A Compendium of Rotator Cuff Imaging

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Overview

• Patient presentation
• Rotator cuff
  – Anatomy
  – Function
  – Pathology
• Menu of radiologic tests
• Normal rotator cuff anatomy on MRI
• MRI examples of rotator cuff tears
Patient Presentation

• 53 year-old woman presents to rheumatology clinic for routine follow-up six months after diagnosis of likely seronegative rheumatoid arthritis
  – Since beginning treatment with MTX, her bilateral joint pain and stiffness resolved with the exception of right shoulder pain
  – She has experienced right shoulder pain intermittently for a number of years, worsening with overhead activity and improving with rest and NSAIDs
  – In recent months, the right shoulder pain has worsened and become more frequent, sometimes awakening her at night.

• Physical Exam: R shoulder exam significant for pain and weakness with limited ROM presumed secondary to pain
  – Clinic note does not document other details of shoulder physical exam, such as impingement signs or detailed rotator cuff exam
Shoulder Anatomy

- The shoulder has the greatest range of motion of any joint in the body
- Three bones: humerus, clavicle, and scapula
- Four joints:
  - Glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic

http://www.shoulderdoc.co.uk/
Glenohumeral Joint

- Ball (humeral head) and socket (glenoid fossa) joint
  - Glenoid fossa is shallow, allowing large ROM at the cost of skeletal instability
  - Static stabilizers:
    - Glenohumeral ligaments, labrum, bony structures, and capsule
  - Dynamic stabilizers:
    - Rotator cuff muscles/tendons, long head of the biceps, and scapular stabilizer muscles

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Rotator Cuff Anatomy and Function

- Four muscles and their tendons
  - Supraspinatus
  - Infraspinatus
  - Teres minor
  - Subscapularis
  - Mnemonic “SITS”
- Originate from the scapula
- Form musculotendinous “cuff” that inserts on the proximal humerus (greater and lesser tuberosities)
- **Function:** primary dynamic stabilizers of glenohumeral joint
  - Muscles actively compress the humeral head in the glenoid fossa
  - Counterbalance forces from large muscles acting on humerus
  - Contribute to humeral movement: external rotation (infraspinatus, teres minor), internal rotation (subscapularis), and abduction (supraspinatus)
Rotator Cuff Anatomy

Anterior

Posterior

Lateral

UpToDate; http://www.shoulderdoc.co.uk/
Tendon of Long Head of Biceps

- Not part of rotator cuff
- Contributes to glenohumeral stability
- Intimate anatomic relationship with rotator cuff and labrum
  - Originates at superior glenoid tubercle
  - Travels intraarticularly over the humeral head
  - Travels in bicipital groove between the greater and lesser tuberosities
- Biceps tendinopathy and tendon rupture frequently is associated with rotator cuff pathology

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Rotator Cuff Pathology

- Most common reason for seeking treatment among patients with shoulder pain
  - 4.5 million office visits and 40,000 surgeries annually in USA
- **Subacromial impingement**
  - Repetitive compression of rotator cuff between greater tuberosity and acromion
  - Pain with overhead activities
  - Risk factors: repetitive overhead activity (e.g. sports, occupations), narrow coracoacromial arch (from anatomic variants of acromion or bone spurs)
  - Spectrum of disease from subacromial bursitis, to tendinopathy (chronic injury to rotator cuff), to partial and full thickness rotator cuff tears
- **Rotator cuff tears**
  - Etiology: extrinsic (chronic subacromial impingement) and/or intrinsic (tension overload such as from overhead throwing; tendon degeneration from aging, microvascular disease, and comorbidities such as RA)
  - Classically, patients have weakness/pain with overhead activities and at night
    - In reality, many tears are asymptomatic or produce mild pain
  - Supraspinatus is most commonly torn
Menu of Radiologic Tests for Rotator Cuff

- Shoulder plain films
- Musculoskeletal ultrasound
- Magnetic resonance imaging
- MR Arthrography
Companion Patient 1: Acromial Bone Spur on Shoulder Plain Film

