Added value of MR myelography using 3D COSMIC sequence in the diagnosis of lumbar canal stenosis: comparison with routine MR imaging

Poster No.: C-1099
Congress: ECR 2012
Type: Scientific Exhibit
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Keywords: Abdomen, Spine, Liver, MR, CT, PET, Technical aspects, Pathology
DOI: 10.1594/ecr2012/C-1099

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Purpose

Some reports have indicated that MRM is useful for patients with multisegmental spinal lesion or scoliosis, and that it can reveal the precise boundary of the nerve root or the dural sac\(^1\). It is noninvasive and enables visualization of the anatomic and pathophysiologic features of bone and soft tissue\(^2\)–\(^5\).

To evaluate whether there is additional diagnostic value of 3D magnetic resonance (MR) myelography using three-dimensional coherent oscillatory state acquisition for the manipulation of image contrast (3D-COSMIC) sequence in the diagnosis of lumbar canal stenosis.

Methods and Materials

Patients

15 female and 15 male patients (mean age 65 and age range, 18-93 years) who underwent surgical operation in the diagnosis of the lumbar canal stenosis or lumbar disc herniation were enrolled in the current study. Exclusion criteria were standard contraindications for the use of MRI, including presence of a pacemaker and claustrophobia.

MR imaging protocol

All examinations in the 30 patients were performed at 1.5 T whole body MR system (Signa Horizon, GE Medical Systems, Milwaukee, WI) using a spine array coil.

Routine MR examination

First, the routine protocol was initially performed as follows; Sagittal T1-weighted FSE images were obtained using the following parameters: TR/TE = 550/14 msec; echo-train length (ETL) = 5; slice thickness = 4 mm, 0.4 mm gap; FOV = 16 cm, matrix = 320 × 224; number of excitations = 3; and a total acquisition time = 1 minutes 46 seconds. Sagittal T2-weighted FSE imaging was performed using the following parameters: TR/TE = 2700/110; ETL = 16; slice thickness = 4 mm; 0.4-mm gap; field of view (FOV) = 16 cm; matrix = 384 × 256; number of excitations = 3; bandwidth = ±32 kHz; and total acquisition time = 2 minutes 11 seconds. Transverse T1-weighted FSE imaging was performed using the following parameters: TR/TE = 650/14; ETL = 5; slice thickness = 4 mm; 2-mm gap; FOV = 16 cm; matrix = 256 × 224; number of excitations = 2; bandwidth = ± 22.7 kHz; and total acquisition time = 2 minutes 6 seconds. Transverse T2-weighted FSE imaging
was performed using the following parameters: TR/TE = 3100/110; flip angle = 90°; slice thickness = 4 mm; 2-mm gap; FOV = 16 cm; matrix = 256 × 192; number of excitations = 16; bandwidth = ± 25 kHz, and total acquisition time = 1 minutes 58 seconds.

**Additional 3D MR Myelography**

Then, additional MR examination was performed as follows; Sagittal intermediate-weighted FRFSE images were obtained using the following parameters: TR/TE,5.5/2.7, ms;flip angle,45°;FOV300mm# Matrix,320×224#bandwidth 62.5khz per pixel; acquisition time, 3 minutes 40 seconds.

The acquisition plane was coronal, with a right-left phase encoding direction. For each patient, thin maximum intensity projection (MIP) and multiplanar reconstruction reformatted coronal and coronal oblique were obtained from the same 3D dataset. The slice thickness of the thin MIP was between 3 to 5 mm; the reconstruction was interleaved every 1 mm.

**Evaluation on MR images#Diagnostic Performance**

Two musculoskeletal radiologists (O.T.; 21 years experience, Y.H; 10 years experience) who were blinded to the spine surgery results and original radiology reports independently evaluated the two sets of MR images retrospectively. The readers first evaluated the routine MR images alone, and at a second session 2 weeks later, they evaluated both routine MR images and MR myelography images. The images obtained in each patient were randomly presented at each reading session and were evaluated by using a 3D DICOM viewer. The lumbar segments were divided into 15 segments, from L1-2 to L5-S; right, middle, and left. A four-point scale was used to grade each lesion: grade 0 = normal, grade 1 = probable absence of stenosis (Figure.1), grade 2 = probable presence of stenosis (Figure.2) and grade 3 = definite presence of stenosis (Figure.3).

