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Radiologic Evaluation of the Lateral Approach: Diagnostic and Postoperative Imaging

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The cautious seldom err.
— Confucius

BACKGROUND

Ever since Sir Robert Jones demonstrated the utility of radiographs for the diagnosis of fractures,¹ the quality and value of diagnostic imaging has steadily increased. The spinal surgeon and the spinal patient have in recent decades benefited from the development of imaging modalities specific for soft or hard tissue. For lateral approach spinal surgery, these modalities are critical for diagnosis preoperatively, guidance intraoperatively, and evaluation postoperatively. If a surgeon using the lateral approach is to succeed at minimizing surgical trauma to the patient and achieving an optimal clinical outcome, the surgeon must be skilled at obtaining and interpreting the appropriate diagnostic imaging.

DIAGNOSTIC IMAGING

Imaging modalities are a powerful tool for diagnosing patients and planning their treatment. When high-quality radiographs are collected and appropriately archived with the patient's identifying information, date of examination, and markers to indicate the patient's position during imaging, they can be extremely valuable in identifying the current state of the pathology as well as progression of deformity or device failure over time. Although written reports can provide confidence in consensus, the surgeon must always personally review the films to appropriately treat the patient. It must be emphasized that even excellent images are not a substitute for a careful, detailed history and physical examina-

tion. Rather, the skilled spinal surgeon uses diagnostic imaging to confirm the suspected diagnosis, as it has been well documented that imaging may reveal spinal abnormalities that have no bearing on the patient's complaint.^{2,3}

Radiographs

Plain radiographs remain a useful tool, not only for the initial evaluation of a spinal complaint, but also for the evaluation of spinal deformity and trauma. Plain radiographs provide information on the presence of degenerative and traumatic changes of the spine or loss of vertebral body integrity. When performed upright and full length, plain radiographs demonstrate spinal alignment in the coronal and sagittal planes. The height of the iliac wings is a variable when contemplating lateral access to the caudal lumbar spine, particularly in deformity surgery, and is best appreciated with a true lateral radiograph (Fig. 6-1).

Although flexion-extension lateral radiographs of the spine are effort dependent, they may confirm the presence of spinal instability. Supine side-bending or traction radiographs are an aid in determining the flexibility of a coronal deformity, as are supine extension radiographs over a bolster for sagittal deformity.

The surgeon should be mindful of the effect of parallax if the x-ray beam passes through the image receptor system at an angle. The effect can be particularly marked when imaging a deformity. Therefore to minimize parallax, the truest possible anteroposterior and lateral exposure of the portion of the spine of interest should be made.

Computed Tomography

When more detail of the bony anatomy is required for diagnosis, CT is the imaging modality of choice. Coupled with the instillation of intrathecal contrast material, CT can confirm the presence of spinal stenosis

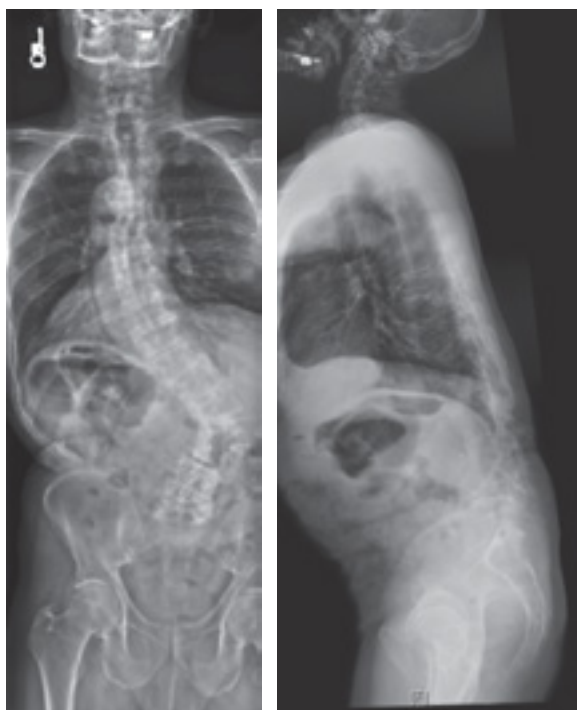


FIG. 6-1 Standing, full-length spinal radiographs are necessary to satisfactorily evaluate spinal deformity, as in this individual with degenerative lumbar scoliosis and kyphosis. In this instance, the downward tilt of the L3-4 and L4-5 discs to the right facilitates lateral access from the left. The more cranial lumbar vertebrae may be more easily approached from the right.

