MRI of the Hip: Technical Considerations

- Survey images of entire pelvis: body coil
  - Coronal FMIR (fat suppression)
  - Axial FSE
- Surface coil (shoulder PA; center over head)
  - Cartilage-sensitive coronal, sagittal, axial FSE 332 x 442μ by 2.5-3mm
- Preserves hip arthroscopy as a therapeutic (rather than diagnostic) tool

MRI of the Hip: Planes of Imaging to assess anatomy

- **Coronal:**
  - Cartilage: suprafoveal head, acetabular dome
  - Superior labrum
  - Iliofemoral ligament, capsule
  - Hip abductors, +/- psoas
- **Sagittal:**
  - Cartilage: dome, posterior and suprafoveal head
  - Anterior labrum
  - Sciatic nerve
- **Axial:**
  - Cartilage: anterior/posterior walls, head, bare area
  - Anterior and posterior labrum
  - Iliopsoas muscle/tendon
  - Sciatic and obturator nerves

Imaging of Cartilage Structure

- Water proton pools:
  - Free water (accounts for bulk of MRI signal)
  - Bound to PG by electrostatic charge (assess fixed charge density)
    - Sodium MRI
    - Gd-DTPA-2 techniques (dGEMRIC)
    - T1 rho imaging
  - Associated with collagen fibrils and macrostructure
    - Quantitative T2 mapping: internuclear dephasing of unbalanced dipole interactions
    - Assess alterations in collagen orientation
      - Correlated to dynamic mechanical properties at 1.5T and 9.4T*

*Lammentausta et al; JOR 2006;24:366-374.*
Cartilage Structure: Collagen
- Deep radial zone (40-60%): collagen oriented perpendicular to subchondral zone—strong angular dependence: vertical striations evident and short T2 values
- Transitional zone (20-30%): more random collagen orientation—less angular dependence and longer T2s
- Superficial zone (<10%): parallel to surface (maybe beyond resolution of clinical MRI)

32 year-old asymptomatic man           52 year-old man with OA

Xia et al; Osteoarthritis and Cart 2001; 9:393-406

Quantitative MR in hip disease
- Kim et al studied pts with DDH and found the dGEMRIC index was sensitive to OA changes as well as symptoms (WOMAC)  (JBJS 2003;85A:1987-1992)
- F/U study of pts with DDH treated with osteotomy showed that pts. who clinically failed osteotomy had more OA on radiographs and lower dGEMRIC indices, but dGEMRIC index was more predictive of failure  (Cunningham et al; JBJS  2006; 88A:1540-1548)
- Nishii et al studied pts with DDH with mild or no OA and normal controls with T2 mapping at 3T; prolongation of T2 was noted in the majority of the early OA pts (Osteoarthritis and Cart 2008; 16:227-233)

Femoroacetabular Impingement
Mechanisms (Ganz)
- “Cam” type
  - Insufficient neck head off-set
  - Post SCFE, fracture w/retroverted neck;
  - cartilage loss maybe rapid over the anterosuperior margin
- “Pincer” type
  - Anterosuperior head and neck impinge against the proximal medial acetabular rim; labral ossification
  - Acetabular retroversion
  - Primary labral failure followed by slower cartilage loss
Measurement of the $\alpha$ angle on oblique axial MR images (abnormal >55 degrees):

1. Center of femoral neck and center of head
2. Center of femoral head to where “bump” exceeds head radius

Notzli et al; JBJS(Br) 2002; 84:556-560
Pfirrmann et al; Radiology 2006; 240:778-785

Labral tears: Diagnostic considerations and pitfalls

- Most labral tears affect anterior labrum; best seen on sagittal images
- Posterior labral tears: typically related to posterior subluxation/dislocation
- Ganglion cysts associated with nonacute tears; common with DDH: dissect outside capsule and into bone
- Morphology and signal characteristics vary with age: increased mobility of water in senescent fibrocartilage
- Obesity limits proximity of shoulder coil to hip: increased distance from center of FOV limits SNR
- Synovitis typically due to cartilage damage rather than labrum