**Standard of reference**

Surgical operation was performed by an experienced orthopedic surgeon (K.S. with 30 years of experience in spinal surgery, A.Y. with 15 years of experience in spinal surgery). Disc herniation or canal stenosis was found at 65 lumber disc levels (L1/2 level; n = 2, L2/3 level; n = 3, L3/4; n = 14, L4/5 level; n = 30, L5/S level; n=16). In evaluating the rest of 385 segments, the standard of reference was based on image analysis by two musculoskeletal radiologists (E.I., with 11 years of experience in musculoskeletal MR imaging, T.U., with 5 years of experience in musculoskeletal MR imaging) and an orthopedic surgeon (K.S.) in consensus, performed independently, after the study readings, with all available sequences as well clinical examinations and history of each patient. The two readers (O.T., Y.H.) who evaluated the diagnostic performance were
excluded from the preparation of the standard reference based on the MR abnormalities to exclude the potential of learning bias.

**Statistical analysis**

First, sensitivity, specificity, and accuracy of both routine MRI alone and routine MRI + MR myelography using 3D-COSMIC were calculated for both readers. The ratings of the images in diagnostic performance were used to calculate the sensitivity, specificity, and accuracy of each observer in diagnosing lumbar canal stenosis or lumbar disc herniation. Ratings of 0-1 indicated an absence of lesions, and ratings of 2-3 indicated a presence of lesions. Second, the sensitivity, specificity, and accuracy of routine MRI + MR myelography were compared with routine MRI alone by the use of the student t test. Finally, the weighted # value was calculated to assess inter-variability in the assignment of the reader ratings by using the special software program. The level of agreement was defined as follows; weighted # values < 0.00 indicated no agreement; weighted # values of 0.00-0.40 indicated a poor agreement; weighted # values of 0.41-0.75 represented a good agreement; and weighted # values of 0.76-1.00 represented an excellent agreement. The P values < 0.05 were considered to indicate a statistically significant difference.

**Images for this section:**
Fig. 1: A 60-years-old man who had acute low back pain. (a) Axial and sagittal T2-weighted images show L2/3 hernia bulging outside the central and left paracentral zone. Magnetic resonance myelography demonstrates slight compression the left side thecal sac at L3 nerve root.
A 60-years-old man who had acute low back pain. (a) Axial and sagittal T2-weighted images show L2/3 hernia bulging outside the central and left paracentral zone. Magnetic resonance myelography demonstrates slight compression the left side thecal sac at L3 nerve root.
**Fig. 3:** A 60-years-old man who had acute low back pain. (a) Axial and sagittal T2-weighted images show L2/3 hernia bulging outside the central and left paracentral zone. Magnetic resonance myelography demonstrates slight compression the left side thecal sac at L3 nerve root.
Fig. 4: A 78-years-old man who presented with a 2 weeks history of right leg pain. 

Sagittal T2-weighted image shows right L4/5 disc herniation. 

Axial T2-weighted image indicates in the central and left paracentral zone. 

Magnetic resonance myelography demonstrates mild compression the right side thecal sac at L4 nerve root.
Fig. 5: Figure.2b A 78-years-old man who presented with a 2 weeks history of right leg pain. Sagittal T2-weighted image shows right L4/5 disc herniation. Axial T2-weighted image indicates in the central and left paracentral zone. Magnetic resonance myelography demonstrates mild compression the right side thecal sac at L4 nerve root.
**Fig. 6:** A 78-years-old man who presented with a 2 weeks history of right leg pain. **a** Sagittal T2-weighted image shows right L4/5 disc herniation. **b** Axial T2-weighted image indicates in the central and left paracentral zone. **c** Magnetic resonance myelography demonstrates mild compression the right side thecal sac at L4 nerve root.
Fig. 7: A 84-years-old woman who presented with a 1 month history of right leg pain. (a) Sagittal T2- and (b) axial T2 weighted images show right L4/5 disc protrusion. (c) Magnetic resonance myelography demonstrates severe compression the right side thecal sac at L4 nerve root.
Fig. 8: A 84-years-old woman who presented with a 1 month history of right leg pain. (a) Sagittal T2- and (b) axial T2 weighted images show right L4/5 disc protrusion. (c) Magnetic resonance myelography demonstrates severe compression the right side thecal sac at L4 nerve root.
**Fig. 9:** A 84-years-old woman who presented with a 1 month history of right leg pain. (a) Sagittal T2- and (b) axial T2 weighted images show right L4/5 disc protrusion. (c) Magnetic resonance myelography demonstrates severe compression the right side thecal sac at L4 nerve root.
Results

The results of the diagnostic performance of routine MRI alone and routine MRI + MRM in 450 lesions of 30 patients are listed in Table 1.

