Imaging the Postoperative Spine

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INTRODUCTION

Imaging assessment of the spine after surgery is complex and depends on several factors, including the age and anatomy of the patient, indication for and type of surgery performed, biomaterials used, time elapsed since the surgical procedure, and (most importantly) the duration and the nature of the postsurgical syndrome.¹

Imaging plays an important role in the preoperative and postoperative evaluation of patients undergoing spinal surgery. Postoperative imaging examinations evaluate the position of implants, adequacy of decompression fusion status, and potential complications. For the optimal evaluation of patients who have had previous spinal instrumentation, proper adoption of the appropriate imaging techniques and knowledge of their advantages and limitations are essential.

This article provides a review of various imaging techniques, with their advantages and disadvantages, for the evaluation of the postoperative spine. It also gives an overview of normal and abnormal postoperative appearances of the spine via various modalities, with an emphasis on postoperative complications.

KEYWORDS

• Postoperative spine • Imaging • Complications • Surgery

KEY POINTS

• Imaging plays an important role in the preoperative and postoperative evaluation of patients undergoing spinal surgery.
• Appropriate imaging techniques and knowledge of their advantages and limitations are essential for optimal evaluation of the postoperative spine.
• Postoperative imaging examinations allow for the evaluation of implant positioning, adequacy of decompression, fusion status, and potential complications.
• This article provides an overview of the normal and abnormal postoperative appearances of the spine via various modalities, with an emphasis on postoperative complications.
SURGICAL PROCEDURES

Goals

Surgical procedures in the spine are typically performed with the following goals in mind:

- Decompression of neural elements via removal of herniated disk material or decompression of a stenotic spinal canal or neural foramen
- Stabilization and fusion of motion segments for existing instability or deformity (such as spondylolisthesis, scoliosis, or posttraumatic injury) or after iatrogenic instability (such as facetectomy or multilevel laminectomies)
- Excision of tumor or debridement of infection.

Decompressive Surgeries

1. Laminotomy: the bone resection is limited to small segments of inferior margin of the cephalic lamina and the superior margin of the caudal lamina to decompress the neural structures. This procedure is often performed in conjunction with a diskectomy (Fig. 1).

2. Laminectomy: the bone resection is extended to include the entire width of a lamina, as well as a small segment of the margin of the adjacent lamina, to decompress a larger area. The primary purpose is to relieve central stenosis or to give greater exposure to a herniated disk during diskectomy (Fig. 2).

3. Laminectomy and facetectomy: the bone resection is extended to include a part of or...

Fig. 1. Laminotomy of the lumbar spine. (A) An axial T1-weighted image (repetition time/echo time: 550/10.67), (B) an axial T2-weighted image (repetition time/echo time: 5966/118), and (C) an axial postcontrast T1-weighted image (repetition time/echo time: 550/10.67) show partial removal of the right-side lamina, identifying the laminotomy site (arrows).
the complete facet joint in addition to the cephalic and caudal laminae to gain maximum exposure of the herniated disk and to relieve foraminal, lateral recess, and central stenoses.

4. Diskectomy: the herniated disk material that is causing compression on neural elements is removed.

**Spinal Fusion**

Surgical implants in spinal fusion surgeries are used to stabilize the spine, replace resected components (ie, vertebral body), and maintain anatomic alignment. Radiologists should be able to identify the devices most commonly used and understand the general rationale for their use.³

Commonly used devices are the following:

1. Rods and plates: rods can extend to single or multiple spine segments. They are attached to the spine most commonly by pedicle screws in the thoracic and lumbar spine and via lateral mass and other screws in the cervical spine. Hooks, sublaminar or interspinous wires, and cables can also be used. Various shapes and sizes of plates have been developed for anterior or posterior spinal fusion (Figs. 3 and 4).³⁻⁶

2. Translaminar or facet screws: these devices can be used when posterior elements are intact. They attach the laminae of 2 adjacent vertebrae.

