MRI of Degenerative Disease of the Lumbar Spine

Expires Sunday, May 31, 2020 Radiology William G Bradley , MD, PhD, FACR

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1. Discuss the various forms of disk herniation from protrusion to extrusion to sequestration and their MR appearance.
2. Describe the MR techniques that the author has found to be the best in evaluating the lumbar spine.
3. Discuss the various findings and the MR appearance that may be seen in the postoperative spine.
4. Explain the meaning of spondylosis and describe the types of changes that can be seen and their MR appearance.

Article

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Introduction

The vast majority of adult Americans will experience acute onset of low back pain during their lifetimes. Most of these will recover within a few days to a few weeks without any medical intervention. Some will require muscle relaxants and pain medication. Only a very few will require surgery. For this reason, many managed care organizations are not authorizing MR scanning until six to 12 weeks following the onset of pain.

In a similar fashion, treatment of low back pain with radiculopathy (or pain radiating down the leg) has become more conservative over the last several decades. While a foot drop used to be an indication for surgery, this is no longer the case. The current indications for surgery are worsening neurologic symptoms, loss of bowel and bladder control, and excruciating pain. Most patients today will attempt a conservative course of medical therapy, including high dose steroids tapered rapidly, epidural injections, painkillers, muscle relaxants, and physical therapy. European studies have demonstrated that known disk herniations can be treated in this fashion with the same result in 1 to 2 years, as surgery. In both cases, 85% of patients are essentially pain free and functional. Of course, the herniated disk must be documented by CT or MRI because there are much more serious conditions that can mimic disk herniation and lead to low back pain and "sciatica" (or pain radiating down the leg). In a recent series of 625 patients with an initial diagnosis of low back pain, 3% had serious disease that would not have been effectively managed with pain medications or epidural injections. Two thirds of these cases (2% of the total group) were metastatic disease, only half of whom had a known primary and half of whom did not. In the other third (or 1% of the total group), the cause of radiculopathy was a primary tumor (such as nerve sheath tumors or schwannomas, conus ependymomas, meningioma, or sarcomas (figure 1). Thus, before a patient can be medically managed, the diagnosis of disk herniation must be confirmed. Although CT can make this diagnosis, disk herniation and the other causes of low back pain and radiculopathy are better evaluated by MRI.

MR Technique

Although we have tried many MR techniques over the last two decades, the one which has proven most satisfactory for the evaluation of lumbar disk disease is a combination of proton density and T2-weighted fast spin echo sagittal and axial images with a T1-weighted conventional spin echo sagittal image. The slice thickness is typically 4 mm with a 1 mm gap. We usually perform a low-resolution T1-weighted coronal scout view that is also printed and can occasionally be quite helpful for the evaluation of scoliosis or paraspinous masses. We do not use gadolinium for the usual evaluation of low back pain and radiculopathy in the non-operated spine. In patients with prior surgery, however, gadolinium is given if there appears to be a recurrent disk herniation using the conventional technique noted above. In such cases, we generally perform additional T1-weighted sagittal and axial imaging with 3 mm sections before and after administration of intravenous gadolinium. Axial sections are generally only performed at the level(s) of suspicion.

The field-of-view (FOV) on the sagittal acquisition is set to include the conus as conus ependymomas and schwannomas can occasionally lead to radiculopathy. On axial images, the FOV is generally set to 22 cm or less to maximize spatial resolution.

Spectrum of Disk Disease

The earliest sign of disk herniation is decreased signal on a T2-weighted image due to desiccation and dehydration of the disk (figure 2). This is usually associated with loss of height and bulging of the annulus fibrosus circumferentially. On axial images, a posterior convexity is noted, which is abnormal at all lumbar levels except L5 to S1 and occasionally L4 to L5.

With focal tearing of the inner fibers of the annulus fibrosus, a more focal disk herniation occurs known as a "protrusion" (figure 3). With additional tearing of the annular ligamentous complex, a larger disk herniation occurs known as an "extrusion" (figure 4). Extrusions tend to be more spherical than protrusions (which are more broad based). The ratio of the height to the base is less than 1 in protrusions and greater than 1 with extrusions. Disk extrusions tend to be larger than protrusions. When the herniated disk fragment becomes separated from the parent disk, it is known as a "sequestration" or a "free fragment". If a pedicle can be identified connecting the disk herniation to the parent disk, however, it remains an extrusion.

