

Briefly Noted

■ Dynamic Degenerative Lumbar Spondylolisthesis: Diagnosis With Axial Loaded Magnetic Resonance Imaging

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Study Design. Retrospective review of case notes and imaging.

Objective. To show the advantage of axial loaded magnetic resonance imaging (MRI) for identification of dynamic degenerative spondylolisthesis as a suspected cause of spinal claudication.

Summary of Background Data. Degenerative spondylolisthesis typically occurs at L4/L5 and is usually evident on plain radiography. However, dynamic degenerative spondylolisthesis may become evident on erect radiographs when not shown on supine radiographs or MRI.

Methods. The case notes and imaging (radiography, conventional MRI, and axial loaded MRI) in 2 patients with symptoms of spinal claudication were reviewed.

Results. A 44-year-old female presented with a 3-year history of intermittent low back pain and right leg numbness after a fall. A 52-year-old female presented with a 4-year history of low back pain, bilateral leg weakness, and right leg numbness. In both cases, conventional MRI studies showed mild-to-moderate degenerative disc disease only with no evidence of abnormal spinal alignment or nerve root compression. Axial loaded MRI clearly showed the development of a degenerative spondylolisthesis with central canal stenosis and facet ganglion formation in 1 case.

Conclusions. Axial loaded MRI identified occult dynamic degenerative spondylolisthesis, which correlated with the clinical picture but was not shown on initial conventional MRI or plain radiography.

Key words: degenerative spondylolisthesis, axial loaded magnetic resonance imaging, spinal stenosis.
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Spondylolisthesis is defined as the forward displacement of 1 vertebra on that below. This “slip” usually occurs when a locking mechanism constituted by the laminae and facet joints has failed, and may subsequently remain static or progress over time. Of cases, 90% occur at the L4/L5 and L5/S1 levels.¹ There are well-known classifications of this condition.^{1–5} In general, spondylolisthesis is often secondary to facet joint osteoarthritis and disc degeneration (type 3: degenerative), bilateral pars defects (type 2: isthmic), or dysplasia of the lumbosacral facet joints (type 1: dysplastic). The change in vertebral alignment may be associated with spinal canal stenosis, either central in the case of type 3, or foraminal with any etiology. Clinically, lumbar spondylolisthesis may be asymptomatic or present with low back pain with or without referred leg pain. In the symptomatic population, there is an equal incidence in males and females.⁶ Primary imaging and diagnosis is by plain radiography, but conventional magnetic resonance imaging (MRI) is used to identify disc degeneration and central canal or foraminal stenosis resulting in nerve root entrapment.

Occult spondylolisthesis, with no obvious plain radiographic features, has been shown under dynamic loading during MRI for back pain.² Dynamic or weight-bearing MRI of the spine can be achieved by imaging the patient in the supine position in combination with an axial loading device (Dynawell, Dynamed AB, Stockholm, Sweden)⁷ or by using open MR systems, which obtain images in the seated or standing positions.⁸ We describe the demonstration of dynamic degenerative spondylolisthesis identified by axial loaded MRI in a low-field open MR unit.

Case Reports

Case 1. A 44-year-old female accountant presented with a 3-year history of low back pain following a fall after slipping on snow. The pain involving the low back and right leg was exacerbated by sitting and standing, and was associated with weakness and numbness of the right leg down to the foot. Neurologic examination revealed no motor or sensory deficits, but her low back pain considerably affected her activities of

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The device(s)/drug(s) is/are FDA-approved or approved by corresponding national agency for this indication.

