Clinical Study

Sensitivity of magnetic resonance imaging in the diagnosis of mobile and nonmobile L4–L5 degenerative spondylolisthesis

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Abstract

BACKGROUND CONTEXT: Lumbar degenerative spondylolisthesis (LDS) is often diagnosed by conventional supine magnetic resonance imaging (MRI). Numerous studies have shown, however, that the degree of spondylolisthesis can be reduced or disappears when the patient is supine as compared with standing lateral and flexion-extension (SLFE) radiographs.

PURPOSE: To compare the sensitivity of supine MRI with SLFE radiographs in patients with L4–L5 LDS.

STUDY DESIGN: A retrospective imaging study.

PATIENT SAMPLE: Included patients diagnosed with L4–L5 LDS with both SLFE films and supine MRI.

METHODS: Lumbar degenerative spondylolisthesis was defined radiographically as a slip greater than 4.5 mm. Mobile LDS was defined as a difference of greater than 3% in slip percentage between lateral radiographs and sagittal MRIs. Additional measurements included L4–L5 facet effusion diameter on axial MRIs. Measurements were performed by two independent examiners. The kappa coefficient was used to assess the interobserver agreement.

RESULTS: Of 103 patients assessed, 68% were women and the average age was 66 years. Lumbar degenerative spondylolisthesis was seen on 101 (98%) lateral films and 80 (78%) MRIs. Average slip was 10.0 mm for lateral standing radiographs and 6.6 mm on MRI ($p<.0001$). Fifty (48%) patients were identified with mobile LDS. The positive predictive value of facet joint effusion for mobile LDS increased from 52% for effusions greater than 1 mm to 100% for effusions greater than 3.5 mm.

CONCLUSIONS: This study found that MRI had a sensitivity of 78% for detecting L4–L5 LDS compared with 98% for lateral standing films. We also identified facet effusion size as a marker to predict mobile LDS. These findings suggest that, particularly in the setting of facet effusions, the

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IRB approval (IRB # 13-892) was obtained before the initiation of the study.

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complete workup of patients in whom LDS is possible should include standing radiographs.

Keywords: Degenerative spondylolisthesis; Imaging; Diagnosis; MRI; SLFE; Facet effusion

Introduction

Lumbar degenerative spondylolisthesis (LDS) often presents with low back pain but the variable compression of the spinal canal can result in diverse presentations [1,2]. Often suspected clinically, the diagnosis requires radiologic confirmation to further evaluate the severity of the slip and the associated degenerative changes [3]. The surgical treatment of lumbar stenosis in patients with LDS ranges from decompression to decompression with fusion. Surgeons often perform fusions for patients with LDS, particularly if the slips are mobile.

Historically, the gold standard for diagnosing LDS was flexion-extension radiographs [1,3,4]. Although radiographs are recommended for detecting vertebral body translation, magnetic resonance imaging (MRI) is the more appropriate test for determining the degree of stenosis accompanying the spondylolisthesis [5]. Advantages of MRI include the ability to demonstrate central canal narrowing, compression of the cauda equina, thickening of the ligamentum flavum, and facet joint degenerative changes [6]. Despite this utility, conventional MRIs are limited in that the patient must remain in the supine position, which decreases the axial loading pressure on the lumbar spine when compared with standing films. Recent studies have demonstrated a reduction in the degree of spondylolisthesis viewed on MRI when compared with radiographs [4,7–10]. Using conventional MRI as the sole imaging modality in the diagnosis of LDS has the potential for obscuring the clinical picture and potentially altering surgical decision making [8,10,11]. In this study, we evaluated a cohort of patients diagnosed with L4–L5 degenerative spondylolisthesis (DS) by flexion-extension and lateral radiographs to determine the sensitivity of MRI in the diagnosis of LDS. Additionally, we analyzed the disc height, sagittal translation, segmental angulation, and facet effusion to determine if these parameters affect the severity of spondylolisthesis. We hypothesized that MRI would be less sensitive in diagnosing LDS when compared with standing lateral and flexion-extension (SLFE) films and aimed to quantify the reduction in spondylolisthesis between standing and supine imaging modalities.

