Free Diffusion

Restricted Diffusion

Normal marrow

Infiltrated marrow

Dow-Mu Koh et al. Diffusion Weighted MR in the Body: Applications and challenges in oncology. AJR 188. 1622-34
metastatic disease
Diffusion and spine metastases

- Karchevsky M, Babb JS, Schweitzer ME. Can diffusion-weighted imaging be used to differentiate benign from pathologic fractures? A meta-analysis. Skeletal Radiol. 2008 Sep;37(9):791-5
Diffusion weighted imaging facilitates detection of spinal metastases

Parag* Y, Delman B, Pawha P, Tanenbaum L
Mount Sinai School of Medicine
New York, NY

American Society of Spine Radiology 2010 Annual meeting
European College of Radiology 2010 Annual Meeting
American Society of Neuroradiology 2010 Annual meeting
spine DWI in metastatic disease

Diffusion and spine metastases lesion conspicuity

- 23/85 (27%) similar on conventional and DWI
- 40/85 (47%) more conspicuous on the diffusion sequence
- 16/85 (19%) more conspicuous on conventional sequences
- 6 (7%) lesions identified on DWI were initially missed on conventional sequence evaluation
Diffusion weighted imaging facilitates detection of spinal multiple myeloma

James Kessler, Puneet S. Pawha, Katya Shpilberg, Lawrence N. Tanenbaum
Mount Sinai School of Medicine
New York, NY
myeloma
Lesion Conspicuity

- 32 of 105 lesions (30%) were deemed similar in conspicuity between traditional sequences and DWI
- 51 of 105 lesions (49%) were more conspicuous on DWI
- 22 of 105 lesions (21%) were more conspicuous on traditional sequences
- 11 of 105 lesions (10%) were missed on conventional sequences and detected on DWI
Myeloma
myeloma
myeloma
Compression fracture

Senececent vs. pathologic

• theory
  – benign fracture
    • “edema” \textit{freely} diffusing in bone interstices
    • low signal on DWI (high ADC)
  – malignant fracture
    • water \textit{in} tumor cells infiltrating bone
    • high signal on DWI (low ADC)
multiple myeloma
Diffusion imaging
spine indications

- infection
  - detection
  - surveillance
  - problem solving
Osteomyelitis and discitis
Epidural abscess
• Degenerative Disc Disease
Diffusion imaging
spine indications

DWI
Type I
degenerative
disc disease
changes
Problem solving

- Modic et al. characterized and classified signal changes in vertebral body marrow adjacent to the endplates of degenerative discs

<table>
<thead>
<tr>
<th>Modic Classification</th>
<th>T1</th>
<th>T2</th>
<th>Represents</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>-</td>
<td>+</td>
<td>Vascularized bone marrow and/or edema</td>
</tr>
<tr>
<td>II</td>
<td>+</td>
<td>+</td>
<td>Proliferation of fatty tissue</td>
</tr>
<tr>
<td>III</td>
<td>-</td>
<td>-</td>
<td>Sclerotic bone</td>
</tr>
</tbody>
</table>
Problem solving

- Type I Modic signal difficult to differentiate from osteomyelitis/discitis
- more likely to be clinically symptomatic
DWI “claw sign”

- well marginated, linear, typically paired regions of high signal on trace/combined DWI
- seen at the boundary of the vascularized bone marrow and/or edema and the normal marrow
Type I degenerative signal changes
Diffusion-weighted MRI “claw sign” in differentiation of infectious from degenerative disease

Lawrence N. Tanenbaum, MD FACR
Michael Poplawski, PhD
Puneet Pawha MD
Thomas P. Naidich MD
Mount Sinai School of Medicine
New York, NY
Study groups:

1. **Modic I**
   - type I pattern on MR imaging
   - no suggestion of infection in original report
   - no clinical evidence of infection

2. **Suggested infection (disproved)**
   - type I pattern on MR imaging
   - signal changes suggestive of discitis in original report
   - no clinical evidence of infection
   - minimal change, resolution, or evolution to type II on follow-up MR (if available)

3. **Infection (confirmed)**
   - type I pattern on MR imaging
   - signal changes highly suggestive of discitis in original report
   - evidence of infection (e.g. positive biopsy, PET, laboratory findings, blood culture)