3. Transpedicular screws: the use of pedicle screws in conjunction with plates or rods is generally well accepted as creating a primary stable construct, providing immediate postoperative stabilization without external support.⁷,⁸

4. Interbody spacers: interbody cages are available in various shapes and materials. After the removal of a disk, these spacers are inserted into the intervertebral space with or without additional screw and plate/rod fixation.⁹ Cages are usually made of titanium, carbon fiber, polyetheretherketone (PEEK), or cortical or corticocancellous bone graft. Interbody cages are filled with bone graft material and inserted into the intervertebral space, or may be used to replace a vertebra after it is removed (ie, corpectomy). Most radiolucent cages contain 2 or more radiopaque markers to identify their position on radiographs and to enable their assessment. For a stand-alone interbody fusion cage, the interbody spacer is fixed to the adjacent vertebral body with screws to eliminate the need for additional instrumentation. Advantages of interbody devices include a larger surface area for fusion to occur and better restoration of spinal alignment through anterior column correction and support. Complications of interbody cages include retropulsion and cage subsidence. A distance of 2 mm or less between the posterior marker of the cage and the posterior margin of the vertebra should exist to provide reassurance that the cage is not invading the spinal canal.⁴

This allows early patient mobilization. Transpedicular screws are especially important for cases of posterolateral fusions of the lumbar spine performed for spondylolisthesis, degenerative disk disease, and scoliosis (Fig. 5).

4. Interbody spacers: interbody cages are available in various shapes and materials. After the removal of a disk, these spacers are inserted into the intervertebral space with or without additional screw and plate/rod fixation.⁹ Cages are usually made of titanium, carbon fiber, polyetheretherketone (PEEK), or cortical or corticocancellous bone graft. Interbody cages are filled with bone graft material and inserted into the intervertebral space, or may be used to replace a vertebra after it is removed (ie, corpectomy). Most radiolucent cages contain 2 or more radiopaque markers to identify their position on radiographs and to enable their assessment. For a stand-alone interbody fusion cage, the interbody spacer is fixed to the adjacent vertebral body with screws to eliminate the need for additional instrumentation. Advantages of interbody devices include a larger surface area for fusion to occur and better restoration of spinal alignment through anterior column correction and support. Complications of interbody cages include retropulsion and cage subsidence. A distance of 2 mm or less between the posterior marker of the cage and the posterior margin of the vertebra should exist to provide reassurance that the cage is not invading the spinal canal.⁴
Surgical methods can be divided into minimally invasive or traditional open procedures and by the vector from which the spine is approached (ie, anterior, posterior, or lateral).\textsuperscript{10}

In interbody fusion, the intervertebral disk or a complete vertebra is removed and replaced with a bone graft. This procedure can be performed via an anterior approach (anterior interbody fusion) or a posterior approach (posterior interbody fusion). With anterior lumbar interbody fusions, the advantage is a broader access to the disk space. However, it is limited by potential injury to major vessels and the sympathetic nerve chain.\textsuperscript{11} Oskouian and Johnson\textsuperscript{12} reported an incidence of 5.8\% for vascular complications in patients who underwent anterior thoracolumbar spine reconstruction procedures.

Direct lateral interbody fusion is a newer surgical technique performed transpsoas to fuse L1 to L5 and to minimize the disadvantages of conventional retroperitoneal anterior lumbar interbody fusions. Direct lateral interbody fusions allow for access to the anterior spine through the retroperitoneal space and can also be performed in the thoracic spine. It is a less invasive alternative to traditional anterior retroperitoneal or thoracoabdominal approaches.

With posterior lumbar interbody fusions, bilateral laminectomies are performed, and bone graft material with a cage or spacer is inserted into the disk space after the disk is removed. The disadvantages of this approach are potential injury to the nerve roots and retrograde migration or retropulsion of the graft or cage.\textsuperscript{13}

\textbf{Fig. 4.} Anteroposterior (A) and lateral (B) radiographs of a 73-year-old woman show posterior spinal fusion with bilateral rods and pedicle screws from L2 through S2. There has been posterior laminectomy from L3 through S1. There is evidence for posterior lateral osseous fusion at these levels in the intertransverse process space. (C) CT scan of the coronal section confirms a solid posterior spinal fusion with bilateral rods and pedicle screws from L2 through S2. There has been posterior laminectomy from L3 through S1.
Transforaminal interbody fusion is a modified posterior lumbar interbody fusion technique that uses a more lateral approach and thus leaves the midline bony structures intact. Min and colleagues showed that anterior and posterior interbody fusion can produce good outcomes in treating lumbar spondylolisthesis, but anterior interbody fusion is more advantageous in preventing the development of adjacent segment degeneration.