Methods

Patient selection

The electronic medical records were reviewed for patients diagnosed with acquired spondylolisthesis from 2008 to 2013. Of the 5,303 patients with this diagnosis, 716 had a diagnosis specified as DS or spondylolisthesis of the lumbar region. Of these, 103 patients met the inclusion criteria of having L4–L5 DS with lateral and flexion-extension radiographs within 1 year of having a lumbar MRI. Exclusion criteria included trauma, tumor, infection, previous lumbar surgery, spondylolysis, pars defect, L5–S1 or L3–L4 spondylolisthesis, and scoliosis.

Imaging assessment

Standing lateral and flexion-extension radiographs and MRIs were analyzed through the EasyViz software (Medical Insight, Chicago, IL, USA) associated with the institution’s electronic medical records. Images were evaluated for vertebral slip, L5 body width, anterior disc height, posterior disc height, and disc width. The EasyViz platform is a mobile imaging platform capable of analyzing full fidelity DICOM images with a precision of 0.1 mm. For flexion-extension radiographs, sagittal translation was measured by the difference in vertebral translation between flexion and extension; segmental angulation was measured by the angular difference between the L4 inferior end plate and L5 superior end plate in flexion and extension. Additional MRI measurements included disc degeneration and facet effusion. Two independent reviewers not related to patient care made the measurements used in this study. Interobserver agreement was evaluated using the kappa statistic. Kappa values between 0.21 and 0.4 were associated with poor agreement, 0.41 and 0.6 were moderate agreement, 0.61 and 0.8 were substantial agreement, and 0.81 and 1.0 were excellent agreement [12,13]. The measurements were averaged between the two observers to determine the final reported values. Disc degeneration was evaluated according to the Pfirrmann classification that rates disc integrity on a scale of one (intact) to five (severe degeneration) [14,15]. Interobserver disagreement for disc degeneration was reconciled in conference [14,16]. We defined spondylolisthesis as a 4.5 mm slip and measured the severity of slip according to the Tailliard method, where the slip distance is divided by the length of the L5 vertebra to obtain a slip percentage [4,7,9,17]. Mobile spondylolisthesis was defined as a greater than 3% difference in slip percentage when comparing standing lateral radiographs with MRIs, as has been previously reported [10]. Disc height was assessed by anterior and posterior heights and the Farfan index was calculated by dividing the sum of the anterior and posterior heights by the disc width [9,18]. Facet effusion was determined by measuring the effusion width orthogonal to the facet joint [4,10]. Effusion width was recorded both as a mean, averaging the effusion width between the right and left facets, and as a maximum, where the largest effusion on either the right or left facets was recorded. Examples of each measurement can be seen in Fig. 1.

Statistical analysis

Paired t test and Wilcoxon signed rank test were used when comparing matching variables (ie, vertebral slip)
between MRIs and radiographs. The Student t test was used for continuous variables and the Fischer exact test for categorical variables. Interobserver agreement was assessed with the Kappa value for ordinal values.

Results

Of 103 patients assessed, 70 (68%) were women, the average age was 66±9.8 years, and the average body mass index was 29.8±6.4. Spondylolisthesis was observed in 101 (98%) standing lateral radiographs and 80 (78%) supine MRIs (Table 1). The average slip in lateral standing radiograph was 10±2.9 mm with a slip percentage of 22.7±6.7 compared with as lip of 6.6±2.5 mm (p<.0001) and a slip percent of 19.8±7.3 (p<.001) for MRI (Table 2). There were no cases in our cohort that showed an undetectable slip in the MRI, with the smallest observed slip at 2.25 mm. The anterior disc height was 8.4±3.8 mm for lateral radiographs and 9.25±2.75 mm (p<.0001) for MRIs, whereas the Farfan index was 0.53±0.18 for lateral radiographs and 0.68±0.17 (p<.0001) for MRIs. Flexion-extension radiographs showed a sagittal translation of 1.78±1.58 mm and segmental angulation of 4.28°±3.37°.

