Range of findings on coronal T2 TIRM sequences in routine MR imaging of the lumbar spine in patients with lumbar pain syndrome

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Learning objectives

Demonstration of the range of additional pathologic findings on coronal T2TIRM sequences (compared to standard SE sequences) as part of a routine MRI protocol of the lumbar spine (LS) in outpatients referred for lumbar pain syndrome (LPS).
Background

Routine MR imaging of the LS usually consists of sagittal T1 and T2SE and transversal T2SE sequences. More series frequently are added, but although the value of T2-weighted fat-suppressed series has been outlined earlier, their use is not a common standard\(^1\). Despite the widespread and growing use of MRI in patients with LPS, there is no systematic study on the most appropriate MR imaging protocol in terms of clinical relevance and cost-effectiveness, which likely is due to the complexity of the etiology of LPS, the multiplicity of degenerative and other findings on MRI and the resulting difficulties in proving the true reason of LPS in each patient.

The main advantage of a fat suppressed T2 sequence like T2TIRM (Turbo Inversion Recovery Magnitude) sequence in musculoskeletal imaging is its high ability to detect bone marrow edema (BME)\(^2\). The value of fat suppressed T2 weighted series in MR of degenerative disease in the LS has been emphasized earlier. This fact is well known to all radiologists. Nevertheless, mainly musculoskeletal radiologist have an eye on BME, while neuroradiologists and general radiologists seem to be primarily focused on discs and nerve roots. More recent studies state that edematous/inflammatory subchondral vertebral endplate changes (Modic type 1) are associated with LPS\(^3,4\). Activated osteoarthritis of the facet joints (with facet joint edema) can be another source of LPS and has a prevalence of about 14% in LPS patients\(^5\).

The detection of BME in patients with LPS in close correlation with the clinical findings can help to determine the painful lumbar segment and guide therapy, e.g. facet joint infiltration. In cases of intervertebral or facet joint osteoarthritis with additional fatty or sclerotic/hypertrophic ("mixed") changes, BME often cannot be reliably detected on SE sequences.

Multiplanarity is one main advantage of MRI, but remains frequently unused in MRI of the LS. Coronal T2TIRM with a big Field of View (FoV) detects more areas with BME in the spine plus multiple other, often unexpected pathologies in the paraspinal and sacral region, areas that otherwise remain unvisualised\(^6\). Furthermore, the presence and degree of underreported scoliosis\(^7\) is much easier appreciated on coronal series.
509 LS MRIs of outpatients referred to a private radiological practice for LPS with or without radicular pain between 2011 and 2013 were retrospectively evaluated by one radiologist (L.A.R.) The imaging protocol consisted of sagittal T1 and T2SE, transversal T2SE and coronal T2TIRM (29-33 slices, slice thickness 4.5mm, FoV 400 x 360mm, TA ca. 03:30). The FoV of the coronal T2TIRM included the whole lumbar spine including Th12, the sacroiliac joints (SIJ) and at least the upper part of the hip joints.

Only the main findings in each case were registered, meaning pathologies that were, together with clinical information given beforehand, most likely to be responsible for the clinical LPS in each patient. So if a patient had a disc herniation with probable nerve root affection and/or a more severe spinal canal stenosis that roughly matched with the clinical picture, other, in this situation minor findings were not registered separately. Thus the absolute rate of e.g. activated osteoarthritis was higher than in the tabloid of the main findings Fig. 1 on page 6.

In 35% of the patients, no or moderate degenerative changes were found, 23% had disc herniations, 12% significant (absolute) spinal stenosis, 4,1% spondylolisthesis and 7,5% double (e.g. disc herniation and spinal stenosis) or miscellaneous (e.g. plasmocytoma, neurinoma) pathologies.

In 58 cases (11,4%) activated intervertebral Fig. 2 on page 6 Fig. 3 on page 7 and/or facet joint osteoarthritis Fig. 4 on page 8 Fig. 5 on page 9 were seen exclusively or with a significantly higher conspicuity on coronal T2TIRM. The presence of mixed changes in subchondral bone often masked subchondral edema on the TSE sequences. Probably due to the small amount of bone marrow in the articular processus, especially in hypertrophic facet joint osteoarthritis, BME in facet joints often only was evident on T2TIRM.