When diagnosing disk herniation, it is important to note the relationship of the herniated fragment to the local nerve roots. In general, the "traversing" root comes off the thecal sac at the level of the disk (figure 5). This nerve root corresponds to the lower lumbar vertebral level (for example, the L5 nerve root comes off at the L4 to L5 disk level and the S1 nerve root comes off at the L5 to S1 disk level). The "exiting" nerve root exits higher up under the pedicle of the vertebral body of the same number (for example, the L3 nerve root exits under the L3 pedicle, half a vertebral body level above the L3 to L4 disk) (figure 6).

Most disk herniations are para-central or within the spinal canal and just off midline. It is important to determine if the traversing nerve root is merely abutted, displaced, or compressed against the medial articular facet.

Approximately 10% of disk herniations are lateral to the spinal canal. These can be subdivided into "foraminal" and "far lateral" disk herniations. They will typically affect the exiting root, compressing it against the pedicle of the same number. Lateral disk herniations are best diagnosed on parasagittal images demonstrating the neural foramina. Continuity with the parent disk is generally a sufficient finding to diagnose a disk herniation as opposed to a non-contiguous schwannoma. While schwannomas and disk herniations have similar intensity on T1- and T2-weighted images, schwannomas enhance intensely with gadolinium while early disk fragments do not.

Post Operative Spine

The natural history of disk herniation is that it will elicit a fibrovascular response. With vascular ingrowth due to angiogenesis, enhancement is seen on T1-weighted images following administration of gadolinium. Early on, however, disk fragments should not enhance. This allows the distinction of a recurrent recent disk herniation from epidural fibrosis, which enhances ubiquitously and is generally asymptomatic. Unfortunately, the increasing tendency of managed care organizations to delay MR imaging following the onset of symptoms results in imaging in the subacute phase after vascular ingrowth has occurred. This leads to the finding of a "wrapped disk" (which is a central disk fragment surrounded by enhancing scar tissue). In such cases, particularly thin T1-weighted images are required to distinguish scar from disk.

When surgery has been performed for spinal stenosis (figure 7), it is generally more extensive, involving a laminectomy and a medial facetectomy. Should the surgeon take more than one third of the medial facet, there is a tendency for it to fracture and the upper vertebral body to translate anteriorly relative to the lower vertebral body (called an "anterolisthesis"), which is usually caused by a stress fracture (figure 8). Such iatrogenic spondylosis may be treated by a lateral fusion that consists of fragments

of bone positioned between the transverse processes of the vertebral bodies bilaterally. Following such a procedure, the clinical question is generally whether the fusion mass is stable or not. While this can generally be determined from flexion and extension plane films, MRI performed with fat saturated T2-weighted fast spin echo or fast STIR technique may demonstrate fluid in a pseudoarthrosis between components of the bony fusion mass. In more severe cases of spinal instability, an inner body fusion may also be performed. Stability of an inner body fusion is also best determined using fat saturated T2-weighted FSE T2 or STIR images, which demonstrate bony edema when instability is present.

Spondylosis

With disk degeneration, the natural cushion between vertebral bodies is lost and bone begins to rub on bone. This is called spondylosis of the lumbar spine. When the vertebral bones rub against each other, this leads to changes in the vertebral endplates on either side of the intervertebral disk. Initially, these are characterized as low signal on T1-weighted images and high signal on T2-weighted images due to an ingrowth of fibro-granulation tissue (also called "type I" changes). With continued, worsening disease, fatty changes are elicited in the endplates, which appear bright on the T1-weighted images (or "type II" changes – figure 8). Eventually, such bone on bone irritation leads to sclerotic changes, which are dark on both T1- and T2-weighted images (or "type III" changes).

Summary

As one can see from the above discussion, MRI has become a very useful tool in diagnosing some of the common causes for chronic back pain and sciatica related to lumbar spine disorders. In addition, it is a useful tool in evaluating patients who have already undergone surgery to determine if the problem is new, a recurrernce, or related to the healing process.

