Lumbar Spine Imaging: Role in Clinical Decision Making

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Abstract

Imaging studies are an integral component of the evaluation of the lumbar spine. For each study there is a specific role, an appropriate indication, and a correct time for utilization during the course of a patient's illness. The physician must know the specificity and sensitivity of each test, as well as the prevalence of abnormal findings in asymptomatic persons, to properly order and interpret the results of the studies. Many errors in decision making arise, not from misinterpretation of what is seen on imaging studies, but rather from misuse of imaging information in the clinical decision-making process. Because all neurodiagnostic imaging modalities reveal abnormalities in at least a third of asymptomatic persons, the use of these tests for general screening is dangerous. The challenge for the future is to be able to better correlate what is seen on imaging studies with the patient's symptoms. Obtaining these expensive studies too early in the treatment of self-limited disorders is costly and often misleading for both the physician and the patient. The authors outline an approach to the judicious timing of imaging studies and discuss pitfalls in their interpretation in the evaluation of degenerative diseases of the lumbar spine.

J Am Acad Orthop Surg 1996;4:238-248

Imaging studies are an integral part of the evaluation of the patient with signs and symptoms of a lumbar spine disorder. The physician's challenge is to select diagnostic tests on the basis of their performance characteristics so that the correct diagnosis can be obtained with the least morbidity for the patient and the lowest cost for society. Each test has a designated position in the temporal sequence of the evaluation of a patient with a spinal disorder. Advanced imaging studies can be expensive and should be obtained only at the time when the result is likely to influence treatment.

The goal of this article is to review the most frequently utilized imaging studies, with emphasis on their clinical value, specific indications, and limitations. We will discuss both preoperative and postoperative diagnostic studies, as well as evaluation of the patient with low back pain who has undergone multiple surgical procedures on the spine. An algorithm for effectively and efficiently using these examinations will also be presented.

Assessing the Clinical Value of Imaging Modalities

The performance of a diagnostic study can be assessed by calculating its sensitivity and specificity. Sensitivity, which is lowered by false-negative results, is a reflection of the usefulness of the study in detecting disease when it is present. Specificity, which is lowered by false-positive results, is a reflection of the consistency of the test in providing negative results in the absence of clinical disease. Specificity is more relevant to the avoidance of unnecessary interventions. Both the specificity and the sensitivity of any particular study are assessed in symptomatic patients who have undergone surgery to confirm the imaging prediction.

Another crucial piece of information for each imaging test is the incidence of its being positive for a specific pathologic entity in an asymptomatic population. Since some of the most commonly used studies—myelography, computed

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tomography (CT), and magnetic resonance (MR) imaging—will demonstrate abnormalities in more than 30% of asymptomatic volunteers, one should use these diagnostic tests to confirm the core of information gathered from the history and physical examination.[1] If a positive test is not interpreted in light of the findings from the history and physical examination, the physician may end up treating a condition that is asymptomatic. In the authors' opinion, poor outcomes after surgical management of patients with spinal disorders often can be attributed directly to excessive reliance on diagnostic studies without precise clinical correlation. A recurring theme of this article will be that an abnormality visualized on an imaging study may not be the cause of a particular patient's pain.

Plain Radiography

Plain radiographs may be useful for suggesting diagnoses such as developmental spinal stenosis, spondylolisthesis, spondyloarthropathy, fractures, and late-stage tumors or infections. Bone scanning and MR imaging are far more sensitive for the latter three entities. Excessive motion may be seen on lateral flexion-extension bending films. The lack of measurement precision on uniplanar radiographs often limits the ability to reliably detect motion even when it is present. Another difficult problem is identifying pathologic motion (translational instability). The current consensus, based on cadaveric and in vivo studies, is that up to 3 mm of dynamic lumbar motion (sagittal translation) from flexion to extension may be normal in asymptomatic individuals.[2]

The radiograph must be of excellent quality and taken with attention to detail. In general, only three views are needed to assess the lumbosacral spine: an anteroposterior view, a lateral view, and a spot lateral view of the two lowest interspaces. On occasion, two oblique views are obtained to identify subtle pars interarticularis defects when the lateral radiograph is suggestive but not diagnostic of spondylolysis; however, oblique views provide limited information and should not be routinely included.

Although plain films are useful for surveying the osseous elements of the spine, the contents of the spinal canal (cord, dura, ligaments, and encroaching disk) are not visualized. It should also be remembered that bone lesions may not be apparent until a large amount of the cancellous bone has been destroyed. Since most back injuries involve soft tissues (strains and sprains), plain radiographs will rarely add any information, but should be obtained in some cases to rule out other pathologic conditions, such as infection and tumor. The sensitivity of plain radiography may be low in the early stages of an infection or tumor, and other imaging studies (such as MR imaging) may be warranted if the level of clinical suspicion is high.