Posterolateral fusion can be performed alone or in conjunction with interbody fusion. In this approach, the adjacent vertebrae are fused together by placing bone graft material between the transverse processes and facet joints.

**Disk Arthroplasty (Also Known as Total Disk Replacement)**

This procedure includes removal of the diseased disk and insertion of a disk prosthesis to alleviate diskogenic pain and to restore normal disk height. The main goal of disk arthroplasty is to relieve pain while restoring or maintaining normal or near-normal disk space motion in an effort to decrease the potential for adjacent segment disease.

With the help of serial radiographs, one can assess changes in component position, bony alignment, implant fractures, and changes in the bone-implant interface. Radiographs are cost effective and accessible, which combined with their ability to obtain positional information with relatively low exposure to radiation compared with that of computed tomography (CT), makes them an indispensable tool for the assessment of the postoperative spine.

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Various radiographic modalities are used in the evaluation of the postoperative spine. Baseline radiographs are essential for evaluating implant position and serve as a starting point for evaluation of future studies, should patients develop symptoms suggesting possible complications.
Radiographs have a few limitations: they cannot evaluate soft tissue structures (such as neural elements, recurrent disk herniations, or scar tissue) and they are of little value in the noninstrumented postoperative spine.

Regarding disk arthroplasty, the midline placement, AP positioning, and the degree of vertebral body penetration or subsidence need to be identified by imaging. Disk arthroplasty is best evaluated with conventional radiography or CT. Ideally, the device is located in the midline between the 2 pedicles on AP radiographs or axial or coronal CT scans. There should be no penetration of the end plate. With respect to AP positioning, the center of rotation should be located in the posterior half of the disk space, but the implant should not extend beyond the posterior vertebral body line (Fig. 7).²³

CT

The main role of CT in the postoperative spine is assessment after instrumentation or fusion surgery. At present, CT with multiplanar reconstruction is considered the modality of choice for imaging bony detail and assessing osseous formation and implant position despite artifact formation (Fig. 8). CT is also useful in showing the spinal canal and its alignment and is capable of detecting infection and pseudarthrosis.¹⁸ Helical CT scans are useful for detecting and grading spinal and/or foraminal stenosis and can be used in the follow-up of stenosis after surgery. CT after intravenous contrast enhancement provides reliable differentiation between postoperative extradural fibrosis (scarring) and recurrent disk herniation.²⁴⁻²⁶ Braun and colleagues²⁷ reported on a group of 98 postoperative patients, 22 of whom underwent re-exploration, and evaluated enhanced and unenhanced CT scans. CT scans with contrast enhancement were correct 74% of the time compared with surgery, whereas unenhanced CT scans were correct only 43% of the time. The investigators concluded that enhanced CT scans significantly increase the diagnostic accuracy in differentiating between scarring and recurrent disk herniation.

A limitation of CT scans is the beam-hardening artifact caused by the metallic prosthesis, which causes difficulty in soft tissue interpretation in the spinal canal.²⁸ Artifacts are the primary disadvantage of CT, although they are less common with titanium implants than with stainless steel because of the lower beam attenuation coefficient of titanium.⁴ The x-ray beam should be positioned perpendicular to the orthopedic implant.
so that the beam traverses the metallic cross section with the smallest diameter.

Several factors can help reduce metallic artifact:

- **During image acquisition**
  1. Use of high peak voltage (kilovolts peak)
  2. Use of high tube current (milliampere-seconds)
  3. Use of narrow collimation
  4. Use of thin sections
- **During image reconstruction**
  1. Use of thick sections
  2. Use of lower kernel values.

The term kilovolt peak pertains to voltage across the tube, from anode to cathode, or the speed at which the electrons travel during x-ray production. Kilovoltage affects the penetrating ability of the x-ray beam or the average wavelength of the photon. Milliampere-seconds corresponds to the amount of energy used to create certain amounts of radiation. Reconstruction parameters can be expressed as standard (soft tissue) or high spatial (bone) frequency algorithms. Kernels (algorithms) are the reconstruction parameters that determine the image quality. As the kernel number increases, the image gets sharper and noisier. The high spatial frequency algorithms correspond to the higher kernel numbers.