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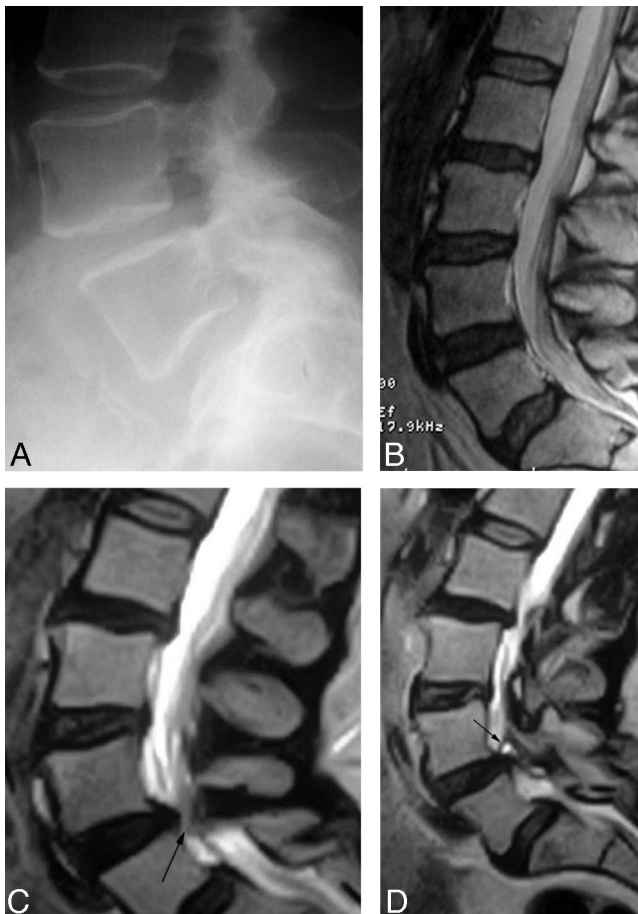


Figure 1. Case 1. **A**, Lateral erect radiograph showing minimal L4/5 spondylolisthesis. **B**, Sagittal T2-weighted fast spin echo MRI of the lumbar spine, indicating normal spinal alignment with minimal degenerative change at the L2/3, L3/4, and L4/5 disc levels. **C**, Axial loaded midsagittal T2-weighted fast spin echo MRI of the lumbar spine showing the development of grade 1 degenerative L4/5 spondylolisthesis with central canal stenosis (arrow) manifest by the complete loss of cerebrospinal fluid around the cauda equina. **D**, Axial loaded right parasagittal T2-weighted fast spin echo MRI of the lumbar spine indicating the development of a facet ganglion (arrow) at L4/5, resulting in compression of the right L5 nerve root in the lateral recess.

daily living. Initial plain radiographs were unremarkable, showing possible minimal L4/5 spondylolisthesis but very adequate bony canal dimensions (Figure 1A). Conventional T2-weighted fast spin echo MRI (Figure 1B) indicated normal spinal alignment and segmentation with only minimal degenerative change at L2/3, L3/4, and L4/5, with good maintenance of disc height. Canal dimensions were very adequate, and there was no evidence of nerve root compression.

Because of continued symptoms, she was referred for axial loaded MRI in a 0.3-T open magnet, using a previously described technique,⁷ which involved placing the patient within the Dynawell device and loading to 50% bodyweight for 5 minutes followed by repeat MRI. Axial loaded MRI (Figure 1C) showed the development of grade 1 degenerative spondylolisthesis at the L4/L5 level, associated with central canal stenosis and cauda equina compression. Right parasagittal T2-weighted fast spin echo MRI (Figure 1D) indicated the development of a facet ganglion, causing additional right L5 lateral recess stenosis and compression of the exiting right L5 nerve



Figure 2. Case 2. **A**, Sagittal T2-weighted fast spin echo MRI of the lumbar spine indicating possible L4/5 spondylolisthesis with minimal degenerative change at the L3/4 and L4/5 disc levels. **B**, Axial loaded midsagittal T2-weighted fast spin echo MRI of the lumbar spine showing the development of grade 1 degenerative L4/5 spondylolisthesis with central canal stenosis and cauda equina compression (arrow). **C**, Axial loaded transverse T2-weighted fast spin echo MRI of the lumbar spine at the L5 pedicle level indicating the development of right L5 lateral recess stenosis (arrow) with compression of the right L5 nerve root.

root. The patient was treated surgically with decompressive lumbar laminectomy and posterior lumbar interbody fusion at the L4/5 level.

