrowds)

Fig. 37
Anteroposterior and lateral lumbar radiographs: Previous patient after undergoing percutaneous transpedicular vertebroplasty. It is shown two dense bands corresponding to residues of materials in the way of surgical access (arrows), are seen as a failure.

Fig. 38

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Conclusion

• The radiologist must be familiar with the normal appearance on imaging of the lumbar spine after stabilization, fusion and disk replacement with various techniques and know surgical complications and its imaging findings, and evaluating the indication of the various imaging techniques to each clinical situation.

• Plain radiography is the most commonly used technique. CT is useful in evaluating the status and progress of the bone fusion, complications of spine surgery, it is considered the modality of choice to evaluate the cement/osteosynthesis material migration and implant failure. MRI is the technique indicated to assess soft tissue masses or spinal cord injuries, but is vulnerable to artifacts induced by the metals used.

• The most common complications were for osteosynthesis.
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