CT provides better evaluation of fusion progression and status than dynamic radiography for patients who have undergone interbody fusion for lumbar spinal disorders. The use of myelography and postmyelography CT for the evaluation of patients with spinal abnormalities has been largely supplanted by the noninvasive modality magnetic resonance (MR) imaging. Despite this trend, myelography and postmyelography CT continue to play an important role in patients who have undergone a spine operation when MR imaging is contraindicated and in cases in which artifacts from surgical hardware may obscure the spinal canal and nerve roots on MR imaging (Fig. 9).

Myelography can be helpful in depicting arachnoiditis, with thickening of the nerve roots causing blunting of the root sleeves. Commonly, myelography and postmyelographic CT show nonspecific extradural defects at the surgical sites, but these studies cannot differentiate recurrent disk herniations from scar. Postmyelographic CT is, however, outstanding at defining the degree of facet arthrosis and subsequent foraminal stenosis. Sagittal and coronal reconstructions of thin, overlapping axial acquisitions can exquisitely define the neural foramina.

**MR Imaging**

MR imaging is the preferred imaging modality in the evaluation of the postoperative spine because...
of its superior soft tissue resolution.\textsuperscript{32} Tissue enhancement is better evaluated on MR imaging than on CT,\textsuperscript{33} allowing easier discrimination between recurrent disk herniation versus epidural fibrosis. Evaluation of bone marrow edema, soft tissue inflammation, nerve root enhancement, hemorrhage, facet joint inflammation, and spinal stenosis is much more accurate with MR imaging than CT or radiography. The high contrast between foraminal or epidural fat and disk material or osteophyte, coupled with multiplanar imaging, allows for accurate assessment of herniations and stenosis in the lumbar and cervical spine.\textsuperscript{34,35}

In the past, MR imaging had limited use in imaging the instrumented spine because of commonly seen artifacts. However, with the introduction of the titanium pedicle screws and specialized pulse sequences, there has been considerable improvement in the MR imaging evaluation of the postoperative spine.\textsuperscript{36–38}
The parameters used to reduce metal artifact in MR imaging are:

- Positioning the patient with the long axis of metallic hardware parallel to \( B_0 \) (\( B_0 \) is the constant, homogenous magnetic field used to polarize spins, creating magnetization. It can refer to both the direction and magnitude of the field. The direction of \( B_0 \) defines the longitudinal axis.)
- Using the optimum sequence, that is, a fast-spin echo sequence (to maintain short echo spacing rather than a short echo train)
- Using inversion recovery fat suppression
- Swapping phase and frequency encoding direction
- Using view-angle tilting
- Increasing the readout bandwidth
- Decreasing the voxel size.

For routine imaging of the postoperative spine, sagittal and axial MR images are usually obtained. In the sagittal plane, T1- and T2-weighted images offer complementary information. Sagittal and axial T2-weighted images can depict the contour of the thecal sac and visualize focal areas of posterior expansion or for regions of compression of the thecal sac by scar tissue or recurrent/residual disk fragments. Axial T1-weighted images are useful for assessing the absence of osseous structures. Also, the normal epidural fat is very bright on T1-weighted images and contrasts well with the dural sac, as well as postoperative epidural fibrosis, which are dark. Additional axial spin echo T1-weighted images after enhancement with intravenous gadolinium are essential in postoperative studies because they can differentiate between scar tissue and recurrent disk herniation; the latter is generally accepted to be a possible indication for additional surgery.

In the immediate postoperative period, expected postdiscectomy changes cause significant alterations in the epidural soft tissue and intervertebral disk; caution must be used in interpreting MR imaging within the first 6 weeks after surgery. MR imaging may be used in the immediate postoperative period for a more gross view of the thecal sac and epidural space to exclude substantial postoperative hemorrhage at the laminectomy site, pseudomeningocele, or disk space infection. T1-weighted images show increased soft tissue signal anterior to the thecal sac and an indistinct posterior annular margin, which can mimic the appearance of preoperative disk herniation and produce mass effect. These changes within the anterior epidural space gradually involute 2 to 6 months after surgery.