The sensitivity was significantly higher on the routine MRI + MRM (87.5%) than on the routine MRI alone (76.92%) for reader 1 ($P < 0.05$). There were no significant differences between the routine MRI alone and routine MRI + MRM in specificity (93.6%, 90.17%, respectively, $P = 0.09$) and accuracy (89.78%, 89.56%, respectively, $P = 0.91$) for reader 1.

The sensitivity (63.4%, 87.5%, $P < 0.001$) and accuracy (88.7%, 94.4%, $P < 0.05$) was significantly higher on the routine MRI + MRM than on the routine MRI alone for reader 2. There were no significant differences between the routine MRI alone and routine MRI + MRM in specificity (96.24%, 96.53%, respectively, $P = 0.84$) for reader 2.

The inter-reader agreement on the degree of stenosis of the selected segment is shown in Table 2. Excellent weighted-k value for inter-reader agreement was 0.782 for level L1/2 (routine MRI), 0.767 for level L1/2 (routine MRI + MRM), and 0.769 for level 4/5 (routine MRI). Good inter-reader agreement was 0.713 for level L2/3 (routine MRI), 0.742 for level L3/4 (routine MRI), 0.649 for level L3/4 (routine MRI + MRM), 0.623 for L4/5 (routine MRI + MRM), 0.567 for level L5/S (routine MRI), and 0.459 for level L5/S (routine MRI + MRM). Poor inter-reader agreement was 0.1960 for level L2/3 (routine MRI + MRM).

Images for this section:
Table 1

<table>
<thead>
<tr>
<th>Imaging Sets</th>
<th>Reader 1</th>
<th>Reader 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
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<tr>
<td>Routine MRI alone</td>
<td>76.92 ± 0.42</td>
<td>63.4 ± 0.48</td>
</tr>
<tr>
<td>Routine MRI + MR Myelography</td>
<td>87.5 ± 0.33</td>
<td>87.5 ± 0.33</td>
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<tr>
<td>P value</td>
<td>&lt; 0.05</td>
<td>&lt; 0.001</td>
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<tr>
<td>95% Confidence Interval</td>
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<td>-0.35, -0.13</td>
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<tr>
<td><strong>Specificity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine MRI alone</td>
<td>93.6 ± 0.24</td>
<td>0.96 ± 0.19</td>
</tr>
<tr>
<td>Routine MRI + MR Myelography</td>
<td>90.17 ± 0.30</td>
<td>0.96 ± 0.18</td>
</tr>
<tr>
<td>P value</td>
<td>0.09</td>
<td>0.84</td>
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<tr>
<td>95% Confidence Interval</td>
<td>-0.06, 0.08</td>
<td>-0.03, 0.03</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td></td>
<td></td>
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<tr>
<td>Routine MRI alone</td>
<td>0.90 ± 0.30</td>
<td>0.89 ± 0.32</td>
</tr>
<tr>
<td>Routine MRI + MR Myelography</td>
<td>0.90 ± 0.31</td>
<td>0.94 ± 0.23</td>
</tr>
<tr>
<td>P value</td>
<td>0.91</td>
<td>&lt; 0.05</td>
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<tr>
<td>95% Confidence Interval</td>
<td>-0.04, 0.04</td>
<td>-0.09, -0.02</td>
</tr>
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</table>

Fig. 10

Table 2

<table>
<thead>
<tr>
<th>Level</th>
<th>Weighted k value for routine MRI</th>
<th>Weighted k value for routine MRI + MRM</th>
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<tr>
<td>L1-2</td>
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<td>L2-3</td>
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<td>0.2</td>
</tr>
<tr>
<td>L3-4</td>
<td>0.74</td>
<td>0.65</td>
</tr>
<tr>
<td>L4-5</td>
<td>0.77</td>
<td>0.62</td>
</tr>
<tr>
<td>L5-S</td>
<td>0.57</td>
<td>0.46</td>
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</table>

Fig. 11
Conclusion

Additional MR myelography using 3D-COSMIC sequence to the routine MR imaging may be useful in the diagnosis of the herniated intervertebral disc or lumbar canal stenosis.

References


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