Severe disc degeneration classified as a Pfirrmann grade of 4 or 5 was seen in 46 (45%) patients. Axial slices at the L4–L5 disc level showed a facet effusion in 74 (72%) cases (Table 2). Fifty patients (49%) had a noticeable (>3%) reduction in slip on MRI and were classified as having “mobile LDS” (κ=0.74) (Table 3). This cohort showed no significant difference in the average slip on X-ray with 10.5±2.7 mm slip compared with 9.5±3.1 mm for those with nonmobile LDS (p=.10). However, the slip percentage on X-ray was significantly greater for cases with mobile LDS at 24.4%±6.2% compared with 21.2%±6.9% (p=.02). For both slip

Table 1
Radiographic detection of spondylolisthesis

<table>
<thead>
<tr>
<th>Imaging technique</th>
<th>Spondylolisthesis (number)</th>
<th>Sensitivity (%)</th>
<th>κ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing lateral</td>
<td>101</td>
<td>98</td>
<td>0.8</td>
</tr>
<tr>
<td>Supine MRI</td>
<td>80</td>
<td>78</td>
<td>0.91</td>
</tr>
</tbody>
</table>

MRI, magnetic resonance imaging.

Note: Standing lateral images and supine MRIs were evaluated for the presence of spondylolisthesis. The cutoff of 4.5 mm or 15% of the L5 disc width was used to determine if spondylolisthesis was present. For MRI, there were no cases where spondylolisthesis reduced completely. The kappa statistic (κ) was used to assess interobserver agreement.

Fig. 1. Imaging measurements. L4 vertebral slip was measured using the Tailliard method for radiographs and magnetic resonance images (MRIs). (A, B) There is a noticeable slip reduction between the lateral standing radiograph and the supine MRI. (C, D) Flexion-extension films were used to determine the segmental angulation, which was the difference in the Cobb angle between flexion and extension and sagittal translation, which was the change in the vertebral slip between flexion and extension. (E) The Farfan index was used to compare disc heights between radiographs and MRIs, where the anterior and posterior disc heights were combined and divided by the disc width. (F) Axial MRIs were used to determine the facet effusion width.
and slip percentage measured on MRI, there was a significant difference between measured slip and slip percentage, with mobile LDS having a slip of 7.5 ± 2.6 mm and slip percentage of 22.1% ± 7.6% compared with 5.7 ± 2.1 mm and 17.4% ± 6.2% for nonmobile LDS. On flexion-extension radiographs, there were no significant differences in sagittal translation or segmental angulation. There were no intergroup differences in the number of facet effusions seen on axial images; however, the mobile LDS cohort had larger effusions compared with the nonmobile LDS cohort (2.0 ± 1.6 mm vs. 1.2 ± 1.0 mm; p = .0016). The positive predictive value (PPV) of facet effusion for mobile LDS increased with effusion width (Fig. 2). The PPV for mobile DS increased from 55% for effusions greater than 1.5 mm to 86% for effusions greater than 2.5 mm and was 100% for patients with effusions greater than 3.5 mm.

Additionally, those with mobile LDS were more likely to have reduced disc degeneration (Pfirrmann grades 1–2) compared with those with nonmobile LDS (six patients (12%) vs. one patient (2%); p = .05). The reverse was not found to be the case as there were no differences between the cohorts among those with greater disc degeneration (Pfirrmann grades 4–5).

### Discussion

**Sensitivity of MRI for diagnosing L4–L5 LDS**

Accurate diagnosis and assessment of LDS impacts surgical decision making in the evaluation of low back pain. Over the past decade, there have been several reports demonstrating that cases of LDS seen on plain films are missed on MRI. The matched pair t test was used to determine the significance when comparing lateral standing images with supine MRIs.