Figures:

1. Meningioma. This lower thoracic meningioma presented with symptoms of disc herniation.
2. Disc extrusion. A. T2-weighted sagittal image demonstrates a dark L5-S1 disc space due to desiccation and a posteriorly extruded nucleus pulposus.
3. Disc protrusion at L5-S1 abuts traversing left S1 nerve root.
4. Disc extrusion. An axial T2-weighted image demonstrates a right para-central disc extrusion, obliterating the traversing right S1 nerve root.
5. Lateral disc protrusion. An axial proton density weighted image at L2-L3 demonstrates a foraminal disc protrusion displacing the exiting L2 nerve root laterally.
6. Lateral disc protrusion. A sagittal proton density weighted image demonstrates a foraminal disc fragment protruding superiorly, compressing the exiting L2 nerve root under the L2 pedicle.
7. Spinal stenosis. Proton density weighted axial image at L4-L5 demonstrates the classic features of spinal stenosis, which are congenitally short pedicles, overgrowth of the facet joints, and hypertrophy of the ligamentum flavum.
8. Lytic spondylolisthesis at L5-S1 is due to a stress fracture of the L5 pars interarticularis bilaterally. Note the "Type II" spondylosis endplate changes (bright on this T1-weighted sagittal image).

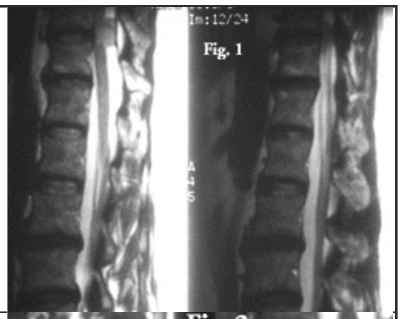
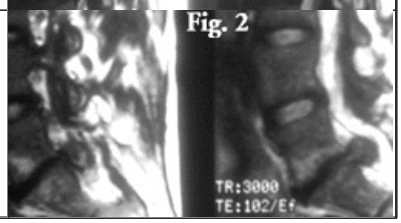
Figure 1	
Figure 2	

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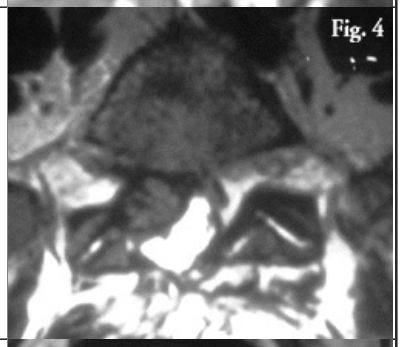
Figure 4	
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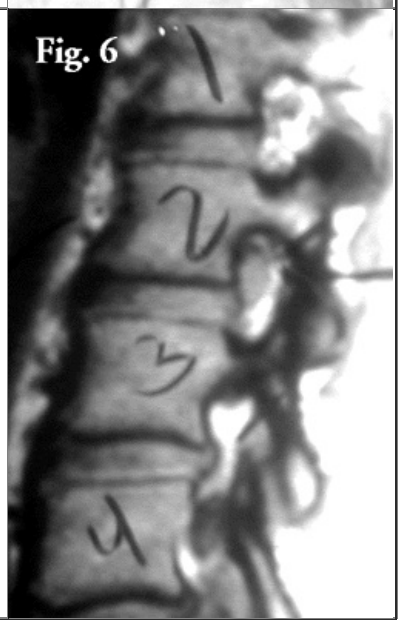
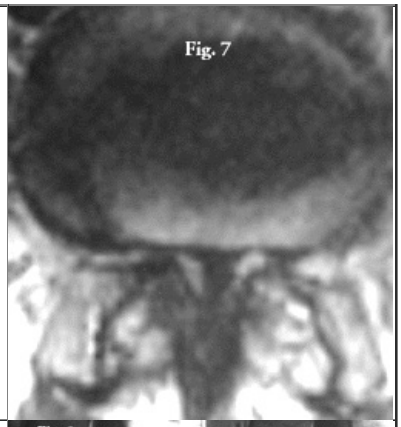
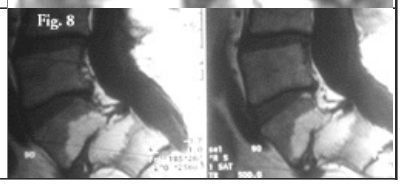
Figure 6	

Figure 7	
Figure 8	

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Dr. William Bradley currently is the director of the Magnetic Resonance Imaging Center at Long Beach Memorial Medical Center, in Long Beach, California. He is also a Professor of Radiology at the University of California, Irvine. He actively teaches Magnetic Resonance Imaging to medical students, Radiology residents and fellows in Radiology.

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