Plain films of shoulder

- Initial imaging modality for shoulder pain of any etiology
- Typical views include frontal, lateral, and outlet view
- Typically normal in cases of rotator cuff tear
- In impingement, outlet view may demonstrate hooked acromion or bone spur

Outlet view demonstrating bone spur (red circle) causing subacromial impingement

http://orthoinfo.aaos.org/topic.cfm?topic=a00032
Companion Patient 2: High Riding Humeral Head on Shoulder Plain Film

Plain films of shoulder

- Humeral head may be high-riding in large or chronic rotator cuff tears

AP view shows high-riding humerus, decreased acromiohumeral distance (black arrows), and secondary arthropathy with osteophytes (white arrow)

Companion Patient 3: Full-Thickness Supraspinatus Tear on Shoulder Ultrasound

**MSK ultrasound**

- Advantages:
  - Bedside evaluation of rotator cuff
  - Visualize moving tendons and compare to contralateral
  - No radiation exposure, low cost
- Disadvantages:
  - Full rotator cuff may not be well visualized
  - Operator dependent
  - Limited evaluation of deeper structures such as labrum
- Sensitivity for diagnosing rotator cuff tears is similar to MRI
- Full thickness rotator cuff tear
  - Tendon is hypoechoic (fluid replaces the torn tendon)
  - Enhanced through transmission results in accentuation of cartilage, resulting in two hyperechoic lines from cartilage and cortex ("double cortex sign")

Magnetic Resonance Imaging

- Highly sensitive and specific for rotator cuff tears
- Provides information about chronicity, which informs treatment decisions
- Excellent soft tissue visualization, including the labrum and capsule
- Disadvantages: expensive, typical contraindications to MRI and gadolinium contrast (if used), CT is superior for evaluating fractures

Technical Details

- Patient supine, typically with arm slightly externally rotated
- Usually performed without IV gadolinium (Gd) contrast
- Phased array coil is applied to shoulder for best possible signal/noise ratio and spatial resolution
- Using MR scout localizer images, typical imaging planes are
  - Axial sections from the top of the acromioclavicular joint to the inferior glenoid margin
  - Coronal oblique images parallel to the plane of the supraspinatus tendon, extending from subscapularis tendon anteriorly to infraspinatus and teres minor posteriorly
  - Sagittal oblique images are perpendicular to the plane of the coronal images, extending from the lateral aspect of the greater tuberosity to the body of the scapula
- Typical sequences include:
  - Proton density or T1-weighted – define anatomy
  - Short tau inversion recovery (STIR) or T2-weighted with fat saturation – fluid sensitive
**MR Arthrography**

**MR arthrography**

- Inject dilute Gd contrast into glenohumeral joint under fluoroscopic guidance before MRI
- Creates joint effusion of Gd contrast that facilitates visualization of small rotator cuff tears, especially partial tears of the undersurface of the tendon, and tears of the labrum and capsule
- CT arthrography is an option when MRI is contraindicated or unavailable

*Injection of gadolinium into glenohumeral joint via the rotator interval approach*
**Rotator Cuff Tear: Full vs. Partial Tear on MRI**

- **Full-thickness tear:**
  - Tendon is discontinuous on anatomy-defining sequences
  - High signal (fluid) fills the tendon defect on fluid-sensitive sequences
  - Ancillary findings: fluid in subacromial space, tendon retraction, high-riding humeral head, rotator cuff muscle atrophy, narrow coracoacromial arch (from bone spurs or acromial orientation)
  - MR arthrography: contrast traverses the rotator cuff tendon and enters the subacromial bursa on T1-weighted fat saturation sequences

- **Partial-thickness tear:**
  - Articular surface (most common), bursal surface, or intrasubstance
  - Partial-thickness tendon discontinuity on anatomy-defining sequences
  - High signal (fluid) fills tendon defect on fluid-sensitive sequences
  - MR arthrography: contrast fills the defect in the case of partial-thickness tears of the articular surface
Rotator Cuff Tear: Sensitivity and Specificity of MRI and MR Arthrography

• **Full-thickness tear:**
  – Conventional MRI: sensitivity 84-96%, specificity 94-98%
  – MR arthrography: sensitivity 98%, specificity 100%