**Other Modalities**

Radionuclide scans are used mainly in the postoperative spine to evaluate for conditions such as pseudarthrosis, infection, or fracture of the fusion site, as well as an altered pattern of biomechanical stresses after a fusion. Radionuclide scans may remain positive for 1 year or more in the region of the operative bed and instrumentation. In recent years, positron emission tomography has been useful for evaluating infection in the region of metal implants.

Sonography is used to detect fluid collections and abscesses in the postoperative spinal fusion. (Tags: radiography, computed tomography, MR imaging, myelography).

**POSTOPERATIVE COMPLICATIONS**

Imaging plays a vital role in evaluating potential complications resulting from procedures that involve spinal instrumentation. The type of complication varies with the type of instrumentation, operative approach, and underlying clinical disorder.

**Implant-Related Complications**

Implant fractures generally occur secondary to metal fatigue from the repetitive stress of spinal movements. The fractured appliance may not be displaced, making its detection difficult. A fractured or dislodged appliance is frequently, but not always, associated with regional motion and instability, which may lead to or be the result of pseudarthrosis. Prominence of the instrumentation can cause chronic tissue irritation, leading to pain, bursa formation, and even pressure sores with tissue necrosis, which occasionally can be indications for hardware removal (Fig. 10).

The pedicle screw is a commonly used implant that provides stabilization for posterior thoracolumbar fusion procedures. Screw placement is considered optimal when it traverses the central aspect of the pedicle and is aligned parallel to the superior end plate (neutral position). Careful attention should be paid to pedicle screws because of their close proximity to neurovascular structures. Potential complications of the pedicle screw are fracture and abnormal screw orientation. The most common clinical complications are nerve root irritation (secondary to excessive medial angulation of the screw) and violation of the medial bony cortex. Lateral position or migration should be carefully evaluated, especially in the cervical spine where the screw can breach the foramen transversarium and potentially damage the vertebral artery.
Implant loosening can be caused by osseous resorption surrounding screws and implants. Loosening in turn allows movement, which causes further osseous resorption, increased mobility, and eventually catastrophic screw pullout or vertebral fractures.\(^{51}\)

Restoration of disk height and achievement of anterior fusion are the major goals of interbody spinal surgery, and for this purpose, interbody spacers are used. Radiopaque markers are designed to allow sequential monitoring of cage position in otherwise radiolucent implants. Some degree of subsidence is expected and may facilitate fusion with the bone graft being loaded under compression. However, excessive subsidence leads to loss of disk height and may cause recurrent radicular symptoms secondary to foraminal height loss. Cage subsidence (defined as a migration of >3 mm into the adjacent vertebra) and lateral displacement are disadvantages of mesh and stand-alone cages (Fig. 11).\(^{52-54}\)

**Adjacent Segment Disease**

Adjacent segment disease, or junctional stenosis, are terms used to designate the development of new clinical symptoms that correlate with radiographic changes adjacent to the level of previous spinal fusion.\(^{55}\) Premature degenerative changes at the disk levels above or below the fused segments can occur because of the reduced number of mobile segments. This complication is reported in 10.2% of patients with posterior fusion and instrumentation\(^{56}\) and even more frequently at long-term follow-up. It is more common in the lumbosacral spine than in the cervical spine, and it is rare in isolated thoracic fusion. It is markedly more common in the segment above the fusion because the rostral spine is levered against the fused caudal segment below (Fig. 12).

**Stenosis**

Stenosis may present years after a surgical procedure as a result of accelerated degeneration. It is best diagnosed with MR imaging. Bony stenosis may show a variety of changes on MR imaging because of the variability of the marrow content of the vertebral body and bony fusion masses and the degree of bony sclerosis. Sclerotic bone has low signal intensity on T1- and T2-weighted images and is recognized by the encroachment on the epidural and foraminal fat. Parasagittal images are most useful in defining bony foraminal stenosis, whether secondary to osteophyte formation or, more generally, secondary to disk degeneration.

