RTC pathology:
U/S vs MRI for diagnosis

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PM&R Sports Medicine Fellow
March 15, 2012
Disclosures

• None
Outline

• Background
• Practice Guidelines for MSK U/S Examination of the Shoulder
• Benefits of U/S versus MRI (and limitations)
• Problematic rotator cuff pathologies
• Review of Literature
  – Retrospective, Prospective, Meta-analysis studies
• Conclusions
Background

- 1977 – Mayer showed rotator cuff abnormalities with U/S in an exhibit at the AIUM annual convention
- Technology has since markedly improved U/S imaging with high frequency transducers allowing visualization of superficial structures with resolutions nearing 200 µm (better than routine MRI)
- Gold standard = Arthroscopic surgery appearance
AIUM Practice Guideline for the Performance of the MSK U/S Shoulder exam

• Indication:
  – Evaluation of shoulder pain or dysfunction

• Examine patient in the sitting position

• Transducer frequency typically \( \geq 10 \text{ MHz} \)
Long Head Biceps Brachii Tendon

- Forearm supinated and resting on thigh
  - Rotates bicipital groove anteriorly
- Exam in axial plane – identify tendon in the groove (correct for anisotropy)
- Exam in longitudinal
- Follow distal to myotendinous junction (pec major tendon)
Long Head Biceps Brachii
Subscapularis

- Externally rotate arm with elbow at the side
- Move transducer superior and inferior over the lesser tuberosity to completely visualize the tendon
- Rotate transducer 90° to view tendon in transverse
Subscapularis
Supraspinatus

- Extend arm posteriorly (hand in back pocket) – rotates greater tuberosity anteriorly
- Longitudinal view – orient transducer 45° between sagittal and coronal planes
- Move transducer anterior and posterior for complete visualization
- Transverse view – Rotate transducer 90°. Sweep medial to acromion and lateral to insertion on greater tuberosity
- Note subacromial-subdeltoid bursa
Supraspinatus
Infraspinatus and Teres Minor

- Use spine of scapula to distinguish supraspinous and infraspinous fossa
- Place transducer at level of GH joint below the scapular spine (forearm on thigh in supination)
- Muscles will be deep to deltoid
- For teres minor – angle transducer inferiorly
Infraspinatus
AIUM practice guideline

• Others (as appropriate)
  – GH joint/labrum, AC joint, supraspinous and spinoglenoid notch
  – Dynamic evaluation for impingement

• Comparison with contralateral side often useful
Benefits of U/S vs MRI

- **U/S**
  - Non-radiative
  - Non-invasive
  - Multi-planar imaging
  - Dynamic examination
  - Side-to-side comparison
  - Economic
  - Time saving
  - Fewer contraindications
  - Patient satisfaction
  - Close contact and interaction with physician
  - Guide procedures

- **MRI**
  - Non-radiative
  - Non-invasive
  - Multi-planar imaging
  - More info on osseous, intra-articular structures
  - Expensive
  - Time consuming
  - More contraindications
Limitations of U/S

• Operator dependent
  – Knowledge (anatomy)
  – Scanning technique
  – Interpretation

• Limited field of view
  – Detailed images of relatively small area

• Limited penetration
  – Limited ability to penetrate beyond bone cortex

• Lack of individual certification

• Surgeon preference for MRI?
Discussion of rotator cuff pathologies where the diagnosis can be problematic – and the advantages and shortcomings of both MRI and U/S in these specific examples

- Calcific Tendinopathy
- Partial-thickness tears
- Full-thickness tears
- Subscapularis tears
- Biceps tendinopathy
Calcific Tendinopathy

- Calcium deposits readily identified on plain radiographs and U/S
- U/S appearance: lobular hyperechoic foci within the tendon, typically with acoustic shadowing → increased conspicuity
  - Shadowing can be large enough to obscure an underlying rotator cuff tear
- MRI appearance: vague regions of low signal intensity (similar to adjacent tendons) → generally not visible
- U/S can be used to guide procedures for treatment
Rotator cuff troublemakers: pitfalls of MRI and ultrasound
Partial-thickness tears

