Overview

- SI joint anatomy
- Sacroiliitis pathophysiology
- Sacroiliitis imaging
  - Disease features
  - Imaging protocols
- Role in diagnosis of JIA / JSpA
SIJ Anatomy

- Largest synovial joint in the body...
- but little synovium
- and minimal motion
  - Complex shape
  - Restraining ligaments
  - Normal 2.5°, 0.7 mm
  - (lax in pregnancy)
    - Sturesson et al., Spine 1969; 14: 162-5
SIJ Microscopic Anatomy

- **Synovial part**
  - Ventral, inferior 1/3 – 1/2
    - Traditional joint with fluid, synovium, cartilage
    - Unique fibrocartilage
    - Normally non-enhancing

- **Ligamentous part**
  - Dorsal, superior ½ - d2/3
    - Non-synovial; enthesis organ
    - Variants, vascular channels, normally enhancing

- Puhakka et al., Skel Radiol 2004; 33:15–28
SIJ normal X-ray appearance

- Curvilinear
- Overlapping structures & bowel
SJJ Pathology

- Case:
- 4 year old boy
- Post MVC
  - pneumothorax
  - liver laceration
  - bony injury?
SIJ Trauma

- 4 yr M
- Post MVC
  - Sacral fracture
  - Widened SI joint
  - Subtle on Xray

1 year earlier, age 3
Abdominal pain
Sacroiliitis

- Clinical:
  - Deep low-back pain worst in AM, tender SIJ

- Xray, CT, MRI:
  - Several imaging features

11 yr M, asymptomatic

12 yr M, known JSpA
Sacroiliitis Pathophysiology

- SI joints
  - Dense fibrocartilage
  - Bone/cartilage interface resembles an enthesis
  - Synovium at margins
Sacroiliitis Pathophysiology

- Initial insult = autoimmune attack of subchondral bone
Sacroiliitis Pathophysiology

- Initial insult = autoimmune attack of subchondral bone
- Followed by destruction of cortical bone (erosion)
- Opposite of RA – inflammation begins in bone, not at synovium
Sacroiliitis Pathophysiology

- Initial insult = autoimmune attack of subchondral bone
- Followed by destruction of cortical bone (erosion)
- Opposite of RA – inflammation begins in bone, not at synovium
- Late: “backfill” narrows the joint; sclerosis, ankylosis
# Imaging Features of Sacroiliitis

<table>
<thead>
<tr>
<th></th>
<th>Sclerosis</th>
<th>Erosion</th>
<th>Ankylosis</th>
<th>Marrow Edema</th>
<th>Fatty metaplasia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X-ray</strong></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MRI</strong></td>
<td>✔</td>
<td>✔</td>
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<td>✔</td>
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</tr>
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</table>
Sclerosis

- Best seen on Xray or GRE MRI
- Nonspecific: chronic sacroiliitis, or mechanical
Erosion

- Chronic structural damage
- Specific for JSpA

15 yr M, JSpA

11 yr M, JSpA
Erosion

- Let’s look a little closer…
  - Focal cortical loss +
  - Subcortical signal changes
Erosion

- Let’s look a little closer…
  - Focal cortical loss +
  - Subcortical signal changes
Erosion mimics

- Vascular channels, ligament attachments…
- (Use caution in ligamentous portion of SIJ)
Ankylosis

- End-stage structural damage
- Rarely complete in children
- “Spot welds” do occur

17 yr M, JSpA
Marrow Edema (BME)

- Marker of active inflammation
- High STIR signal = high water content in bone

12 yr M, JSpA
Marrow edema mimic

- Periarticular flaring

12 yr M, JSpA
Marrow edema mimic

- Periarticular flaring = thin, symmetric, subchondral
- Analogous to normal ‘metaphyseal’ signal

12 yr M, JSpA

12 yr M, knee
Fatty bone marrow

- Rarely fatty in normal pre-teens
- Becomes normal variant in older children
- DDx: fatty replacement of healthy marrow vs. acquired periarticular inflammation.
Diagnostic Value of X-ray Features

- Sclerosis in half of controls, 2/3 of JSpA
- Erosions in 20% of controls, 60% of JSpA
- Both features = weak predictors of JSpA

