Post-operative imaging of the spine

RAD Magazine, 41, 484, 20-22

Dr Sajid Butt
Consultant radiologist
Royal National Orthopaedic Hospital, Stanmore

Dr Artur Wojciechowski
Consultant radiologist
St George’s University Hospital, London

Introduction
Spinal surgery is performed to treat symptomatic patients with spinal pathology, mainly to decompress spinal cord and nerve roots, to provide structural stability to the spinal column and to resect tumours. Given the complex shape and mechanics of the spinal column and close relationship of the vertebrae and intervertebral discs with neuro-vascular and other important structures, these procedures pose relatively high risk to patients.

Post-operative assessment must take into account the following aspects:
- extent of decompression procedure
- possible persistent or recurrent compression of the neural elements
- alignment of spinal column
- to rule out post-operative complications.

Usually a combination of radiographs, CT and MR studies are performed to answer these questions. MR is preferred because of its high sensitivity and specificity and superb soft tissue delineation.1

Common surgical procedures
Decompressive procedures
Disc prolapse is a common condition. When symptomatic, the prolapsed disc material can cause compression or irritation of the spinal cord and nerve roots. In order to relieve pressure on the nerves, the displaced disc material has to be removed. The following surgical procedures can be performed in order to enable surgical access to reach to the prolapsed disc material:
- laminotomy: resection of ligamentum flavum through interlaminar space
- laminotomy with facetectomy: to allow a more lateral access to resect the disc material that may have extended more laterally in the neural foramen.

Spacer devices between spinous processes can provide opening of the spinal canal providing relief in patients in whom a full decompression technique is not appropriate.

Spinal fusion procedures
These are performed to provide deformity correction – in patients with scoliosis, for stabilisation of the unstable spinal segments demonstrating excessive movements, in patients with significant spondylolisthesis and following wide decompressions to prevent post-operative vertebral segmental instability. Fusion is achieved by inserting transpedicular screws into vertebral bodies and attaching metallic rods and plates to them. Intervertebral body cages and vertebral end plate prosthesis can also be used to obtain a rigid structure and sufficient mechanical support of the spine.

Vertebral resection procedures
These are usually performed in patients with tumours, advanced infections or severe deformities. Patients can undergo resection of vertebral body (corpectomy) or resection of vertebral body and posterior neural arches (vertebrectomy). Space left by the resected vertebral segments is usually replaced with bone grafts, or metallic cages – sometimes containing bone graft and fixed with screws at the cranial and caudal segments. In some cases cement spacers containing slow releasing antibiotic can be used before the final reconstructive surgery is undertaken.

In order to treat the patient effectively, a combination of these procedures may have to be used.

Post-operative assessment
Post-operative assessment is required in patients who continue to have symptoms following surgery or develop new clinical findings. The possible complications are listed below:2

Immediate
- presence of residual disc material or recurrent disc herniation
- post-operative haematoma
- post-operative damage to contents of spinal canal or surrounding structures
- malpositioning of metal work.

Delayed
- post-operative infection
- failure of metal work or loosening
- residual or recurrent disc herniation
- post-operative fibrosis
- adjacent segment abnormalities.

Strategy of post-operative imaging

Plain films
When a patient has continuing abnormal neurological findings or develops new symptoms following surgery, urgent clinical evaluation and diagnostic imaging is necessary. Most frequently, patients following clinical review are assessed with plain x-rays, MRI and CT. In some cases CT SPECT can be used. Ultrasound examination has a marginal and relatively lesser role in post-operative spine assessment.

Plain films are easy to obtain. Good quality films allow assessment of metal work position and alignment. It is usually not possible to assess the spinal alignment in immediate post-operative phase in the erect posture as patients are not allowed to fully weight bear. Later, when the patient is allowed to stand up, segmental or full length spine x-rays can be obtained to evaluate physiological posture and spinal alignment (figure 1a).

MRI
The most important imaging modality in assessment of post-operative spine is MRI. Unfortunately the presence of metal work can be a source of artefact, degrading the image...
quality. Some modifications of standard imaging protocols are necessary to reduce these artefacts. In some cases the post-operative changes can be related to adjacent segment abnormalities and therefor an appropriate planning of the length of the spinal column to be imaged is essential, e.g. in the patient who has had a procedure done at L5-S1 level, sacral bone and spinal canal has to be imaged (figure 2).

In order to minimise post-surgical artefacts, the following adjustment in MR protocols can be implemented:

- using Fast Spin Echo techniques
- using STIR
- avoid using Gradient Echo sequences (unless looking for haemorrhages)
- using frequency encoding axis along the length of placed metal work
- using a broader signal bandwidth.

Every effort should be made to reassure patients so that they are encouraged to keep still during scanning to eliminate motion artefacts. These patients are usually in pain and have a considerable degree of stress given their symptoms. In some cases it could be necessary to perform examination under sedation or general anaesthesia. Appropriate planning in this regard with liaison with the clinical team and anaesthetic department is obviously very important.

When radiologists are reporting these scans, they should review the pre-operative imaging to compare with post-operative changes to fully understand the possible reasons behind the patient’s symptoms. All the abnormal findings have to be conveyed to the clinical team as soon as possible as delayed treatment may have significant influence on the patient’s outcome (figure 3).

Computed tomography

In some patients, the metal work may cause severe artefacts, significantly degrading the MR image quality and therefore the exact relationship with nerves, vessels and spinal canal can only be done by a dedicated CT scan. When the MR images are suggestive of malpositioned metal work, or if the post-operative clinical examination is indicative of a specific nerve root being impinged upon, a CT scan is usually requested along with an MR (figure 4).