Case 2. A 52-year-old secretary presented with a 4-year history of low back pain of insidious onset. The pain was exacerbated by walking, associated with bilateral leg weakness and with numbness of the right leg down to the foot. Neurologic examination revealed no motor deficits but reduced sensation in the right L5 dermatome. Lumbar spine radiographs showed a possible minimal L4/5 spondylolisthesis, but very adequate central canal dimensions. Conventional T2-weighted fast spin echo MRI (Figure 2A) confirmed mild degenerative changes at the L3/4 level and L4/5 levels. There was a possibility of minor L4/5 degenerative spondylolisthesis, but no evidence of central canal stenosis. She was referred for axial loaded MRI (Figures 2B, C), which indicated the development of definite grade 1 degenerative spondylolisthesis at L4/5, with associated central canal and right lateral recess stenosis. The patient was treated

conservatively with an active back pain treatment program and intensive physiotherapy to good functional effect.

Discussion

The presence of instability in spondylolisthesis is widely debated. Previous studies have shown an association between degree of slip and disc height reduction in adults,⁹ possibly caused by degeneration induced-segmental ligamentous laxity. In the normal spine subjected to loading, forces can be separated into a compressive component in line with the long axis of the spine and a translational element perpendicular to this axis.¹⁰ A study by Iguchi *et al*¹¹ suggested that translational changes had more symptomatic consequences than angulation and compression. A scoring system was used in which patients with translations higher than 3 mm observed on plain radiography had a lower score, indicating increased pain and interference with daily activities.

Despite conflicting evidence, lateral flexion-extension radiographs of patients with spondylolisthesis are still used in addition to standard views on plain radiography, allowing the extent of the spondylolisthesis and the intervertebral slip angle to be measured and reproducibly quantified.^{12,13} There is a general consensus that flexion of the spine aggravates spondylolisthesis while extension reduces it.¹⁴ Interestingly, standing and recumbent radiographs in spondylolisthesis have also been compared, and it has been shown that weight bearing accentuates anterior displacement while recumbency, with consequent elimination of axial load, results in a partial reduction of the spondylolisthesis.¹⁵ Although instability and the dynamic nature of degenerative spondylolisthesis can be shown by standard radiography alone, the identification of cauda equina compression requires the addition of MRI.

Open MRI techniques to investigate the intersegmental mobility of the lumbar spine in subjects with isthmic and degenerative spondylolisthesis have been reported previously.² The motion characteristics of subjects in flexed and extended positions were observed, and no detectable evidence of spinal instability or hypermobility could be elicited. The authors concluded that a spondylolytic defect did not result in detectable spinal instability or hypermobility.

In both of our cases, plain radiography and conventional MRI indicated degenerative changes, but no spinal stenosis was identified. Axial loaded MRI allowed the identification of dynamic degenerative spondylolisthesis with associated cauda equina compression, consistent with the clinical picture. Furthermore, in 1 case, the identification of a facet ganglion with associated lateral recess stenosis was possible. Thus, using axial loaded MRI, we have been able to show that the phenomenon of instability in spondylolisthesis does occur and that pathologic features may manifest more clearly under loading. This finding may also suggest the use of axial loaded MRI as a radiographic assistance in proceeding with surgical decompression.

Operative treatment of degenerative lumbar spondylolisthesis remains controversial. Surgical options generally include decompressive lumbar laminectomy^{16,17} and decompression with instrumented¹⁸ or noninstrumented transpedicular fusion.¹⁹ A study comparing decompressive lumbar laminectomy with decompression plus noninstrumented posterolateral fusion showed improved functional results and reduced levels of olisthesis, instability and recurrence of low back, radicular or neuroclaudicatory symptoms.¹⁸ It is suggested that even limited decompression may lead to destabilization of the motion segment.¹⁸ In later studies, it has been shown that instrumented fusion results in an improved and increased fusion rate after posterolateral fusion for degenerative spondylolisthesis compared with noninstrumented fusion, although there are no significant differences in clinical outcome in terms of pain and activities of daily life between the groups.^{20,21}

Axial loaded MRI may substantiate the choice of decompression and instrumented fusion by giving a more dynamic assessment of the motion segment. At present, axial loaded MRI may not be essential for diagnosis or cost effective in all cases of spinal instability. However, our findings are interesting, and suggest that it should be considered a potentially useful investigative tool in patients with clinical symptoms and signs of neurogenic claudication that may be caused by spondylolisthesis, which is occult on plain radiography or conventional MRI.

Key Points

- Dynamic spondylolisthesis may not be indicated on plain radiography or conventional MRI.
- Axial loaded MRI may show occult slip with associated spinal stenosis.

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