MRI vs MRA: Diagnostic Accuracy

<table>
<thead>
<tr>
<th>Study</th>
<th>Description</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
<th>Kappa (range)</th>
<th>Spatial resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schmid et al</td>
<td>MRA in 40 pts (mean age 37) vs. arthroscopy; Cartilage graded as normal or degenerated</td>
<td>79%</td>
<td>77%</td>
<td>78%</td>
<td>0.2-0.31</td>
<td>625 x 625 μ</td>
</tr>
<tr>
<td>keeney et al</td>
<td>MRA in 101 pts (mean age 37) vs. arthroscopy; No standardized cartilage grading</td>
<td>47%</td>
<td>89%</td>
<td>67%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Knuesel et al</td>
<td>MRA in 21 pts (mean age 38.5) vs. arthroscopy; Cartilage lesion present or absent</td>
<td>58-81%</td>
<td>69-100%</td>
<td>69-81%</td>
<td>0.4-0.55</td>
<td>293-312 x 293-312 μ</td>
</tr>
<tr>
<td>Mintz et al</td>
<td>MRI in 92 pts (mean age 39) vs. arthroscopy; Cartilage graded as 0-4 (Outerbridge)</td>
<td>86-91%</td>
<td>85-88%</td>
<td>87-88%</td>
<td>0.7-0.8</td>
<td>332 x 443 μ</td>
</tr>
</tbody>
</table>
NONCONTRAST MRI OF THE HIP: DIAGNOSTIC ACCURACY
HSS study: 92 pts. (mean age 39 yrs); preop MRI followed by arthroscopy
2 independent MR radiologists; 2 surgeons

LABRUM
- 84/88 labral tears seen on MRI
  - 84/88 anterior
  - Sensitivity 97%; Accuracy 93%
- 92% interobserver agreement
- 38% associated with paralabral cysts

CARTILAGE
- Graded by modified Outerbridge classification using standardized forms
- 87% of cases MRI was within one grade of arthroscopy
- Femoral head: Sensitivity 86%, specificity 88%, accuracy 87%, kappa 0.7 (p<0.001)
- Acetabulum: Sensitivity 91%, specificity 85%, accuracy 88%, kappa 0.8 (p<0.001)

Arthroscopy 2005; 21(4):385-393

Is the regionally increased incidence of labral tears a function of differential vascularity?
- Hip labrum is relatively avascular
- Vascularity patterns were not significantly different in the anterior, superior, posterior, and inferior labral regions
- Capsule provided major contribution to the labrum
  - Capsule was the only source of vascularity in 11/12 hips
- Labral tears showed a trend of increased vascularity

Synovial Proliferative Diseases
- Synovial chondromatosis
  - Bodies may be discrete or confluent (cast of synovium)
- Pigmented villonodular synovitis
  - Nodular vs. diffuse
  - Hemosiderin as a paramagnetic agent
- Evaluate degree of intracapsular vs. extracapsular disease
  - Impingement on neurovascular structures

Abductor tendinosis
- Gluteus minimus and medius tendons:
  “rotator cuff of the hip”
- +/- trochanteric bursitis
- Evaluate degree of atrophy

Osteonecrosis: Marrow Viability
SI within Osteonecrotic Segment

<table>
<thead>
<tr>
<th>Short TE</th>
<th>Long TE</th>
<th>Tissue</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>high</td>
<td>fat/blood</td>
<td>good</td>
</tr>
<tr>
<td>low</td>
<td>high</td>
<td>fluid</td>
<td>variable</td>
</tr>
<tr>
<td>low</td>
<td>low</td>
<td>fibrous</td>
<td>poor</td>
</tr>
</tbody>
</table>
Stress Fractures

- MRI is more sensitive than radiographs or Tc\textsuperscript{99}-MDP bone scan
- Shows wider spectrum of stress reaction to bone
- Accelerated remodeling
  - $\rightarrow$ fatigue
  - $\rightarrow$ exhaustion
  - $\rightarrow$ fracture
- Soft tissue edema
  - $\rightarrow$ periosteal reaction
  - $\rightarrow$ cortical fracture
  - $\rightarrow$ nonunion

High Resolution Noncontrast MR Imaging

- Strict attention to imaging technique imperative
- Consider optimized noncontrast imaging as an alternative to intra-articular contrast:
  - Visualize “native” capsule
  - Preserves MR as noninvasive
  - Reduced cost
  - Increased patient throughput; increased unit productivity
  - Same images sensitive for cartilage, ligament and labral pathology

References