<table>
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<tr>
<th>Prevalence (JSpA, controls) \ LR+[^1]</th>
<th>Sclerosis</th>
<th>Erosion</th>
<th>Ankylosis</th>
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<td><strong>X-ray</strong></td>
<td>71%</td>
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<td></td>
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[^1]: Jaremko et al., J Rheum 2014; 41:5
[2]: Herregods et al., Clin Rad, 2015;70(12):1428-38

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Diagonal Value of MRI Features

- Sclerosis most prevalent
- Erosion, BME distinguish best between JSpA / control
- Definition-dependent

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<td>3.2</td>
<td></td>
</tr>
<tr>
<td><strong>X-ray</strong></td>
<td><strong>62%</strong></td>
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<td><strong>6%</strong></td>
<td><strong>56%</strong></td>
<td><strong>29%</strong></td>
</tr>
<tr>
<td>33%</td>
<td>4%</td>
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<tr>
<td>3.0</td>
<td>1.6</td>
<td><strong>14.0</strong></td>
<td>3.8</td>
<td><strong>10.5</strong></td>
<td><strong>2.6</strong></td>
</tr>
</tbody>
</table>

1. Jaremko et al., J Rheum 2014; 41:5
2. Herregods et al., Clin Rad, 2015;70(12):1428-38
Diagnostic Value of Xray, MRI features

- MRI clearly more useful than Xray
- Subchondral defects (e.g., ligament attachments) can mimic erosions
- ~50% of children with JSpA have negative MRI
- Best features = BME, erosions
SIJ Imaging Protocols

- MRI protocol
  - Plan along axes of sacrum
  - 3 mm slices
  - Cor T1 and STIR (3 mm slices)
  - Ax STIR
  - +/- cor GRE
  - +/- DWI

- Main controversy: to use gad or not?
Gadolinium Injection

- Painful IV start in child
- Need nursing, equipment, monitoring
- Add 10-15 minutes / scan
- Complications
  - 0.5%: rash / hives
Gadolinium Injection

- 0.01%: Resuscitate anaphylactic patient

Not just in the movies...
Imaging SIJ – Gad or Not?

- Older work: Gadolinium preferred
  - Bollow et al., J Rheum 1998; 25(3): 556-64
    - Measured ROI pre / post gad: periarticular enhancement
    - Used gad to determine if acute (infection) vs chronic disease
Imaging SIJ – Gad or Not?

- Recent: Gadolinium rarely necessary
  - Herregods et al., Skel Radiol 2015; 44(11):1637-46

- STIR = Gad for BML, enthesitis, capsulitis

- Gad better to confirm synovitis if high STIR in joint but no BML (rare)
- Gad enhancement in joint: can’t be synovium. Indirect arthrogram from hyperemic capsule?
- Otherwise no benefit
Role of Imaging in Diagnosis of JIA

- JIA subtypes
  - Systemic (Still disease)
  - Polyarticular: RF+, RF- (Juvenile RA)
  - Oligoarticular: persistent, extended (common, best Px)
  - Enthesitis-related: IBD+, IBD- (Juvenile SpA)
  - Psoriatic
  - Undifferentiated
    - Sacroiliitis is one of diagnostic criteria

Is there sacroiliitis?

Does the patient have JIA?
- other Dx criteria

SI joint imaging
Sacroiliitis and Inflammatory Arthritis

- Diagnosis of JIA & subtype:
  - Complicated
  - Leave this for the rheumatologist

- Radiologist’s job:
  - Sacroiliitis Y/N?