In 36 or 7,1% of all cases, significant pathologies were only visible on coronal T2TIRM. 27 or 5,3% of these were pathologies of the SIJ Fig. 6 on page 10 Fig. 7 on page 11 Fig. 8 on page 12 Fig. 15 on page 19 or lumbosacral transition Fig. 9 on page 13 Fig. 10 on page 14. Under the remaining 9 were three muscle pathologies (two cases of previously undiagnosed polymyositis Fig. 11 on page 15, one gluteus medius insertional rupture Fig. 12 on page 16) and 6 single entities: one large gluteal lipoma Fig. 13 on page 17, one AVN of the femoral head Fig. 14 on page 18, one unilateral and one bilateral previously undiagnosed hydronephrosis, one adrenal tumor, one liver tumor. Only the last two of these entities seemed to be incidental findings, without any relation to the patient’s LPS.

Paraspinal muscle edema as a sign of rupture or degeneration was also observed Fig. 4 on page 8, as well as interspinous ligament signal changes and edema in and around neoarthrosis of interspinous spaces Fig. 15 on page 19. These findings were
not systematically registered by us and do not appear in the tabloid. Also their presence was easier appreciated on T2TIRM.
### Total: 509

<table>
<thead>
<tr>
<th>Spinal pathologies on TSE sequences:</th>
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<tbody>
<tr>
<td>Disc herniation</td>
<td>117</td>
<td>23,0%</td>
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<tr>
<td>Spinal stenosis</td>
<td>61</td>
<td>12,0%</td>
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<tr>
<td>Spondylolisthesis</td>
<td>21</td>
<td>4,1%</td>
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<tr>
<td>Double pathology</td>
<td>31</td>
<td>6,1%</td>
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<tr>
<td>Miscellaneous</td>
<td>7</td>
<td>1,4%</td>
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<td><strong>Sum:</strong></td>
<td>237</td>
<td>46,6%</td>
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<tr>
<th>Spinal pathologies with BME:</th>
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<tbody>
<tr>
<td>Intervertebral osteoarthritis Modic 1</td>
<td>32</td>
<td>6,3%</td>
</tr>
<tr>
<td>Activated facet joint osteoarthritis</td>
<td>12</td>
<td>2,4%</td>
</tr>
<tr>
<td>Double pathology</td>
<td>14</td>
<td>2,8%</td>
</tr>
<tr>
<td><strong>Sum:</strong></td>
<td>58</td>
<td>11,4%</td>
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<tr>
<th>Paraspinal pathologies on coronal T2TIRM:</th>
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<tbody>
<tr>
<td>Sacroiliitis</td>
<td>5</td>
<td>1,0%</td>
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<tr>
<td>Activated osteoarthritis SI joints</td>
<td>13</td>
<td>2,6%</td>
</tr>
<tr>
<td>Insufficiency or traumatic sacral fracture</td>
<td>6</td>
<td>1,2%</td>
</tr>
<tr>
<td>Lumbosacral transition anomaly</td>
<td>3</td>
<td>0,6%</td>
</tr>
<tr>
<td>Soft tissue pathologies</td>
<td>9</td>
<td>2,0%</td>
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<tr>
<td><strong>Sum:</strong></td>
<td>36</td>
<td>7,1%</td>
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<table>
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<tr>
<th>No significant findings:</th>
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<tr>
<td></td>
<td>178</td>
<td>35,0%</td>
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**Fig. 1:** Pathologic findings in observational retrospective evaluation of 509 outpatients MRs of the LS

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Fig. 2: Modic 1 changes at L5/S1. TSE sequences only depict thin subchondral double line. X-ray is negative for any bone reaction. T2TIRM clearly shows subchondral BME. Annular tear at the same level. 36y/o male, LPS without radicular symptoms. Lat. x-ray, sag T1 and T2 TSE, cor T2TIRM.

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Fig. 3: Mixed subchondral bone changes Modic type 1, 2 and 3 at level L2/3, representing chronic recurrent intervertebral osteoarthritis. X-ray depicts severe sclerosis, TSE sequences show primarily subchondral fat signal with a central area of dark signal on T1 and T2 that likely represents sclerosis; only the dark rim on TSE is suggestive of BME, that clearly is depicted on T2TIRM. Additional Modic type 2 changes in L4. The changes at L2/3 were previously present but not mentioned in the radiologist’s report. Lat. x-ray, sag T1 and T2TSE, cor T2 TIRM. 63y/o male, chronic LPS, severe pain at night.