Degenerative changes, such as disk-space narrowing, osteophytes, vacuum-disk phenomenon, and endplate sclerosis, are seen frequently in asymptomatic older individuals and are of questionable significance. These findings on plain radiographs do not correlate well with clinical symptoms, and the physician must be careful when attempting to attribute a patient's symptoms solely on this basis (Fig. 1).

Fig. 1 Lateral radiograph of the lumbosacral spine of a 54-year-old man with recurrent left leg pain after two diskectomies at L4-5. While spondylolisthesis is not present, moderate disk-space narrowing and osteophytes are seen at L4-5, suggesting a predisposition for foraminal stenosis.

Diskography

Since its introduction in 1948, lumbar diskography has been a controversial test for the diagnosis of low back pain and sciatica. An annular tear can result in posterior extravasation of contrast material injected into the center of the disk (Fig. 2).[3] In asymptomatic individuals, the small tears in the anulus fibrosus that are commonly associated with disk aging may permit extravasation of contrast material.

In 1968, Holt found that 37% of a study group of asymptomatic young men had positive diskograms and concluded that diskography was a nonspecific and unreliable test. Holt's data have been reanalyzed, and his conclusion has been challenged.[4] Reproduction of the patient's typical back pain during disk injection has now become a requisite for a positive diskographic study. Addition of the pain-reproduction criterion decreased the false-positive rate of

Fig. 2 Lumbar diskogram demonstrates relatively normal disks at L3-4 and L4-5. The L4-5 disk demonstrates an annular fissure on the left side without external extravasation. The L5-S1 disk has a posterolateral tear that communicates with the epidural space. The patient had nonradiating low back pain that was not reproduced by the disk injection and that responded well to an aggressive nonoperative back rehabilitation program.

lumbar diskograms to nearly zero in a prospective study of young asymptomatic volunteers.[5] Post-diskography CT is reported to add diagnostic value and has a higher correlation with reproduction of low back pain.

Despite a more rigid definition of what constitutes a positive diskogram, the appropriate clinical use of this diagnostic information remains uncertain. Two problems remain. First, it is unclear precisely which patients with diskogenic pain can be reliably helped by spinal fusion. Second, it has not yet been established which type of spinal fusion should be performed.

Myelography and Computed Tomography

Until recently, the most common test for evaluation of neural compression was myelography. In this procedure, a radiopaque contrast material is injected into the dural sac, where it mixes with the spinal fluid. The outline of the contents of the thecal sac can be visualized radiographically; any extradural mass, such as a herniated disk, will appear as an impression on the contrast column (Fig. 3), while an intrathecal mass will appear as a filling defect. Myelography alone often is not useful in distinguishing the precise cause of soft-tissue encroachment into the dural sac, nor is it useful in the diagnosis of neurologic compression due to far-lateral disease (in or lateral to the neural foramen). Therefore, CT is usually performed in conjunction with myelography.

Myelography is an invasive procedure and, therefore, involves a certain degree of morbidity. Potential complications include severe headache, nausea, vomiting, and occasionally seizures. Before the utilization of water-soluble contrast material, the oil-based agent iophendylate (Pantopaque) was used; it had a much higher incidence of complications and was known to be a potential cause of arachnoiditis. Newer nonionic contrast agents reportedly have many fewer side effects.

A definite advantage of myelography is the ability to identify unsuspected disorders of the lower thoracic spine without additional effort. Myelography can also be used to identify severe stenoses that block the flow of cerebrospinal fluid (CSF). Quantitation of spinal stenosis on a routine MR image is difficult without digital measurements, but a complete block of CSF is usually self-evident on a myelogram. However, newer MR pulse sequencing with phase-contrast techniques now permits assessment of CSF flow dynamics.

Despite the widespread use of myelography in the assessment of radicular leg pain, the incidence of abnormal lumbar myelograms in as many as 24% of asymptomatic persons has been reported.[6] Most studies report comparable accuracy for myelography and CT, although myelography is thought to produce fewer false-positive and more false-negative findings. However, the inability to identify foraminal abnormalities and the complication rate have rendered myelography alone a distant second choice in most centers where both CT and MR imaging are readily available. Myelography

Fig. 3 Lumbar myelogram demonstrates an extradural defect around the exiting nerve root and a curved or deflected path of the exiting root due to a herniated disk.

still plays a role in confirming the diagnosis of arachnoiditis when the diagnosis is otherwise uncertain and in imaging the postoperative spine with implanted metal hardware, which would distort or prevent imaging with CT or MR imaging. In the patient with degenerative disease at multiple levels and spinal stenotic symptoms, myelography is useful in deciding which specific levels need to be decompressed. In addition, myelography still plays an important role in evaluating patients with severe deformities, such as scoliosis.

Computed tomography is a very versatile and widely available modality for evaluating abnormalities of the spine. Multiple cross-sectional (axial) images of the spine can be obtained at various levels, and with reformatting, coronal, sagittal, and three-dimensional images can be created. With the use of differential attenuation characteristics, CT can demonstrate not only the osseous configurations but also the soft tissues, so that ligaments, nerve roots, free fat, and intervertebral disk protrusions can be evaluated as they relate to their osseous environment.