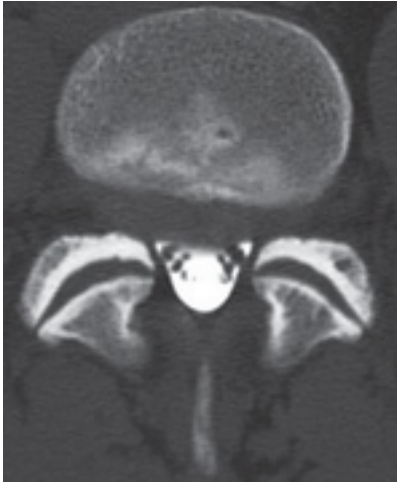


FIG. 6-2 An axial image from a lumbar myelogram CT demonstrates central and lateral recess stenosis secondary to a broad-based disc herniation.

and its cause (e.g., subarticular stenosis). CT performed in this manner is complementary to MRI of the lumbar spine. Moreover, in the presence of prior internal fixation, CT myelography may provide the best imaging of the neural tissues relative to the bony and ligamentous anatomy of the spinal canal (Fig. 6-2).

Magnetic Resonance Imaging

MRI is superior to CT at revealing soft tissue anatomy and, when coupled with gadolinium injected intravenously, can distinguish epidural scar from disc. Disruption of muscle and ligament can be appreciated on MRI when evaluating trauma. MRI also reveals the relative health of the disc nucleus on T2-weighted study by demonstrating its water content or lack thereof. Importantly, MRI is an excellent imaging modality to study the spinal cord and cauda equina. Reconstructions parallel to the vertebral endplates most accurately reveal degrees of spinal stenosis. Because MRI is performed supine at most centers, it may enhance the apparent degree



FIG. 6-3 A T2-weighted midsagittal image from a lumbar MRI demonstrating normal hydration of the T10-11 to L2-3 discs, with desiccation of the L3-4 to L5-S1 discs. Degenerative L3-4 spondylolisthesis with stenosis is evident, but because the image was obtained with the patient in the supine position, the true degree of listhesis is not confirmed on this study. Incidentally noted is a high-intensity zone of the posterior L5-S1 disc wall consistent with an annular tear.

of lumbar lordosis, which may in fact be functionally reduced. Similarly, existing spondylolisthesis may not be apparent because of reduction resulting from supine positioning. Therefore it is best to obtain upright radiographic studies, as described previously, rather than rely on MRI to determine spinal alignment and sagittal contour (Fig. 6-3).

It should be noted that although traditional fat-suppressed T2-weighted MRI is efficacious for identifying vascular or neural anatomy, these structures can produce similar signal intensity that may make their discrimination difficult and time consuming. Further, precise location of a nerve may not be possible because of vascular structures, such as the venous plexus, adjacent to nerves. In lateral access surgery, it is critical to identify the presence of aberrant anatomy and to differ-