**Pseudarthrosis**

Failure of fusion and the development of pseudarthrosis or fibrous union are the sequelae of ongoing low-grade mobility. Pseudarthrosis itself can be a source of pain, or it may provide a lead point for ongoing mobility leading to increased stress on hardware and inevitable failure. Radiographs should be evaluated for the presence of a lucent line or zone traversing the bone graft material with or without adjacent sclerosis. It is more common to use external braces than internal fixation. In asymptomatic patients, intervention may be deferred, and the patient’s condition should be followed up.\(^{57}\)
Complications Associated with the Type of Approach

In the cervical spine, complications of the posterior approach are mainly neurologic and include dural, nerve root, or cord injury. The anterior approach is associated with risks of injuring the vascular structures and damage to the recurrent laryngeal nerve or soft tissues, such as the esophagus, trachea, or lungs. In anterior plate and screw fixation, the screws may back out and impinge upon soft tissue structures or overpenetrate the posterior cortex and impinge on the cord. These complications can be minimized by using a cervical spine locking plate with screw caps and confirming screw position and length with intraoperative fluoroscopy.

Similarly, in the thoracolumbar spine, vascular injuries are more common with anterior procedures and neural injury is more common with the posterior approach. In addition, the use of iliac crest autograft carries with it the potential for donor site morbidity.

Epidural Fibrosis and Recurrent Disk Herniation

Patients with recurrent disk herniation have complaints similar to those with primary disk herniation. Radiographs can be obtained to rule out other causes of back or sciatic pain, such as spondylolisthesis, fracture, and stenosis. Iatrogenic fracture through the pars interarticularis caused by previous laminectomy must be excluded. MRI is the imaging modality of choice to differentiate recurrent disk herniation from other soft tissue disease processes. It is also very important to differentiate recurrent disk herniation from epidural fibrosis or scar formation. Recurrent disk herniation often presents as a polypoidal mass with smooth margins, has low signal on T1- and T2-weighted images, and shows no early enhancement after contrast administration. Epidural scar has intermediate signal intensity with irregular margins and shows early heterogeneous enhancement because of its vascularity. A recent recurrent disk herniation initially shows no enhancement because it is devoid of any vascularization. However, it may be surrounded by epidural fibrosis that does show enhancement. Contrast material diffuses from the epidural scar into the disk material causing mild enhancement from outside in, late after contrast injection. Therefore, images after gadolinium administration should be acquired as quickly as possible. Exuberant epidural fibrosis is itself a risk factor for persistent radiculitis even in the absence of recurrent disk herniation.

Postoperative Infection

Postoperative infection may be the result of implantation at the time of surgery, or it may occur.
later in the course of recovery. Infection leads to bone destruction and resorption around the implant. On imaging, a lucent area around the implant implies a loose appliance and potential infection. Image-guided aspiration can be used to isolate the microorganisms. Radionuclide scans and MR imaging can be helpful in detecting infection in the early stages. On MR imaging scans, the key features that point toward the presence of infection are the presence of peridiscal marrow changes (low signal intensity on T1-weighted images and high signal intensity on T2-weighted images), enhancement of the intervertebral disk space, and an enhancing soft tissue mass surrounding the affected spinal level in the perivertebral and epidural spaces.

Fig. 12. Junctional lumbar stenosis above a previous instrumented fusion. (A) A sagittal T2-weighted image shows junctional stenosis (arrow) at the L2-3 level in a patient who has undergone prior L3-5 laminectomy and instrumented fusion. Note the minimal artifact from the pedicle screws (arrowheads). (B) An axial T2-weighted image at the level of the L3 pedicle screws shows moderate-severe stenosis and pedicle screw artifacts (arrows). Note the presence of the pedicle screws obscures the region of the lateral recess and foramen but does not prevent the evaluation of the central canal. (C) An axial T2-weighted image at the level of the L2-3 disk shows severe stenosis and only minimal residual artifact (arrow) from the pedicle screw below this level in the L3 vertebral body. Note the localizing sagittal image seen as an inset with each axial image (B, C). (Reprinted from Okubadejo GO, Daftary AR, Buchowski JM, et al. The lumbar and thoracic spine. In: MRI for orthopaedic surgeons. New York: Thieme; 2010. p. 309; Fig. 11.46; with permission.)
Arachnoiditis