### Table 2

<table>
<thead>
<tr>
<th>Measure</th>
<th>Lateral standing</th>
<th>Supine MRI</th>
<th>p</th>
<th>Measure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slip (mm) mean (SD)</td>
<td>10.0 (2.9)</td>
<td>6.6 (2.5)</td>
<td>&lt;.0001</td>
<td>Sagittal translation (mm)</td>
<td>1.8 (1.6)</td>
</tr>
<tr>
<td>Slip percentage mean (SD)</td>
<td>22.7 (6.7)</td>
<td>19.8 (7.3)</td>
<td>&lt;.0001</td>
<td>Flexion-extension; mean (SD)</td>
<td>4.3 (3.4)</td>
</tr>
<tr>
<td>Anterior height (mm) mean (SD)</td>
<td>8.4 (3.8)</td>
<td>9.2 (2.8)</td>
<td>&lt;.0001</td>
<td>Segmental angulation (°)</td>
<td>46 (45)</td>
</tr>
<tr>
<td>Farfan index mean (SD)</td>
<td>0.52 (0.2)</td>
<td>0.68 (0.2)</td>
<td>&lt;.0001</td>
<td>Severe disc degeneration MRI; number (%)</td>
<td>74 (72)</td>
</tr>
</tbody>
</table>

MRI, magnetic resonance imaging; SD, standard deviation.

Bold, p < .05 was considered statistically significant.

Note: Lateral standing radiographs were compared with supine MRI to determine the differences in slip, slip percentage, anterior disc height, and Farfan index. Sagittal translation was defined as the difference in slip between flexion and extension radiographs. Segmental angulation was calculated using the difference in Cobb angle between flexion and extension. Disc degeneration was determined according to the Pfirrmann classification. L4–L5 facet joint effusion width was measured on axial MRI. The matched pair t test was used to determine the significance when comparing lateral standing images with supine MRIs.

### Table 3

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Nonmobile LDS</th>
<th>Mobile LDS</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients; number (%)</td>
<td>53 (51)</td>
<td>50 (49)</td>
<td>.08</td>
</tr>
<tr>
<td>Age (y); mean (SD)</td>
<td>67 (11)</td>
<td>64 (8)</td>
<td>.1</td>
</tr>
<tr>
<td>X-ray slip (mm); mean (SD)</td>
<td>9.5 (3.1)</td>
<td>10.5 (2.7)</td>
<td>.02</td>
</tr>
<tr>
<td>X-ray anterior disc height (mm); mean (SD)</td>
<td>9.0 (3.9)</td>
<td>7.7 (3.6)</td>
<td>.07</td>
</tr>
<tr>
<td>X-ray Farfan index; mean (SD)</td>
<td>0.53 (0.18)</td>
<td>0.53 (0.19)</td>
<td>.99</td>
</tr>
<tr>
<td>LDS on MRI; number (%)</td>
<td>46 (87%)</td>
<td>34 (68)</td>
<td>.02</td>
</tr>
<tr>
<td>MRI slip (mm); mean (SD)</td>
<td>7.5 (2.6)</td>
<td>5.7 (2.1)</td>
<td>.0002</td>
</tr>
<tr>
<td>MRI slip percentage; mean (SD)</td>
<td>22.1 (7.6)</td>
<td>17.4 (6.2)</td>
<td>.0007</td>
</tr>
<tr>
<td>MRI anterior height (mm); mean (SD)</td>
<td>9.2 (2.9)</td>
<td>9.3 (2.6)</td>
<td>.93</td>
</tr>
<tr>
<td>MRI Farfan index; mean (SD)</td>
<td>0.67 (0.18)</td>
<td>0.70 (0.17)</td>
<td>.38</td>
</tr>
<tr>
<td>Flex-ext sagittal translation (mm); mean (SD)</td>
<td>1.8 (1.8)</td>
<td>1.7 (1.3)</td>
<td>.83</td>
</tr>
<tr>
<td>Flex-ext segmental angulation (°); mean (SD)</td>
<td>4.1 (3.1)</td>
<td>4.4 (3.7)</td>
<td>.66</td>
</tr>
<tr>
<td>Axial MRI effusion; number (%)</td>
<td>36 (68)</td>
<td>38 (76)</td>
<td>.25</td>
</tr>
<tr>
<td>Effusion width (mm); mean (SD)</td>
<td>1.2 (1.0)</td>
<td>2.0 (1.6)</td>
<td>.0016</td>
</tr>
<tr>
<td>Maximum effusion (&gt;2 mm); number (%)</td>
<td>24 (45)</td>
<td>32 (64)</td>
<td>.04</td>
</tr>
<tr>
<td>Mean effusion (&gt;2 mm); number (%)</td>
<td>8 (15)</td>
<td>25 (50)</td>
<td>.0001</td>
</tr>
<tr>
<td>Disc degeneration grade 1–2; number (%)</td>
<td>1 (2)</td>
<td>6 (12)</td>
<td>.05</td>
</tr>
<tr>
<td>Disc degeneration grade 4–5; number (%)</td>
<td>25 (47)</td>
<td>21 (42)</td>
<td>.7</td>
</tr>
</tbody>
</table>