Several prospective comparisons with myelography have demonstrated that CT has comparable sensitivity (approximately 95%) and specificity (approximately 78%) for the diagnosis of disk herniation. Technical variables, such as section thickness and intersection gap size, may affect the accuracy of the CT scan. Foraminal stenosis may be overestimated or missed if the intersection gap is too large. Similarly, a pars interarticularis fracture may be missed if the section thickness is too large or if true bone windows are not obtained. Scoliosis may also complicate the assessment of foraminal stenosis. In such cases, sagittal reformatted CT or parasagittal MR imaging through the foramen is more helpful. Another weakness of CT is the inability to reliably demonstrate intrathecal abnormalities (e.g., tumors) and to depict unsuspected disorders at the thoracolumbar junction, since routinely only the lower three lumbar levels are imaged.

A common practice is to employ myelography and CT together. This combination has been shown to demonstrate additional abnormalities in as many as 30% of cases and is particularly useful in the evaluation of patients with spinal stenosis (Fig. 4).

Both studies have high prevalence rates of abnormal findings in the asymptomatic population. In one study,[7] 34% of asymptomatic subjects had abnormal CT scans when the images were reviewed blindly. In another study,[6] 24% of asymptomatic subjects had abnormal myelograms. The implication is that a patient whose history and physical examination show no evidence of a spinal lesion has a one-in-three chance of having an abnormal CT scan or myelogram. If the decision for surgery is based on only the imaging test results, there is an unacceptably high chance that the patient will undergo an unnecessary operation. If the clinical picture correlates with the abnormalities observed on imaging studies, however, they can be very useful confirmatory diagnostic tools.

Fig. 4 Postmyelography CT scan (same patient as in Fig. 3) demonstrates lateralized disk herniation displacing the thecal sac.

Magnetic Resonance Imaging

The newest modality used to evaluate the spine is MR imaging. The images are derived from the extremely small differences in magnetic properties of the various types of tissues as revealed by differences in relaxation times and proton densities. An advantage with MR imaging is that it is noninvasive and does not require ionizing radiation. In addition, multiplanar images are directly available.

There is a wide variety in the quality of MR imaging equipment. Decision making on the basis of MR findings should rely on images obtained with high-quality equipment and without excessive artifact due to patient movement or spasm. The best images are obtained with high-strength (>1.0 T) magnets. New software makes possible increasingly shorter image-acquisition times when used in combination with surface-coil receivers.

Several studies suggest that MR imaging can more easily detect degenerative disk disease than myelography or CT. Due to its enhanced ability to distinguish soft tissues, MR imaging is ideal for depicting infection, tumor, and neural and other soft-tissue trauma. The accuracy of MR imaging in the diagnosis of spinal stenosis, posterolateral disk herniations (Fig. 5), and far-lateral disk herniations is comparable to that of CT. The best correlation of imaging studies with surgical findings may be achieved with the combination of CT and MR imaging.

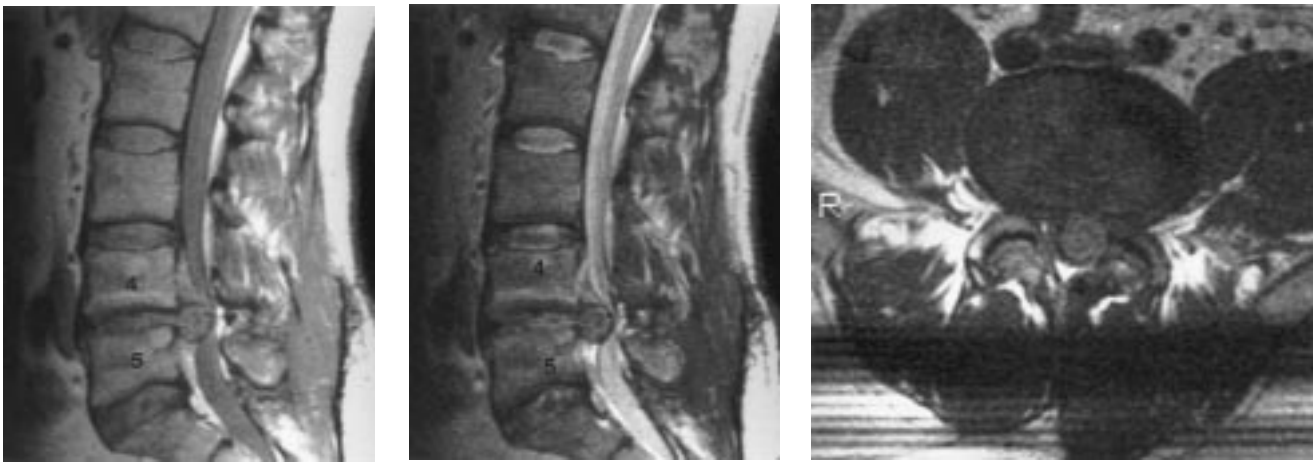


Fig. 5 **A**, Sagittal T1-weighted MR image demonstrates a large herniated disk at L4-5 with cauda equina compression. **B**, Sagittal T2-weighted MR image demonstrates the herniated disk as well as decreased disk signal intensity at several lumbar levels. **C**, Axial MR image is difficult to interpret because the disk fragment is so large that it is almost mistaken for the thecal sac.