Appropriate planning must be made so that the usually difficult to mobilise patient can have both investigations done in the same sitting. This would mean a radiologist being present during MR scanning, their urgent assessment of MR images and a decision on whether a CT scan is needed or not. Such forward planning could help in a more efficient post-operative assessment and saving crucial time. Unfortunately CT scans are also prone to artefacts related to presence of metal work and appropriate adjustment in CT technique is therefore required to optimise imaging.∗ These steps include using:

- higher KVP of >120KVP can increase the ability of x-ray beam to penetrate metal
- smooth reconstruction filter and wide window settings
- volume rendering software
- iterative reconstruction algorithms. These not only improve image details but also reduce the radiation dose
- careful planning of scan range and volume to ensure that the volume of the patient scanned is appropriate to answer all clinical questions.

Metal work integrity is better assessed by reviewing thicker reconstructed volumes. Thinner slices sometimes mask the break in continuity of metal work.

Delayed complications

One of the common post-operative scenarios is to see if the soft tissue that is causing pressure on the spinal nerve or partially filling the spinal canal represents post-operative scar tissue or a disc fragment.

Disc fragments are usually low signal on T1 weighted and T2 weighted sequences. Post-operative scar tissue shows intermediate signal on both T1 and T2-weighted sequences. On contrast enhanced T1-weighted images following IV gadolinium administration, disc shows a lack of enhancement as opposed to scar tissue which shows avid contrast uptake. Contrast enhanced sequences should be obtained in relatively early phase (within two to three minutes of completing the gadolinium injection) as delayed imaging (beyond five minutes following the injection) would result in the disc fragments also being enhanced, making distinction between a disc fragment (which may need re-operation) and scar tissue (which is treated conservatively) difficult.

Post-operative infection is an entity which would require meticulous imaging assessment. Comparison with pre-operative studies is very important. Presence of bright T2 signal intensity fluid around the metal work or in the disc is the usual MR finding. When gadolinium is used, this can show rim enhancement of the post-operative fluid accumulation.

In difficult cases CT SPECT imaging is also very useful. A CT scan can show resorption of adjacent bones and mass effect caused by fluid accumulation. Sometimes it is not possible to differentiate between post-operative serous fluid collection and an abscess formation. In these cases image guided (usually ultrasound) aspiration or biopsy are required.

CT SPECT

This imaging technique allows for simultaneous acquisition of anatomical (CT) and functional information (SPECT). The scanner has two components mounted within the gantry, the x-ray tube and the gamma camera. The X-ray tube allows acquisition of anatomical images and correction of attenuation values necessary for image calibration. The most frequently used isotopes allow for targeting the metabolically active parts of the skeleton. Increased activity may be related to degenerative changes and inflammatory complication following surgery.

CT SPECT allows assessment of:

- metalwork loosening
- insufficient implant stabilising function indicated by metabolically active facet joint arthritis
- adjacent segment instability defined as metabolically degenerative disease in the segments adjacent to instrumented region.

Ultrasound

Ultrasound examination has limited value in assessment of bony structures and metal work following spinal surgery. This method can be used for real-time guided procedures for treatment of possible complications – drainage of fluid collection, injections of anti-inflammatory agents and steroids. Ultrasound examinations are quick and pose no risk related to radiation exposure compared to CT and plain x-rays. The examination can be performed on-site, so not requiring patient transport to a radiology department.

Summary

Spine surgery is heavily dependent on diagnostic imaging methods which play a crucial role in pre and post-operative assessment. When dealing with the need for assessment of post-operative complications, close liaison between the clinical team, radiographers and radiologists is of utmost importance. Timely imaging and its assessment can help in making correct management decisions.

References


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Figure 1a
Lateral radiograph of cervical spine shows intervertebral body cage at C5-6. C6-7 shows vertebral end plate prosthesis. Alignment of spine and of the metal work is satisfactory.

Figure 1b
T1-weighted MRI examination sagittal view shows that there is marrow continuity across C5-6 indicating that vertebral body fusion is satisfactory. Note the artefact produced by the vertebral endplates. This artefact can be minimised by using the techniques mentioned in the text.

Figure 2
65-year-old female. Presented with continuing pain following a discectomy performed three months ago at L4-5. MR examination fat suppressed T2-weighted sagittal image (A) shows that there is fluid signal present in the operated disc (white arrow). A small anterior prevertebral abscess cavity is also seen (red arrow). Post gadolinium sagittal T1 fat saturated image (B) shows a large extradural collection present in posterior vertebral space extending from T11 to S1-2 (white arrows) and enhancement of the vertebral endplates of L4-5. This abscess was causing compression of spinal canal and therefore needed urgent drainage. Use of fat saturated post gadolinium imaging is very useful to see the full extent of such an abscess.
Figure 3
(A) 55-year-old woman who had a posterior decompression and metal work fixation done three days previously. She developed reduced urinary bladder sensation on third post-operative day. An urgent MRI shows that on sagittal T1-weighted image, an extra-dural collection is seen at the posterior aspect of L5-S1 (three white arrows). This is slightly hyperintense to CSF signal (arrowhead). Note the artefact produced by metal work at L4-5 vertebral level (red arrow). (B) Sagittal STIR image shows that the signal from this fluid collection is hyperintense. This would represent a post-operative hyperacute haematoma. Because of the patient’s loss of urinary sensations, an urgent drainage of this haematoma by surgery was performed.
Figure 4
Axial CT image shows that the right sided screw is passing through right lateral recess (white arrow). Depending on patient's symptoms, this screw might need replacement in a more lateral position as has been done on the left side. Such precise assessment of metallic screw placement is best done on CT scan.