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**Fig. 4:** Bilat. facet joint activation L4/5, not visible on sag. T1 and T2 TSE. Additional paraspinal muscle edema L2/3 left and L3/4 bilat. 56y/o female; LPS with pain radiating in both legs. Right parasag T1 and T2 TSE, cor T2TIRM.

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**Fig. 5:** Unilaterally activated, bilateral hypertrophic facet joint osteoarthritis L5/S1. Only cor T2TIRM clearly depicts the right sided BME and adjacent soft tissue edema. On tra T2TSE, a small joint effusion is the only hint for an aggravation of the facet joint osteoarthritis on the right side. 74y/o female with right-sided L5 syndrome. Cor T2TIRM, right parasag T1 and T2 TSE, tra T2 TSE (inlay).

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**Fig. 6:** Bilat. sacroiliitis, previously undiagnosed. 28y/o female with LPS, radiating to left > right leg. Cor T2TIRM.

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Fig. 7: Activated SIJ osteoarthritis on the right side, slightly also on the left. 60y/o female with right sided LPS without radiation. Cor T2TIRM.

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Fig. 8: Right-sided sacral insufficiency fracture. 67y/o female. LPS since 5 weeks. Cor T2TIRM.

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Fig. 9: Hemisacralisation L5 right, slightly activated, not equivocally detectable on transversal slices (due to moderate, probably secondary scoliosis). 76y/o female with chronic LPS without radicular symptoms. Cor T2TIRM.

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Fig. 10: Lumbosacral scoliosis due to right-sided, ca. 25% loss of vertebral height L5. Scoliosis is not evident on sagittal series. Probably dysplastic, less likely chronic posttraumatic vertebral height loss. 61y/o female, chronic LPS. Cor T2TIRM from anterior to posterior, sag T2TSE from right to left.

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**Fig. 11:** Polymyositis, previously undiagnosed. Generalized, streaky hyperintens signal alterations in all muscles on T2TIRM, indistinguishable from fatty muscle degeneration on TSE images. 83y/o male with LPS and weakness in both legs, deteriorating over the last 6 weeks. Cor and additional tra T2TIRM (left and lower right), tra T2 TSE (upper right)

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**Fig. 12:** Insertional muscle tear right gluteus medius. 36y/o male; right-sided LPS radiating into the leg after lifting a heavy weight 1 week before. Normal MR of LS. No prior i.m. injection. Cor T2TIRM.

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Fig. 13: Not all pathologies are bright on T2TIRM: 10cm large left gluteal lipoma. 45y/o male; left-sided sciatica since 4 years. Cor T2TIRM.

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**Fig. 14:** AVN of right femoral head, previously undiagnosed. 60y/o male. Right-sided LPS. Cor T2TIRM.

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Fig. 15: Activated interspinous nearthrosis L3/4 > L2/3, not visible on sag TSE series, bright on cor T2TIRM. Additional sacroiliitis, right > left, with sclerosis, BME and bilat. contrast enhancement on additional series. 47y/o female with chronic LPS. Sag T1 and T2TSE, cor T2TIRM, additional paracor T1SE FatSat after i.v. contrast.

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Conclusion

The etiology of LPS is complex and not yet fully understood, nevertheless the amount of LS MRIs rises continuously. In our outpatient’s setting, about one third of routine LS MRIs do not explain LPS. In our observational study we estimate that coronal T2TIRM with a big FoV can detect the reason for LPS in at least an additional 7% of these patients. This estimated rate is higher than reported for additional coronal turbo STIR of the sacrum alone⁸. This can be explained by the greater FoV of our cor T2TIRM, enabling us to view more pathologies besides those in the sacrum and SIJ. Another reason may be the different patient population.

Our estimation of additional findings is conservative, because it only takes into account undoubtedly relevant findings visible on the big FoV coronal scan in paraspinal locations, mainly the SIJ and paraspinal muscles, that are not covered by the commonly used sagittal and transversal TSE sequences. It seems likely that this number has to be raised by the cases where BME in the LS only is visible on T2TIRM.

Radiologists should be familiar with the range of findings detectable on coronal T2TIRM in MRIs of the LS. We propose to include a coronal T2TIRM sequence in the routine LS MR imaging protocol of patients with LPS.
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8) Coronal oblique turbo STIR imaging of the sacrum and sacroiliac joints at routine MR imaging of the lumbar spine.

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