It can be misleading to attempt to equate the radiologically depicted morphologic features with the cause of an individual patient's symptoms. With many studies, one problem in attempting to correlate imaging findings with intraoperative findings is the lack of confirmation of resolution of clinical symptoms after surgery. Surgical correction of lesions that are depicted with MR imaging does not ensure that the visualized problem was the cause of the patient's pain. In a study of extraspinal causes of lumbar radiculopathy, the imaging studies of several patients demonstrated disk herniation or spinal stenosis; the patients underwent lumbar surgery but nevertheless died as a result of the intrapelvic or retroperitoneal tumors that were the true cause of their symptoms.[8]

Magnetic resonance imaging is not exempt from demonstrating abnormal findings in asymptomatic individuals. In a study of the lumbar spine,[1] the MR images of 22% of the asymptomatic subjects under age 60 and 57% of those over age 60 were abnormal, depicting disk herniation or spinal stenosis (Table 1). In addition, the prevalence of "disk degeneration" in one or more disks in individuals over the age of 60 was over 90%. Thus, planning surgical interventions solely on the basis of an MR finding, such as diminished intervertebral-disk signal intensity, must be avoided.

Table 1
Lumbar Spine Abnormalities on MR Images of Asymptomatic Subjects*

	Patient Age, yr		
Finding	20–39	40–59	60–80
Herniated disk	21	22	36
Spinal stenosis	1	0	21
Disk bulge	56	50	79
Disk degeneration	34	59	93

* Values are percentages of total study group of 67 subjects.

Role of Imaging Modalities in Specific Clinical Situations

Persistent Low Back Pain After Spine Surgery

Low back pain in the patient who has undergone multiple surgical procedures on the spine is an ever-increasing problem. Approximately 300,000 lumbar laminectomies are performed annually in the United States, and it has been estimated that as many as 15% of the patients who have undergone these procedures have residual disabling symptoms.[9]

The primary goal in the evaluation of patients who have previously undergone spine surgery is to determine whether another operation or nonoperative treatment is better. The greatest challenge is to determine whether the cause of the pain is mechanical or nonmechanical. The common types of mechanical lesions include recurrent or residual herniated disk material, spinal instability (including pseudarthrosis after unsuccessful fusion), and spinal stenosis. These problems may cause pain due to constant pressure on neural elements or intermittent pressure from abnormal motion, both of which are potentially amenable to surgery. Scar tissue (either intradural [arachnoiditis] or extradural [epidural fibrosis]), psychosocial instability, and systemic medical disease are nonmechanical problems. These entities are not responsive to more surgery and may be worsened. Postoperative disk-space infections must also be considered in the differential diagnosis of postoperative back or leg pain.

Pseudarthrosis

Failure to achieve solid bone union after an attempted spinal fusion may be due to a host of systemic metabolic factors and local factors. Radiographic diagnosis of pseudarthrosis is difficult, and clinical diagnosis is even more challenging because not all radiographically apparent pseudarthroses are symptomatic. The presence of asymptomatic nonunions may sometimes be explained by achievement of adequate stabilization by fibrous tissue.

Clinical suspicion must be the driving force in making the diagnosis of pseudarthrosis. Mechanical back pain that is relieved with rest or changes in posture is the hallmark. Imaging is unreliable for confirming the diagnosis. The accuracy of plain radiography in assessing fusion success or failure is less than 70%.[10] Absence of excessive motion on dynamic radiographs does not necessarily mean that a solid fusion is present.

Plain tomography is useful for evaluating the geometry of fusion mass but is hampered by the inability to be reformatted or to provide axially oriented images. Anterior interbody fusions usually can be assessed for the presence of bridging bone trabeculae across the fusion segments. In contrast, a posterolateral fusion mass may appear continuous on an anteroposterior tomogram, when in fact the fusion mass does not actually make contact with one of the two vertebrae. Even CT, which has the advantage of axial imaging, is often not sufficient to detect a pseudarthrosis.

In summary, the optimal diagnostic combination for lumbar pseudarthrosis has yet to be determined. What has been established, however, is that, particularly for assessment of posterolateral fusions, plain radiographs alone are unquestionably inadequate.

Postoperative Disk-Space Infection

There are two obstacles to making the diagnosis of postoperative disk-space infection. First, because it is relatively uncommon, it is often not considered as a possibility. This is compounded by the fact that the usual clinical signs of fever, leukocytosis, and wound infection are seen in only the minority of cases. Second, MR signal changes seen in the disk space after surgery are often assumed to be normal postsurgical changes. Actually, it is uncommon to see MR signal changes within the central disk space after uncomplicated disk excision, but it is common to see enhancement within the surgical tract through the anulus fibrosus.