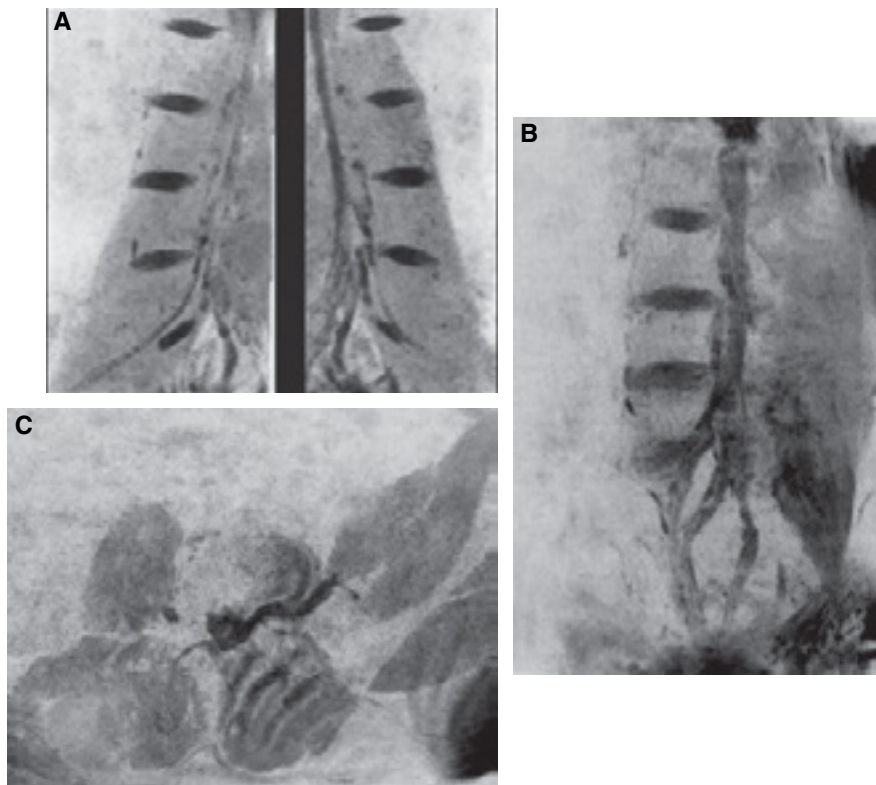


FIG. 6-4 **A**, Three-dimensional diffusion-weighted reverse fast image with steady-state precession (3DDW-PSIF) neurography, sagittally oriented, demonstrating a posterior position of the lumbar plexus at the L4-5 level. Note the junction of L3 and L4 spinal nerves to form the femoral nerve (contributions from L2, L3, L4). **B**, Transitional lumbosacral segment on 3DDW-PSIF; at the L4-TV (transitional vertebra) the plexus is at the middle posterior half of the disc space. **C**, Axial 3DDW-PSIF view at the same level. Note the plexus in an anterior position over the disc space.

entiate between vascular and neural structures during preoperative planning.

Three-dimensional diffusion-weighted reverse fast image with steady-state precession (3DDW-PSIF) MRI is a relatively new technique for neurography that has been increasingly used to evaluate abnormal conditions of entire nerves and nerve bundles. The technique suppresses the signal from the surrounding muscles and vessels to highlight the neural anatomy. A short T1 inversion recovery (STIR) prepulse is also used for fat suppression. Although currently unstudied for the application of lateral approach interbody fusion, this technology may have utility in the assessment of the lumbar plexus and may overcome some of the disadvantages of

conventional neurography by providing better contrast between the nerves and the surrounding tissues (Fig. 6-4).

Other Diagnostic Tools

Fluoroscopy, or real-time radiography, is used at some centers when facet injection or discography is employed to confirm the diagnosis of a symptomatic motion segment. However, these diagnostic procedures are not uniformly accepted and it is recommended that the reader consult the literature specific to those procedures for an in-depth discussion.⁴

LIMITATIONS

Although there are no known risks to MRI, plain radiography and CT expose the patient to ionizing radiation. Present-day technology has reduced that exposure considerably in the case of plain radiography; a standard spinal radiograph typically results in less than 8% of the quarterly limit that is defined as safe by OSHA.⁵ Should it be necessary, a second plain radiographic image may be safely obtained if the first is inadequate. Because CT requires multiple axial radiographs to obtain an image, it necessarily increases the exposure to ionizing radiation. Therefore, although CT imaging is very useful, the frequency of its use and the length of spine exposed should be minimized for each individual consistent with the clinical scenario.⁶

POSTOPERATIVE IMAGING

When spinal implants are used, their implanted position should be confirmed by intraoperative fluoroscopy or plain radiographs. During the postoperative course it is important to confirm the maintenance of implant position and internal fixation, if any, to the spine. Thereafter, it is a matter of surgeon discretion what schedule to fol-

low in monitoring the patient's course. Nevertheless, it is suggested that in the case of extreme lateral interbody fusion (XLIF[®], NuVasive[®], Inc., San Diego, CA), plain radiographs be obtained at 3 and 6 months postoperatively. If the patient is progressing as anticipated there may be no need for additional plain radiographs until 1 and 2 years postoperatively. If the patient becomes unexpectedly symptomatic, additional interim imaging may be required to determine the cause. For example, MRI is helpful to assess for the presence of psoas hematoma, and myelogram CT is useful for detailed evaluation of pseudarthrosis or the position of implants relative to the neural elements (Fig. 6-5).

A goal of XLIF is maintenance or restoration of disc height. This is dependent in large part on proper placement of the interbody cage on the cortical bone comprising the ring apophysis. It is anticipated that some slight settling of a cage will occur in the course of bone healing following any lumbar interbody fusion. Subsidence of a cage, on the other hand, may compromise fusion healing, spinal alignment, and the indirect decompression achieved at the time of surgery, particularly when multilevel surgery has been performed or there is severe osteoporosis.⁷⁻⁹ This phenomenon can be

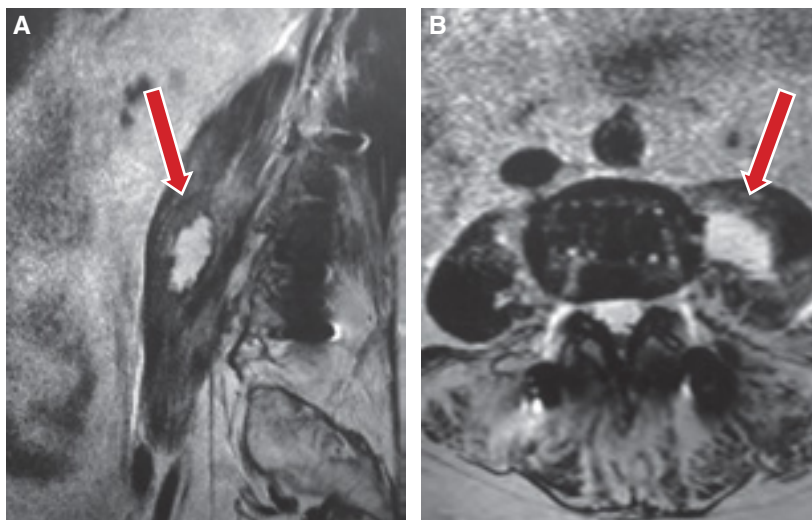


FIG. 6-5 Immediate postoperative hematoma (*red arrows*) following XLIF[®] (NuVasive, Inc.), identified on, **A**, sagittal and, **B**, axial MRI views.