Potential factors leading to arachnoiditis are the surgical procedure itself, the presence of intradural blood after surgery, treated perioperative spinal infection, and the previous use of myelographic contrast media. CT myelography and MR imaging can be used to diagnose these complications; however, MR imaging is superior and considered the imaging modality of choice. The 3 MR imaging patterns described in adhesive arachnoiditis are scattered groups of matted or “clumped” nerve roots, an “empty” thecal sac caused by adhesion of the nerve roots to its walls, and an intrathecal soft tissue “mass” with a broad dural base, representing a large group of matted roots that may obstruct the cerebrospinal fluid pathways. In most cases, there is little enhancement of arachnoiditis with gadolinium on MR imaging scans (Fig. 14)."&n

Sterile Radiculitis

On MR imaging scans, sterile radiculitis is seen as enhancement of the intrathecal spinal nerve roots of the cauda equina after contrast administration because a breach in the blood-nerve barrier occurs as a sequel to chronic neural trauma and ischemia. It is believed to be the cause of the abnormal neurophysiologic changes resulting in clinical radiculopathy that may continue long after the disk herniation has been surgically removed. It can extend cranially and caudally away from the surgical site in the chronic postoperative period (more than 6–8 months after the surgery)."&n

Postoperative Fluid Collections

Pseudomeningocele, a fairly common postoperative finding, results from a tear in the dura during the surgery. It is located posterior to the thecal sac and projects through posterior element surgical deformities. Pseudomeningoceles can be complex in signal intensity on MR imaging scans secondary to hemorrhage, and fluid-fluid levels can be present. In chronic cases, the fluid collection should follow cerebrospinal fluid on all sequences; however, the fluid signal characteristics can differ, depending on the amount of protein or blood (Fig. 15)."&n

Hematoma or seroma can also be formed in the epidural space or in the postoperative bed in the soft tissue posterior to the thecal sac. MR imaging is most sensitive in identifying the blood products. Hematomas may be hyperintense on T1-weighted images in the subacute phase because the signal is caused primarily by methemoglobin. Pure seroma should follow cerebrospinal fluid on all pulse sequences. Sterile fluid collections should resolve slowly over time; however, needle aspiration is necessary to rule out secondary infection (Fig. 16)."
Ossification of the anterior longitudinal ligament and facet disease are common complications of anterior plating and posterior screw fixation. Anterior plating can result in impingement of the adjacent segment vertebral body during flexion, contributing to adjacent segment disease. This complication can be avoided by selecting a plate length that results in the end of the plate being equal to or greater than 5 mm from the vertebral body.

**Fig. 14.** Sagittal (A) and axial (B) T2-weighted images of a patient with arachnoiditis after L4-5 laminectomy and instrumented posterior fusion who had several previous decompressive surgeries. Note the central adhesion of the nerve roots within the thecal sac into a central clump of soft tissue signal (pseudocord) instead of their normal feathery appearance. The axial image (B) is at the L4-S level. (Reprinted from Okubadejo GO, Daftary AR, Buchowski JM, et al. The lumbar and thoracic spine. In: MRI for orthopaedic surgeons. New York: Thieme; 2010. p. 312; Fig. 11.50; with permission.)

**Fig. 15.** Sagittal (A) and axial (B) T2-weighted images of a patient with pseudomeningocele who had sustained a durotomy during revision L4-S1 laminectomy and instrumented posterior fusion. The images show a well-circumscribed fluid collection that does not compress the thecal sac. Note that on the axial image (B) at the LS level, the central canal can be well visualized in the presence of pedicle screws. (Reprinted from Okubadejo GO, Daftary AR, Buchowski JM, et al. The lumbar and thoracic spine. In: MRI for orthopaedic surgeons. New York: Thieme; 2010. p. 312; Fig. 11.49; with permission.)
Preservation of the facet capsule and avoidance of violating the adjacent segment facet joint during posterior instrumentation helps to minimize the potential for facet degeneration.

**SUMMARY**

Despite advances in imaging technology, imaging of the postoperative spine remains a challenging and difficult issue. Adequate understanding of various surgical techniques and instruments, coupled with an appropriate awareness of the possible complications, is vital when interpreting postoperative studies. To evaluate the postoperative spine optimally, it is essential that the radiologist knows the potential advantages and disadvantages of the various modalities.

**REFERENCES**