Postoperative diskitis is characterized by a triad of MR findings (Fig. 6): (1) gadolinium enhancement of the adjacent vertebral bone

A B

Fig. 6 **A**, MR images of a patient with back pain and spasm 4 weeks after lumbar diskectomy. The classic findings of postoperative diskitis are well demonstrated at L5-S1. T1-weighted sequence **(left)** demonstrates decreased signal intensity of the bone marrow adjacent to the affected disk. More T2-weighted sequence **(right)** demonstrates increased marrow signal as well as increased signal within the disk space itself. **B**, Gadolinium enhancement of the adjacent marrow and the posterior disk space produces findings consistent with diskitis. (Reproduced with permission from Boden SD, Davis DO, Dina TS, et al: Postoperative diskitis: Distinguishing early MR imaging findings from normal postoperative disk space changes. *Radiology* 1992;184:765-771.)

marrow on each side of the affected disk; (2) decreased intradiskal signal on T1-weighted images and increased signal on T2-weighted images on nonenhanced sequences; and (3) gadolinium enhancement of the disk space and/or posterior anulus fibrosus.[11]

Tumor and degenerative disk disease can also cause MR signal changes in the paradiskal bone marrow (Table 2). Neoplastic disorders do not usually destroy the cartilaginous disk space, whereas degenerative disk disease or an infection will usually involve changes within the disk. A more confusing issue arises because marrow changes from degenerative disk disease can mimic the findings of early postoperative diskitis. In ambiguous cases, it should be determined whether marrow changes associated with degenerative disk disease were present on MR images obtained before surgery.[12] In addition, patients with disk-space infection will often demonstrate increased central disk signal on nonenhanced T2-weighted MR images; however, this finding is easily distinguished from the appearance of a degenerative disk, which typically is characterized by decreased central disk signal intensity.

It is important to understand the natural history of diskitis as observed on MR images. In the authors' experience, it is common for the MR findings of postoperative diskitis to appear to worsen before improving, despite appropriate treatment and improvement of clinical symptoms. Therefore, because there is not necessarily good correlation between the clinical course and the MR findings, the normalization of symptoms, the erythrocyte sedimentation rate, and the C-reactive protein level should be used to guide treatment decisions.

Distinguishing Recurrent or Residual Disk Material From Scar

One of the more difficult challenges in planning the treatment of patients with previous spine surgery is to distinguish recurrent or residual disk material from epidural scar. Gadolinium-enhanced MR imaging has the highest accuracy in this regard.[14] Before the advent of MR imaging, plain CT and CT enhanced with intravenous contrast material were used to make these distinctions.

Normal postoperative changes must be distinguished from pathologic abnormalities. In one study,[15] the CT studies of more than 40% of asymptomatic postoperative patients showed persistent herniated disk and other findings. Studies with nonenhanced MR imaging have revealed that almost 70% of patients who have undergone clinically successful diskectomy have findings that mimic the preoperative herniated disk.

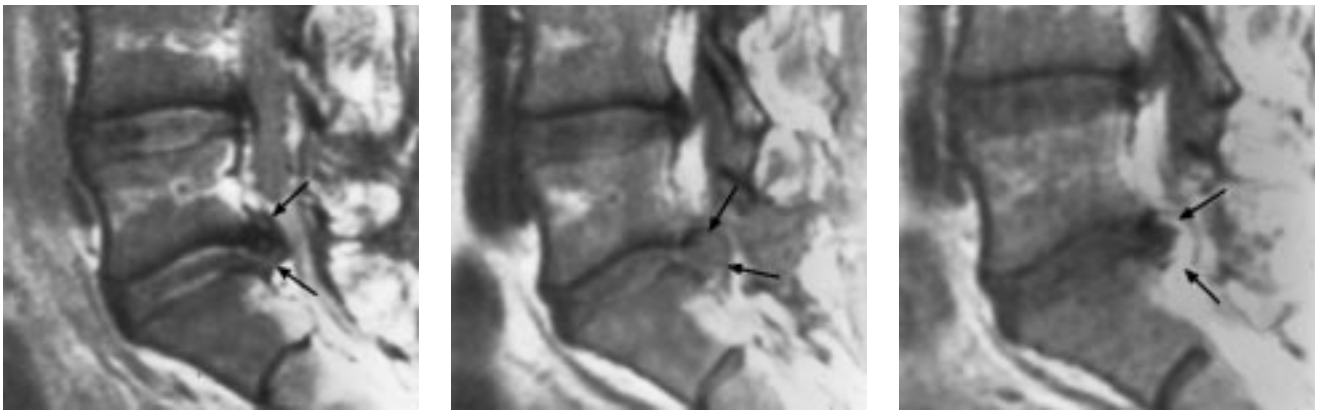
The normal sequence and timing of changes seen on gadolinium-enhanced MR images after successful lumbar disk surgery (asymptomatic patients) have been recently described.[16] The most surprising normal postoperative MR finding was a persistent mass effect similar to the appearance of preoperative disk herniation (Fig. 7). This has been described with nonenhanced MR imaging of patients who had persistent symptoms. In a prospective study,[16] some anterior epidural mass effect was noted after surgery in all patients even though they had complete relief of radicular symptoms. The mass effect diminished over the initial 6-month postoperative period and probably represented normal postoperative hematoma.