- U/S has excellent resolution for visualization of these tears but beware of anisotropy → false positives
  - Superior spatial resolution and dynamic exam → best non-invasive modality to generally assess partial thickness tears
- MRI diagnosis when T2 fluid signal intensity extends to the bursal or articular surface or intrasubstance
- MR arthrography better for diagnosing partial thickness articular-sided tears (most common)
  - Invasive
Rotator cuff troublemakers: pitfalls of MRI and ultrasound
• Full-thickness tears
  – Generally easy to diagnose with both U/S and MRI
  – Presence and degree of muscle atrophy and tendon retraction optimally visualized on MRI (visualizing retracted muscle under the acromion difficult on U/S)
• **Subscapularis tears**
  – Exposure of tendon on U/S may be difficult if patient has limited ER
  – On MRI – tears best visualized on oblique sagittal fat-suppressed sequences
Rotator cuff troublemakers: pitfalls of MRI and ultrasound

• Biceps tendinopathy
  – Exquisitely illustrated on U/S with excellent spatial resolution and color doppler
  – U/S shows tendon thickening, abnormal echogenicity, excessive fluid within the sheath, increased peritendinous vascularity, dynamic exam (ER)
  – MRI pitfall – “magic angle” effect – false hyperintense signal when a structure with uniformly arranged collagen is imaged at an angle of 55 degrees to the main magnetic field
    • does not occur on T2 weighted sequence
Rotator cuff troublemakers: pitfalls of MRI and ultrasound

• Biceps tendinopathy
Common U/S Errors


- Causes of errors for diagnosing and measuring RTC tears with U/S

- Most errors due to limitations inherent with the test...
  - Difficult to differentiate an extensive partial-thickness or large bursal side tear from a full-thickness tear
  - Difficult to distinguish a partial-thickness tear from a focal area of tendinopathy
Review of the Literature

• Ideal Imaging Technique
  – High sensitivity – rule out disease
    • negative result $\rightarrow$ disease not likely present
  – High specificity – rule in disease
    • positive result $\rightarrow$ disease is likely present
Retrospective Studies
• Retrospective study
• 422 patients who underwent both shoulder U/S and MRI (75 subsequently underwent shoulder surgery)
• 2 different U/S performers – one a technician with 5 years experience, the other a radiologist with 10 years experience
• MRI: 1.5 Tesla – reported by one of three experienced MSK radiologists
• All reporters were blinded to the other imaging dx
• Surgery (gold standard for comparison) – one orthopedic surgeon performed all of the operations and had knowledge of the imaging reports
• Percentage of concordance between MRI and U/S for full-thickness RTC tears
  – Group 1 (tech with 5 years experience)
    • κ value = 0.35 (fair agreement)
  – Group 2 (radiologist with 10 years experience)
    • κ value = 0.97 (almost perfect agreement)
  – Conclusion: More experience is better
Comparison of shoulder ultrasound and MR imaging in diagnosing full-thickness rotator cuff tears

Cheng-Yen Chang¹,³, Su-Fang Wang¹,³,*, Hong-Jen Chiou¹,³, Hsiao-Li Ma²,³, Ying-Chou Sun¹,³, Hong-Dar Wu¹,³

| Table 1 | Correlation of sonography and surgical findings in Group 1 patients for diagnosing full-thickness rotator cuff |
|---------------------------------|--------------------------------------------------|---------------------------------|
| US/surgery | Positive | Negative | Total |
| Positive | 16 | 1 | 17 |
| Negative | 15 | 11 | 26 |
| Total | 31 | 12 | 43 |