DS, degenerative spondylolisthesis; LDS, lumbar degenerative spondylolisthesis; SD, standard deviation; MRI, magnetic resonance imaging; flex-ext, flexion-extension.

Bold, p < .05 was considered statistically significant.

Note: Patients were classified with mobile DS if the vertebral slip reduction on MRI was greater than 3%. The Student t test was used to determine the significance for numerical variables. Fisher exact test was used to determine the significance for categorical variables.
Several reports have called attention to the observation that MRI can miss cases of DS diagnosed on standing radiographs [4,8,19]. In a prospective study evaluating facet joint effusions in 52 patients, Caterini et al. [7] found 12 (22%) cases of LDS based on flexion radiographs, whereas only 2 of these 12 (17%) were detectable on MRI. In another recent study of 114 lumbar vertebral levels in 90 patients with LDS, Even et al. [8] found that LDS was undetectable on MRI 63% of the time [8]. Furthermore, in a study investigating the role of facet effusions in LDS, Chaput et al. [4] found that in a cohort of 54 patients with LDS on SLFE films, 12 patients (22%) did not show evidence of spondylolisthesis on MRI. Although our study did not find any cases with a radiographically undetectable spondylolisthesis on MRI, we found that only 78% of images met the 4.5 mm slip criteria we used for diagnosing LDS. This is identical to the 78% MRI sensitivity found by Chaput et al. [4], but our study differed in that all patients in our cohort demonstrated a measurable spondylolisthesis. Based on previous studies, the percentage of LDS cases missed on MRI ranged from 17% to 78% [7]. Variability in MRI sensitivity may be possibly because of an imprecise definition of LDS on MRI, as these studies did not report what categorized an undetectable spondylolisthesis. Our study is unique in that we applied a 4.5 mm cutoff for clinically significant spondylolisthesis, a number that had been previously established by White and Panjabi [17] based on earlier biomechanical and radiographic studies. Using this criterion, we identified MRI as having 78% sensitivity in the diagnosis of LDS, consistent with the upper limit of the range found in previous studies.

**Mobile versus nonmobile LDS**

Several studies have suggested that there are multiple subtypes of DS, which represent distinct clinical entities based on the progression of disease [7,10,22]. Kirkaldy-Willis and Farfan [23] proposed that lumbar degenerative disease advances along three clinical stages, beginning with temporary dysfunction, followed by an unstable phase, and culminating in restabilization. Reports have variably defined this unstable phase of LDS (can be referred to as mobile LDS) based on the changes in slip seen between flexion-extension radiographs and between supine and weight-bearing imaging [8,10]. One recent study by Lattig et al. [10] evaluating 160 patients with LDS segregated their sample into two cohorts, mobile and nonmobile LDS, with mobile LDS defined as a 3% or greater reduction on MRI compared with standing lateral films [10]. Using this definition for mobile LDS, our study demonstrated significant increases among mobile LDS patients in slip percentage (24.4% vs. 21.2% [p=0.02]) on standing lateral radiographs and significant decreases in slip (7.5 vs. 5.7 mm [p=0.002]) and slip percentage on MRI (22.1% vs. 17.4%; p<0.0001). For mobile LDS, the increased slip percentage on lateral X-rays and decreased slip percentage on MRI reflects the increased mobility of the L4–L5 vertebral