In the same study,[16] almost 40% of the postoperative patients without symptoms had a mass effect with a peripheral gadolinium enhancement pattern consistent with disk rather than scar (Fig 8). Thus, even with gadolinium-enhanced MR imaging, an anterior

Table 2
MR Imaging Findings in the Differential Diagnosis of Diskitis and Degenerative Disk Disease

	MR Signal Characteristics*					
	Marrow			Disk		
	T1	T2	T1+Gd	T1	T2	T1+Gd
Degenerative disk disease†						
Type I	–	+	+	I/–	–	I/+
Type II	+	I/+	I	I/–	–	I/+
Type III	–	–	I	I/–	–	I/+
Diskitis	–	+	+	–	+	+

* MR signal characteristics in the central (nuclear) portion of the intervertebral disk space and adjacent vertebral bone marrow in degenerative disk disease on nonenhanced T1-weighted (T1), T2-weighted (T2), and gadolinium-enhanced T1-weighted (T1+Gd) images.[12,13] Intensity of signal is reported relative to the same structure at an adjacent normal level: I = isointense; – = hypointense; + = hyperintense.
† Three patterns of degenerative disk disease have been described by Modic et al.[12,13] Their categorization is based on the MR signal of the adjacent bone marrow.



A B C

Fig. 7 Sagittal MR images of a patient who underwent uncomplicated lumbar diskectomy and experienced immediate and complete relief of symptoms. **A**, Preoperative T1-weighted image shows a herniated L5-S1 disk (arrows). **B**, Nonenhanced T1-weighted image obtained 3 weeks after surgery demonstrates a large mass contiguous to the site of, and at least as large as, the original disk herniation. **C**, Gadolinium-enhanced image also obtained 3 weeks after surgery shows a peripheral enhancement pattern (arrows) strongly suggestive of residual disk material rather than scar. This mass effect diminished in size over the ensuing 5 months, and a homogeneous enhancement pattern developed, consistent with scar. (Reproduced with permission from Boden SD, Davis DO, Dina TS, et al: Contrast-enhanced MR imaging performed after successful lumbar disk surgery: Prospective study. *Radiology* 1992;182:59-64.)

epidural mass can easily be misinterpreted as recurrent or residual disk material in the early postoperative period. Therefore, decisions about further operative interventions made on the basis of MR imaging findings during the first 3 to 6 months after spine surgery must be made with caution.

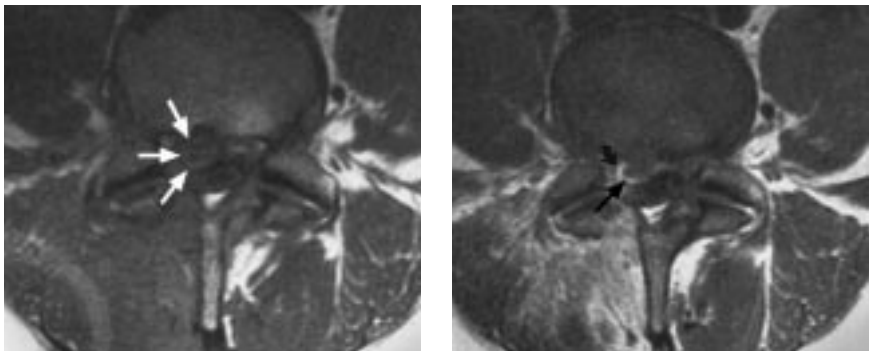


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Fig. 8 Axial MR images obtained 3 weeks after routine diskectomy, which resulted in immediate and complete relief of symptoms. **A**, Nonenhanced T1-weighted image shows a large anterior epidural mass of intermediate signal intensity at the site of the original L4-5 disk herniation, which compresses the thecal sac. **B**, Gadolinium-enhanced study obtained at the same time demonstrates a peripheral-rim enhancement pattern (arrows) consistent with disk material rather than scar. The patient remained asymptomatic after surgery. The mass effect diminished in size over the ensuing 5 months, and a homogeneous enhancement pattern developed, consistent with scar. (Reproduced with permission from Boden SD, Davis DO, Dina TS, et al: Contrast-enhanced MR imaging performed after successful lumbar disk surgery: Prospective study. *Radiology* 1992;182:59-64.)