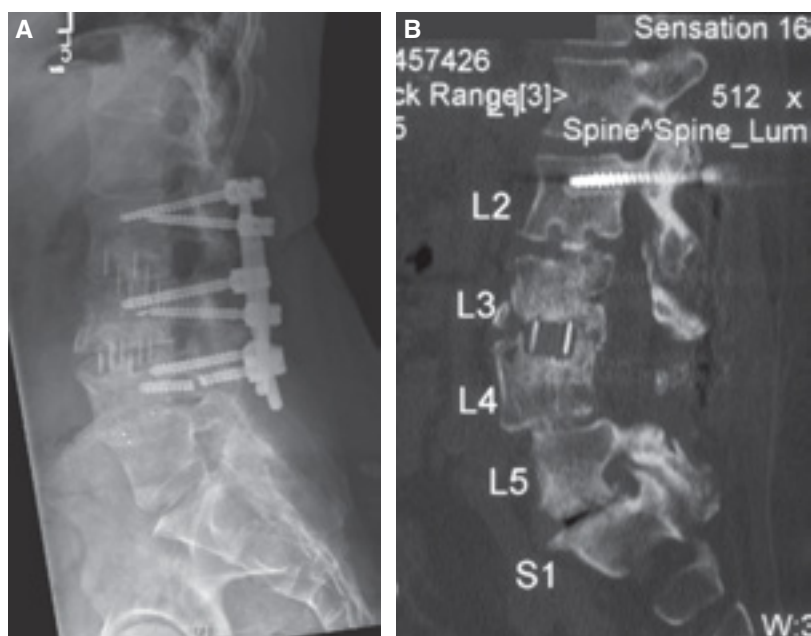


FIG. 6-6 A, This lateral radiograph of the lumbar spine following L2-3 and L3-4 XLIF® (NuVasive, Inc.) with pedicle screw fixation reveals cage subsidence at both levels and fracture of one of the L4 pedicle screws consistent with a pseudarthrosis. B, A sagittal midline reconstruction of a noncontrast lumbar CT of the same individual demonstrates in more detail the degree of subsidence at each level as well as likely pseudarthroses. Incidentally noted on the CT image is a halo sign at one of the L2 pedicle screws. An interbody fusion at L4-5 antedated the XLIF procedures and appears united. Degenerative disc and facet joint changes are evident at L5-S1.

monitored with plain radiographs, provided the motion segment of interest is imaged in a true lateral projection (Fig. 6-6).

Likewise, while a polyetheretherketone (PEEK) cage permits good visualization of a developing fusion (Fig. 6-7), it is important to obtain plain radiographic images that demonstrate the motion segment of interest in a true lateral projection. Otherwise, assessing the development of bridging bone may be compromised. If a detailed examination of a fused motion segment is desired, fine-cut CT images with coronal and sagittal reformations are recommended. When a pseudarthrosis is suspected, fine-cut CT is arguably the best imaging modality to make the diagnosis absent actual surgical exploration. However, the CT should be confined to the motion segment(s) of concern rather than the entire lumbar spine to minimize x-ray exposure.

Flexion-extension plain radiographs have been used in an attempt to confirm fusion of a motion segment.



FIG. 6-7 One year postoperatively, this lateral lumbar radiograph demonstrates likely healing of XLIF® (NuVasive, Inc.) at L3-4.

However, unless there is gross motion due to implant loosening, which should be readily apparent in any case, the interbody device and internal fixation are likely to preclude motion, even in the event of a pseudarthrosis. Therefore it is our opinion that flexion-extension lateral radiographs provide little information regarding the presence or absence of a fusion postoperatively.

If documentation of indirect decompression is desired, it is suggested that MRI be used. Although CT imaging can provide the same information regarding spinal canal dimensions, it does so with the risk of x-ray exposure.¹⁰

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CONCLUSION

Achieving an optimal clinical outcome with lateral access surgery requires accurate preoperative diagnosis and careful postoperative monitoring. Diagnostic imaging is an important adjunct to a detailed history and physical examination for both accurate diagnosis and appreciation of aberrant anatomy. Prudently timed and appropriately selected imaging is an important adjunct to postoperative care.