Fig. 2. The PPV of facet effusion for mobile LDS. The PPV increased from 51% for a 0.5 mm effusion to 100% for a 3.5 mm effusion. The most significant increase was between 1.5 mm with a PPV of 55% and 2.5 mm with a PPV of 86%. n: Number of patients with an effusion of the selected size or greater (ie, 0.5 mm effusion category selected patients who had a 0.5 mm effusion or greater). PPV, positive predictive value; LDS, lumbar degenerative spondylolisthesis.

MRI [4,7,8,10,19]. These studies show that the MRI misses between 17% and 78% of cases of LDS seen on SLFE films [4,7]. The present study was designed to quantify the slip reduction between weight-bearing radiographs and MRI and determine the sensitivity of MRI in the radiographic diagnosis of LDS. In addition to assessing the sensitivity of MRI in diagnosing LDS, we sought to determine if the cohort of patients that showed substantial reduction (>3%) was a cohort with other unique radiographic findings. To do so, we compared patients with mobile and nonmobile LDS based on parameters such as slip, slip percentage, disc height, facet joint effusion, and disc degeneration. Our hypothesis was that MRI would miss cases of LDS seen on SLFE radiographs. Our goal, therefore, was to quantify the sensitivity of MRI in diagnosing LDS and to determine if patients that demonstrate a reduced slip on MRI have additional unique radiographic characteristics.

Before the recent increase in the use of MRIs for the assessment of degenerative lumbar disease, LDS was diagnosed by analyzing vertebral translation on SLFE radiographs [3,8]. Although MRIs have proven advantageous for assessing the degree of stenosis and degeneration accompanying LDS, SLFE radiographs are more appropriate for determining the severity of the slip [3,20,21]. Standing lateral and flexion-extension films have the dual advantage of being weight bearing, which exacerbates the slip and, thus, the likelihood of diagnosis, and providing a more accurate representation of the bony anatomy. When analyzing lateral standing films, we found 98% sensitivity for LDS as defined by flexion-extension radiographs and 78% sensitivity for detecting LDS by MRI.
bodies compared with nonmobile LDS. Although our results for the difference in slip percentage between lateral radiographs and MRI were consistent with Lattig et al. [10], their group did not find significant differences for percent slip on lateral X-ray between mobile and nonmobile LDS (20.6% vs. 20.2% [p=.70]). Discrepancies between our findings and those of Lattig et al. [10] may be because of differences in the patient population, as they focused on patients requiring lumbar decompression, whereas we included both surgical and nonsurgical patients. Furthermore, we found that MRI was diagnostic of mobile LDS in only 68% cases compared with 87% cases for nonmobile LDS, indicating that MRI was more likely to miss the mobile variant of LDS. While this conclusion is intuitive based on the definition of mobile LDS, since mobile LDS reflects a clinically distinct subgroup, the decreased sensitivity of MRI emphasizes the importance of obtaining radiographs.