Algorithm for Imaging of the Lumbar Spine

An algorithm can be defined as a procedure for solving a problem in a finite number of steps. Each step represents a decision-making point. In the case of imaging of the lumbar spine, the key issues are whether an imaging study should generally be obtained at a particular point in the evaluation of the universal population of patients with low back and/or leg pain and which study is the most appropriate.

The algorithm for imaging of the lumbar spine shown in Figure 9 is derived from standards of care, guidelines, and the authors' clinical experience. The decision points in the algorithm vary as to the level of their scientific validity. With appropriate evidence in the medical literature, some decision points can be considered the standard of care that will hold true in over 95% of cases. Other decision points have not been scientifically validated and should be considered guidelines because

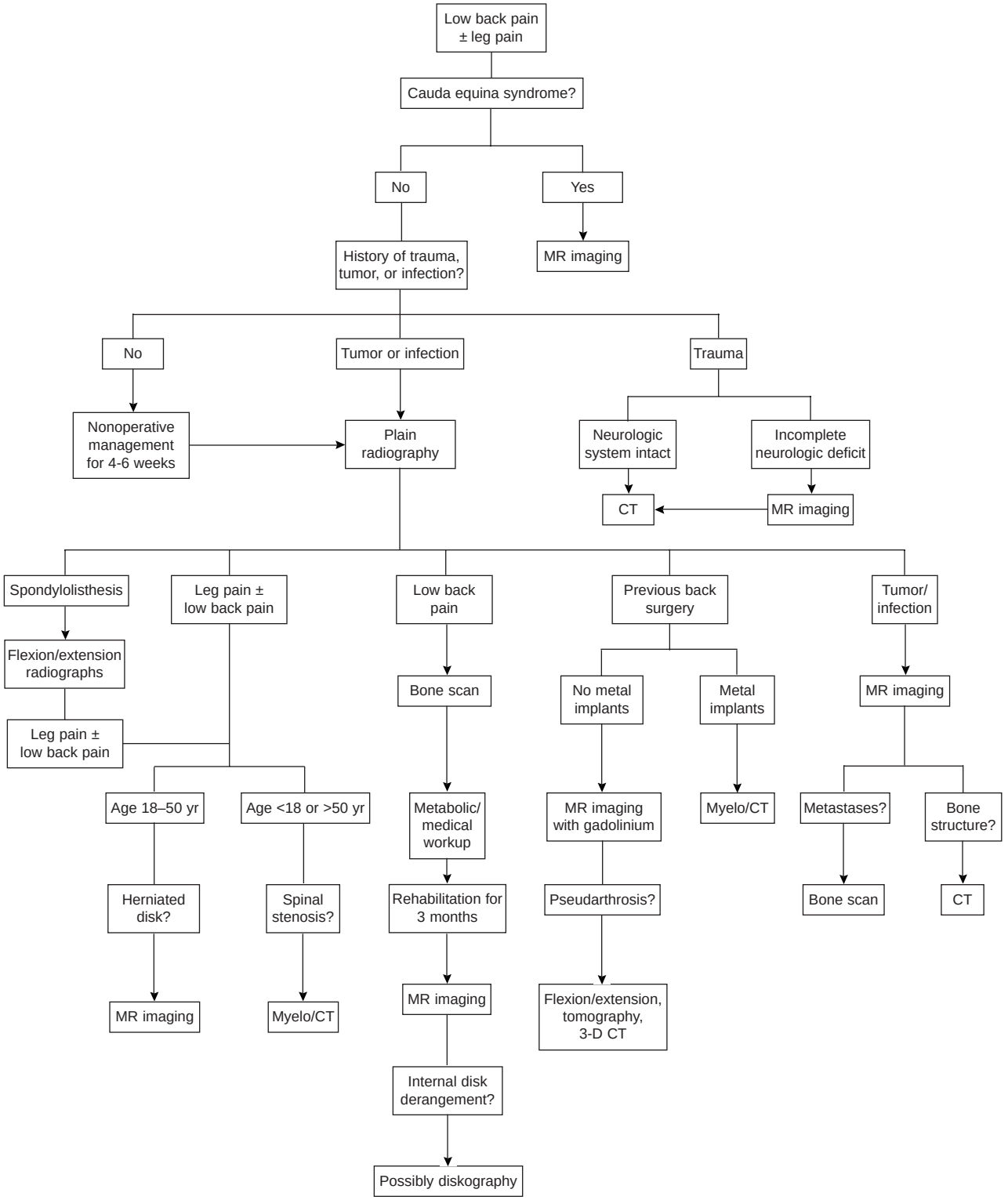

Fig. 9 Algorithm for utilization of imaging modalities in the evaluation of patients with lumbar spine disorders. Myelo/CT = myelography and CT; 3-D CT = three-dimensional CT.

they are based on only a broad consensus of medical opinion. In general, guidelines can be followed in most cases, but deviations can occur in up to a third of patients.