### Group characteristics:

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Age</th>
<th>Male%</th>
<th>Female%</th>
<th>Affected spine level</th>
<th>% studies w/contrast</th>
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<tbody>
<tr>
<td>Modic I</td>
<td>33</td>
<td>58.7±15</td>
<td>58</td>
<td>42</td>
<td>C (0); T (1); L (32)</td>
<td>64</td>
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<tr>
<td>Suggested Infection</td>
<td>20</td>
<td>63.2±17</td>
<td>50</td>
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<td>C (0); T (1); L (19)</td>
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<tr>
<td>Infection (confirmed)</td>
<td>20</td>
<td>53.5±14</td>
<td>65</td>
<td>35</td>
<td>C (3); T (5); L (12)</td>
<td>65</td>
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</table>
52yo M with Modic I degenerative change

57yo M with confirmed osteomyelitis

Definite “claw” - 1

Absent “claw” - 4
## Results – DWI “claw”

<table>
<thead>
<tr>
<th></th>
<th>Reader 1</th>
<th>Reader 2</th>
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<tbody>
<tr>
<td>Claw score (ave±SE)</td>
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<tr>
<td>Modic I</td>
<td>1.21±0.07</td>
<td>1.58±0.14</td>
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<tr>
<td>Suggested Infection</td>
<td>1.45±0.13</td>
<td>1.70±0.18</td>
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<tr>
<td>Infection (confirmed)</td>
<td>3.75±0.16</td>
<td>3.50±0.17</td>
</tr>
</tbody>
</table>

**Rating scale:** 1 - definite, 2 probable, 3 doubtful, 4 absent
Results – DWI “claw”

Neuroradiologist 1

Neuroradiologist 2

Results

Utility of the *absence* of the “claw sign” (grade 3 and 4) for predicting discitis

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
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<tbody>
<tr>
<td></td>
<td>Neurorad #1</td>
<td>Neurorad #2</td>
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<tr>
<td>All groups</td>
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<tr>
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<th>PPV</th>
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<tr>
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<td>Infection suggested or suspected</td>
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<td></td>
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<tr>
<td></td>
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<td>84</td>
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## Results

Utility of *high T2 disc signal* for predicting discitis

### All groups

<table>
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<tr>
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<th>Sensitivity</th>
<th>Specificity</th>
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<tbody>
<tr>
<td>Neurorad #1</td>
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<tr>
<td>Neurorad #2</td>
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<td>70</td>
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### Infection suggested or suspected

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<td>Neurorad #2</td>
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<table>
<thead>
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<th>Neurorad #1</th>
<th>Neurorad #2</th>
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<td>49</td>
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<td>52</td>
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<tr>
<td>52</td>
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</table>

### Results – disc C+ enhancement

Utility of moderate-severe disc enhancement for predicting discitis:

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<th>Specificity</th>
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<tbody>
<tr>
<td>Neurorad #1</td>
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<td>Neurorad #2</td>
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<tr>
<td>Neurorad #1</td>
<td>73</td>
<td>60</td>
</tr>
<tr>
<td>Neurorad #2</td>
<td>73</td>
<td>60</td>
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</tbody>
</table>

#### All groups

#### Infection suggested or suspected
Symptomatic Modic I pattern

- high disc T2
  - Diffuse DWI signal (absent “claw”)
    - DISCITIS
  - DWI “claw”
    - No infection

- low/normal disc T2
  - No infection

No infection

Limited utility of C+ study
~70% of discitis cases had no disc enhancement
All type I degenerative and discitis cases had some endplate enhancement
Conclusions
Potential cost benefits

• Avoid:
  • routine use of contrast in suspected infection
  • characterization C+ study
    • contrast agent
    • scanning sequences
    • interpretation
  • follow-up exams generated by concern
• avoid patient anxiety, diagnostic aspiration, lab testing
New Diffusion Techniques

- Parallel imaging
- 3 in 1
- Restricted FOV
  - FOCUS
- Multishot
  - RESOLVE
New Diffusion Techniques

• Parallel imaging
• 3 in 1
• Restricted FOV
  – FOCUS
• Multishot
  – RESOLVE
FOCUS 3T Spine DTI with 1.09x1.09mm in-plane resolution
RESOLVE DWI

- High-quality, high-resolution DWI and DTI
- Readout-segmented, multi-shot EPI for reduced TE and encoding time
  - reduced susceptibility and blurring artifacts
- Parallel imaging (IPAT) compatible
- Motion correction with 2D phase navigator and real-time image reacquisition

RESOLVE
Multishot
EPI
Spine Diffusion Imaging

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