Sensitivity: 52%
Specificity: 92%
PPV: 94%
NPV: 42%
Accuracy: 63%

| Table 3 | Correlation of US and surgical findings in Group 2 patients for diagnosing full-thickness rotator cuff |
|---------------------------------|--------------------------------------------------|---------------------------------|
| US/surgery | Positive | Negative | Total |
| Positive | 23 | 0 | 23 |
| Negative | 2 | 7 | 9 |
| Total | 25 | 7 | 32 |

Sensitivity: 92%
Specificity: 100%
PPV: 100%
NPV: 78%
Accuracy: 94%
Comparison of shoulder ultrasound and MR imaging in diagnosing full-thickness rotator cuff tears

Cheng-Yen Chang, Su-Fang Wang, Hong-Jen Chiou, Hsiao-Li Ma, Ying-Chou Sun, Hong-Dar Wu

Table 1
Correlation of sonography and surgical findings in Group 1 patients for diagnosing full-thickness rotator cuff

<table>
<thead>
<tr>
<th>US/surgery</th>
<th>Positive</th>
<th>Negative</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Positive</td>
<td>16</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Negative</td>
<td>15</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>12</td>
<td>43</td>
</tr>
</tbody>
</table>

Sensitivity: 52%
Specificity: 92%
PPV: 94%
NPV: 42%
Accuracy: 63%

Table 2
Correlation of MRI and surgical findings in Group 1 patients for diagnosing full-thickness rotator cuff

<table>
<thead>
<tr>
<th>MRI/surgery</th>
<th>Positive</th>
<th>Negative</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>27</td>
<td>0</td>
<td>27</td>
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<tr>
<td>Negative</td>
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<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>12</td>
<td>43</td>
</tr>
</tbody>
</table>

Sensitivity: 87%
Specificity: 100%
PPV: 100%
NPV: 75%
Accuracy: 90%
Comparison of shoulder ultrasound and MR imaging in diagnosing full-thickness rotator cuff tears

Cheng-Yen Chang\textsuperscript{a,c}, Su-Fang Wang\textsuperscript{a,c,*}, Hong-Jen Chiou\textsuperscript{a,c}, Hsiao-Li Ma\textsuperscript{b,c}, Ying-Chou Sun\textsuperscript{a,c}, Hong-Dar Wu\textsuperscript{a,c}

Table 3
Correlation of US and surgical findings in Group 2 patients for diagnosing full-thickness rotator cuff

<table>
<thead>
<tr>
<th>US/surgery</th>
<th>Positive</th>
<th>Negative</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>23</td>
<td>0</td>
<td>23</td>
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<tr>
<td>Negative</td>
<td>2</td>
<td>7</td>
<td>9</td>
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<tr>
<td>Total</td>
<td>25</td>
<td>7</td>
<td>32</td>
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</tbody>
</table>

Sensitivity: 92%
Specificity: 100%
PPV: 100%
NPV: 78%
Accuracy: 94%

Table 4
Correlation of MRI and surgical findings in Group 2 patients for diagnosing full-thickness rotator cuff

<table>
<thead>
<tr>
<th>MRI/surgery</th>
<th>Positive</th>
<th>Negative</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Positive</td>
<td>24</td>
<td>1</td>
<td>25</td>
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<tr>
<td>Negative</td>
<td>1</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>7</td>
<td>32</td>
</tr>
</tbody>
</table>

Sensitivity: 96%
Specificity: 86%
PPV: 96%
NPV: 85%
Accuracy: 94%
• Conclusions
  – The use of shoulder U/S in diagnosing full-thickness RTC tears is highly operator-dependent
  – U/S can be considered the imaging modality of choice when an expert is available
    • If RTC tear is diagnosed on U/S → MRI for surgical purposes
  – If no expert sonographer available, better to get MRI
  – Considering cost – use MRI if U/S was negative or uncertain in a patient not improving with therapy
Ultrasonography of the Rotator Cuff

A Comparison of Ultrasonographic and Arthroscopic Findings in One Hundred Consecutive Cases*