• **Partial-thickness tear:**
  – Conventional MRI: sensitivity 35-44%, specificity 85-97%
  – MR arthrography: sensitivity 84-95%, specificity 96-100% (data for articular surface tears only)
Normal MRI Anatomy
– Coronal Oblique 1

Deltoid

Infraspinatus

Teres minor

MR arthrogram
T1, fat suppression
BIDMC PACS
Normal MRI Anatomy
– Coronal Oblique 2

- Spine of scapula
- Infraspinatus
- Contrast in glenohumeral joint
- Head of humerus
- Deltoid

MR arthrogram
T1, fat suppression
BIDMC PACS
Normal MRI Anatomy
– Coronal Oblique 3

Acromion
Tendon of long head of biceps
Head of humerus
Deltoid
Supraspinatus
Superior labrum
Glenoid
Inferior labrum

MR arthrogram
T1, fat suppression
BIDMC PACS
Normal MRI Anatomy
– Coronal Oblique 4

- Distal clavicle
- Head of humerus
- Deltoid
- Supraspinatus
- Coracoid process
- Subscapularis

MR arthrogram
T1, fat suppression
BIDMC PACS
Normal MRI Anatomy
– Sagittal Oblique

- Acromion
- Infraspinatus
- Teres minor
- Supraspinatus
- Tendon of long head of biceps
- Head of humerus
- Subscapularis

MR arthrogram
T1, fat suppression
BIDMC PACS
Normal MRI Anatomy
– Axial

- Tendon of long head of biceps (in bicipital groove)
- Head of humerus
- Teres minor
- Subscapularis
- Anterior labrum
- Glenoid
- Posterior labrum
- Infraspinatus

MR arthrogram
T1, fat suppression
BIDMC PACS
Back to Our Patient

- Shoulder plain films normal
- Next step in appropriate workup for suspected rotator cuff tear would be ultrasound or MRI
- In this case, MRI was performed
Our Patient: Full-Thickness Supraspinatus Tear on MRI

Coronal oblique T2 with fat saturation  
Sagittal oblique T2 with fat saturation

**Findings:** 1) High signal, full-thickness defect of the supraspinatus on this fluid-sensitive sequence, consistent with full-thickness supraspinatus tear. The tear is 8mm in width and there is 2cm of tendon retraction.
2) High signal consistent with fluid in subacromial space
3) Laterally sloping acromion with mild narrowing of distance from humeral head to acromion.
**Findings:** Full-thickness discontinuity of supraspinatus tendon on this anatomy-defining sequence, consistent with full-thickness supraspinatus tear.
Companion Patient 4: Partial-Thickness Supraspinatus Tear
Coronal oblique T2 with fat saturation

Findings:
- Partial-thickness disruption of tendons of articular surface of supraspinatus with increased signal on fluid-sensitive sequences.
- Consistent with high grade (>50% of tendon) articular surface partial-thickness tear of supraspinatus.
- There is a tear of the superior labrum (*)
Companion Patient 5:
Massive Full-Thickness Rotator Cuff Tear of Subscapularis, Supraspinatus, and Infraspinatus on MRI

Axial proton density
Coronal oblique T2 with fat saturation
Coronal oblique T2 with fat saturation

Full-thickness tear of subscapularis, with retraction and atrophy
Full-thickness tear of infraspinatus, with retraction and atrophy
Full-thickness tear of supraspinatus, with retraction and atrophy

High-riding humeral head
Treatment of Rotator Cuff Tears

- Treatment options include:
  - Ice
  - Activity restriction
  - NSAIDs
  - Physical therapy
  - Glucocorticoid injection
  - Surgical repair: typically arthroscopic; open technique in some situations

- Choice of treatment depends on specific clinical scenario, including:
  - Partial-thickness versus full-thickness tear
  - Acute vs. chronic vs. acute-on-chronic tear
  - Age, comorbidities, and compliance of patient

- Factors that favor non-operative management include:
  - Partial-thickness tear, chronic tear, elderly patient, patient with multiple comorbidities, non-compliant patient, and tear with minimal or no symptoms

- Our patient is beginning non-operative treatment with physical therapy
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References