### Table 1: Subtypes of Juvenile Idiopathic Arthritis and Clinical Presentations

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligoarthritis</td>
<td>Most common form accounting for up to 60% of most JIA.</td>
</tr>
<tr>
<td></td>
<td>Arthritis affecting 1-4 joints during first 6 mo of disease.</td>
</tr>
<tr>
<td></td>
<td>Two subcategories: 1) persistent (never has more than 4 joints involved through the course of the disease); 2) extended (more than 4 joints involved after the first 6 mo of the disease).</td>
</tr>
<tr>
<td></td>
<td>Uveitis not uncommon.</td>
</tr>
<tr>
<td>Polyarthritis</td>
<td>Accounts for 25%-40% of JIA.</td>
</tr>
<tr>
<td></td>
<td>Two subcategories: 1) rheumatoid factor negative (arthritis in 5 or more joints during the first 6 mo of disease and all tests for rheumatoid factor are negative); 2) rheumatoid factor positive (arthritis in 5 or more joints during the first 6 mo of disease and at least 2 positive tests for rheumatoid factor at least 3 mo apart).</td>
</tr>
<tr>
<td></td>
<td>Anterior uveitis uncommon.</td>
</tr>
<tr>
<td>Systemic onset</td>
<td>Accounts for 10% of JIA.</td>
</tr>
<tr>
<td></td>
<td>Accounts for significant percentage of morbidity and mortality of JIA.</td>
</tr>
<tr>
<td></td>
<td>Arthritis with or preceded by a fever lasting at least 2 wk intermittent fever spiking for at least 3 days, and accompanied by at least 1 of the following: 1) generalized enlargement of the lymph nodes; 2) enlargement of the liver or spleen; 3) inflammation of the lining of the heart or lungs (pericarditis or pleuritis); or 4) rash characteristic of rheumatoid arthritis (ie, flat, pale, pink, and generally not itchy).</td>
</tr>
<tr>
<td>Psoriatic arthritis</td>
<td>Arthritis and psoriasis present at the same time along with at least 2 of the following: 1) inflammation and swelling of an entire finger or toe; 2) nail pitting or splitting; or 3) a first-degree relative with psoriasis.</td>
</tr>
<tr>
<td>Enthesitis-related arthritis</td>
<td>Arthritis and inflammation of an enthesitis site (ie, the enthesis is the point at which a ligament, tendon, or joint capsule attaches to the bone, with the most common locations around the knee and Achilles tendon); or</td>
</tr>
<tr>
<td></td>
<td>Arthritis or enthesitis with at least 2 of the following: 1) inflammation of the sacroiliac joints or pain and stiffness in the lumbosacral area; 2) a positive blood test for the (HLA) B27 gene; 3) onset of arthritis after age 6 yr in males; or 4) a first-degree relative diagnosed with ankylosing spondylitis, enthesitis-related arthritis, or inflammation of the sacroiliac joint in association with inflammatory bowel disease or acute inflammation of the eye.</td>
</tr>
<tr>
<td>Undifferentiated arthritis</td>
<td>Arthritis manifestations do not fulfill the criteria for 1 of the other 6 categories or if they fulfill the criteria for more than 1 category.</td>
</tr>
</tbody>
</table>

Abbreviations: HLA, human leukocyte antigen; JIA, juvenile idiopathic arthritis.
Sacroiliitis

- **Adult definition of sacroiliitis (ASAS)**
  - Xray: modified New York criteria

- **MRI: Must have BME**
  - 1 BME lesion on 2+ slices, or >1 lesion on 1 slice
  - Subchondral / periarticular only
    - Rudwaleit 2009; 68: 1520-7
Sacroiliitis

- **Pediatric definition of sacroiliitis**
  - Currently ILAR does not include imaging criteria!
    - “SI joint tenderness and/or inflammatory low back pain”

- Xray: insensitive, not useful for early diagnosis

- MRI: criteria unknown!
  - Do ASAS criteria for adults work? (BME 2 lesions or 2 slices)
  - Modify?

Herregods et al., Clin Rad, 2015;70(12):1428-38
Current situation

- Sacroiliitis
  - Clinical diagnosis, but symptoms are vague
  - MRI abnormalities ~50%
  - If present, may meet criteria for JSpA (enthesitis-related subtype of JIA), qualify for treatments

- Imaging criteria for sacroiliitis in children?
- How to improve sensitivity above 50%?
Summary

- **SIJ are unique**
  - Complex, nearly rigid joint
  - Synovial vs. ligamentous parts

- **Sacroiliitis begins in subchondral bone**
  - earliest lesion = BME

- **Imaging diagnosis of sacroiliitis is difficult**
  - Xrays: confusing and insensitive
  - MRI: some specific signs, but only abnormal in ~50%
  - Best MRI signs: BME, erosions
  - Gadolinium: no longer routinely necessary

- Current need = pediatric MRI criteria for sacroiliitis
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