When decision making with use of the algorithm is begun in a particular case, the initial task incumbent on the physician is to identify any emergency condition that would necessitate an immediate imaging study. Acute cauda equina compression syndrome is the major entity demanding emergency care in patients with low back pain. If it is suspected after a careful history has been obtained and a thorough physical examination has been performed, either MR imaging or myelography and CT, depending on which is available, should be performed immediately. If the diagnosis is confirmed, the patient requires urgent surgical decompression.

The other situation in which an immediate imaging study may be required is when there is suspicion that an underlying medical condition, such as a tumor or infection, is responsible for the patient's complaints. If the patient has constitutional symptoms (e.g., fever, unexplained weight loss, a positive history of a primary tumor of the prostate or breast, or clinical evidence of a systemic problem), plain x-ray films should be obtained immediately. Additional imaging may also be indicated in this situation, depending on the specific pathologic abnormalities seen.

The vast majority of patients do not fall in either of the above categories and thus will not require an immediate imaging examination. Most back pain is self-limited, and more than 70% of patients will begin to recover within 4 to 6 weeks. If patients do not improve during this initial period, plain x-ray films are appropriate to attempt to identify a mechanical abnormality, such as spondylolisthesis, or to detect an underlying medical condition that was not initially obvious.

If the plain radiographs are not diagnostic, symptomatic treatment is continued for an additional 3 to 4 weeks. At this juncture, if the patient has not evidenced any clinical improvement or is worsening, an additional study is obtained depending on the working diagnosis. If radiculopathy secondary to a herniated disk is considered likely, MR imaging can be performed to confirm the clinical diagnosis, pinpoint the level of disk herniation, and more accurately plan invasive therapy.

If spinal stenosis is suspected, CT and myelography would be appropriate. This combination is the authors' preference in the case of patients over age 50 with leg pain, because they are more likely to have spinal stenosis than a herniated disk. Alternatively, MR imaging can be performed. Some investigators believe that MR imaging may overestimate the degree of stenosis compared with CT scan and myelography. The affected levels are easily evaluated with either study, however, and planning for surgery is facilitated. In patients with atypical symptoms of stenosis, MR imaging is the authors' preferred initial examination, because it is noninvasive.

In one difficult and controversial clinical situation, the patient complains only of low back pain with no improvement over 6 to 8 weeks and has normal plain radiographs. Many believe that MR imaging should be performed at this point as a screening test. Screening can be defined in this scenario as ruling out hidden diagnoses that are not apparent from the history and physical examination. However, it must be stressed that even if entities such as a herniated disk or age-related disk changes are observed, they may not be responsible for the patient's symptoms. Physicians must appreciate that herniated disks and spinal stenosis can occur in asymptomatic patients. It can take a great deal of self-discipline on the part of the treating physician not to order an MR imaging study prematurely. In the authors' experience, many therapeutic decision-making errors have been documented in cases in which treatment was based on an imaging study without correlating history or physical examination findings.

One approach in patients with no warning signs of tumor or infection in the history or physical examination is to use a bone scan and blood tests to rule out a destructive process (tumor or infection). With this strategy, MR imaging is reserved for those whose condition has not improved after 4 to 6 months of aggressive active soft-tissue rehabilitation. This approach is based on the rationale of not undertaking surgical treatment of back pain until an appropriate trial of rehabilitation has failed. Alternatively, many prefer the use of MR imaging to rule out destructive lesions and allow aggressive nonoperative treatment to proceed.

Another controversial situation is when the MR imaging study demonstrates a dark disk, which indicates decreased hydration and disk degeneration. As previously discussed, if no other cause for the patient's symptoms can be found, some believe that diskography is indicated at this point. Even if the diagnosis is positive on the basis of both abnormal imaging findings and reproduction of symptoms, however, there is no consensus of scientifically valid studies to guide the physician in the proper treatment. It is a very difficult position for both the patient and the physi-

cian. On the one hand, there is a positive imaging study, and the physician wants to treat the patient's disorder; on the other hand, the therapeutic choices, which include some form of spinal fusion, have not given consistently good outcomes. This is the area that most requires prospective clinical studies in the immediate future.

Summary

There are a variety of imaging modalities currently available for evaluation of the lumbar spine. Each has a designated role in the workup of the patient and a specific place in the temporal sequence of clinical events. One must appreciate that each of these studies should be used to confirm the clinical impression derived from the history and physical examination but must also be mindful of the fact that the prevalence of abnormal findings in asymptomatic individuals is too high to rely on these tests alone for making major therapeutic decisions.

It is imperative to distinguish findings that are likely to be part of the normal aging process from those that may be clinically significant. Likewise, when imaging patients who have undergone previous spine surgery, it is also critical to distinguish findings that are likely to cause symptoms from those that are part of the normal spectrum of postsurgical changes.

The most important goal must be to meticulously correlate the anatomic location of abnormalities seen on imaging studies with the clinical signs and symptoms. In addition, it is best to refrain from ordering advanced neurodiagnostic imaging studies until appropriate nonoperative management has failed. These principles will help avoid the most common cognitive errors associated with radiographic investigations of the lumbar spine.

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