Other radiographic parameters that have recently been investigated regarding LDS diagnosis are facet joint effusions and disc degeneration, both of which are best visualized on MRI [4,8,10,19]. In a landmark study of 193 patients, Chaput et al. [4] demonstrated that those with DS had statistically greater facet effusion width than those without (0.83 vs. 1.05 mm [p<.0001]). They identified effusions in 43 (80%) patients with LDS based on flexion-extension films and concluded that facet effusion greater than 1 mm would be an indication for SLFE radiographs when LDS was suspected but not detected on MRI. Other studies have shown that facet effusion width is positively associated with anterior slip on MRI and instability on flexion-extension films [8,19]. In a study of 53 patients with lumbar degenerative disc disease at L4–L5, Rihn et al. [19] demonstrated that a facet effusion had a PPV of 83% for spondylolisthesis on flexion radiographs. In a recent study, Even et al. [8] defined a “dynamic” subset of LDS cases as those with greater than 3 mm translation between flexion and extension films (correlates to the “mobile” subset in our cohort). They found that dynamic LDS was associated with a greater number of facet effusions compared with static LDS (74% vs. 52% [p=.018]). Moreover, Lattig et al. [10] showed that patients with mobile LDS had a greater mean effusion width compared with those with nonmobile LDS (1.77 vs. 0.10 mm [p=.0001]). This is consistent with our findings that mobile LDS had a greater mean effusion (2.0 vs. 1.2 mm [p=.0016]). Additionally, we found that the PPV of facet joint effusions increased with the width of the facet effusion. While the presence of an effusion alone could not effectively predict mobile LDS (PPV 51%), the PPV improved to 86% for an effusion of 2.5 mm and reached 100% for an effusion greater than 3.5 mm. This is consistent with the finding of Lattig et al. [10] that demonstrated that effusion width was positively associated with slip reduction on MRI. These findings support the relevance of facet fluid effusions in diagnosing DS and support the importance for obtaining SLFE films when LDS is clinically suspected but absent on MRI.

Future directions

We found that MRI missed 22% of cases with spondylolisthesis compared with 2% for lateral radiographs. This difference is attributed to the decreased axial load with the supine MRI that can obscure the pathology present on weight-bearing films. An interesting alternative to SLFE films in the diagnosis of LDS would be axial loaded or standing and/or dynamic MRIs [11,22]. In addition to resolving the difficulty in assessing vertebral slip in the supine position, axial loaded MRIs can provide additional information such as changes in the cross-sectional area of the thecal sac and facet joint subluxation, which may aid in the characterization of LDS [23–25]. Advantages of upright MRI include a better assessment of instability compared with supine MRI and the potential for identifying cases of LDS missed on supine MRI.

There exist multiple definitions of “instability” in the context of LDS. Studies have variably defined terms such as dynamic versus static, mobile versus nonmobile, and stable versus unstable [8–10]. Some have used increased sagittal translation and segmental angulation on flexion-extension radiographs, which have been used as radiographic markers for instability [8,9,17]. Interestingly, we found no difference in sagittal translation or segmental angulation between mobile and nonmobile LDS, indicating that the reduction in slip between the axial and supine positions in our cohort did not reflect increased vertebral movement between flexion and extension. Whether any of these terms are true determinants of clinically relevant spinal pathology remains to be determined. Evaluating surgical outcomes based on these radiographically defined subsets may help validate these groups as distinct clinical entities and will allow for further investigation into alternate treatment modalities. Future analyses will also be useful in determining if various radiographic parameters such as slip, disc height, and facet effusion are associated with different clinical outcomes.

Limitations

Our study is limited by several factors. We examined cases of LDS only at the L4–L5 level to ensure a homogeneous sample, and although this is the most common level associated with LDS, our conclusions cannot apply to patients with LDS at different vertebral levels (L5–S1) or to patients with LDS at multiple levels. Furthermore, our patient cohort was selected based solely on the diagnosis of LDS as opposed to patients that required a surgical intervention. This difference in patient selection may explain discrepancies between our study and those that evaluated patients needing surgery. Although we identified facet effusions, we did not take into consideration the reason for lack of effusion; that is, because of obliteration of the facet joint, perhaps related to positioning or simple lack of fluid. Additionally, we measured effusion size through the maximum effusion width visualized on axial MRI. Although this serves as a
reliable proxy for effusion size, it does not address the true three-dimensional volume of the effusion [4,10].

Conclusion

In this study, we apply an established radiographic criterion to the assessment of the sensitivity of MRI in the diagnosis of L4–L5 LDS. In our cohort, lateral radiographs had a sensitivity of 98% and MRI had a sensitivity of 78% for LDS as defined by flexion-extension radiographs. We also found that facet effusions on axial MRI can predict mobile LDS, particularly if they are greater than 2.5 mm. Thus, when there is clinical suspicion, providers should be encouraged to obtain lateral standing radiographs and MRI to diagnose LDS.

Acknowledgments

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References