By Sharlene A. Teefey, M.D.†, S. Ashfaq Hasan, M.D.†, William D. Middleton, M.D.†, Mihir Patel, M.D.†, Rick W. Wright, M.D.†, and Ken Yamaguchi, M.D.†

The Journal of Bone and Joint Surgery

Vol. 82-A, No. 4, April 2000
Teefey et al. JBJS 2000

• Retrospective study design
• 100 shoulders in 98 consecutive patients with shoulder pain who underwent U/S by one of two experienced radiologists and subsequent arthroscopic surgery
• Arthroscopic diagnoses:
  – 65: Full thickness RCT
  – 15: Partial thickness RCT
  – 12: RC tendonitis
  – 4: Adhesive capsulitis
  – 2: AC joint arthrosis
  – 1: Superior labral tear
  – 1: Calcific bursitis
**TABLE I**

**FULL-THICKNESS ROTATOR CUFF TEARS: ULTRASONOGRAPHIC VERSUS ARTHROSCOPIC FINDINGS**

<table>
<thead>
<tr>
<th></th>
<th>Arthroscopy</th>
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<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
<td>Total</td>
<td></td>
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<tr>
<td>Ultrasonography</td>
<td>65</td>
<td>3</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>0</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>20</td>
<td>85</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE II**

**PARTIAL-THICKNESS ROTATOR CUFF TEARS: ULTRASONOGRAPHIC VERSUS ARTHROSCOPIC FINDINGS**

<table>
<thead>
<tr>
<th></th>
<th>Arthroscopy</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Ultrasonography</td>
<td>10</td>
<td>3</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>5</td>
<td>17</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>20</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>
Results

• U/S correctly identified
  – 100% (65/65) full thickness RTC tears (no false neg)
  – 67% (10/15) partial thickness RTC tears (5 false neg)
• Specificity = 85%
  – 17 true neg, 3 false pos
• Overall accuracy = 96%
• Prediction of size of full-thickness RTC tear (by transverse measurement)
  – Supraspinatus tear only: 86% (21/26)
  – Supraspinatus + Infraspinatus tear: 89% (33/37)
  – Subscapularis tear: 6/7
• Biceps tendon
  – U/S correctly identified 5/6 tendon dislocations and 7/11 ruptures of the tendon
Conclusions

• U/S is highly accurate for detecting full-thickness RTC tears and less effective for detecting partial-thickness RTC tears
• U/S may not be able to differentiate extensive partial-thickness tears from full-thickness tears
Prospective Studies
Accuracy of Office-Based Ultrasonography of the Shoulder for the Diagnosis of Rotator Cuff Tears

By Joseph P. Iannotti, MD, PhD, James Ciccone, CRNA, Daniel D. Buss, MD, Jeffrey L. Visotsky, MD, Edward Mascha, MS, Kathy Cotman, BS, and Nandkumar M. Rawool, MD, RDMS

Investigation performed at the Department of Orthopaedic Surgery, The Cleveland Clinic Foundation, Cleveland, Ohio

The Journal of Bone & Joint Surgery • jbjs.org
Volume 87-A • Number 6 • June 2005

JBJS The Journal of Bone and Joint Surgery
Prospective multi-institutional study

98 patients (99 shoulders) with clinical diagnosis of rotator cuff problem underwent office-based U/S

At each institution, the same person performed and recorded all of the U/S exams

Anatomic diagnoses were made by the study investigator (ortho surgeon) and study radiologist by watching the recording
  – Tendon involved, size of tear (cm), partial- or full-thickness

U/S interpretation was compared to MRI results and shoulder surgery (gold standard)
### TABLE I Accuracy of Ultrasonographic Examination*

<table>
<thead>
<tr>
<th>Operative Report</th>
<th>Ultrasonographic Findings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Tear</td>
<td>Partial-Thickness Tear Only</td>
</tr>
<tr>
<td>No tear</td>
<td>16 (80%)</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Partial-thickness tear only</td>
<td>2 (5%)</td>
<td>26 (70%)</td>
</tr>
<tr>
<td>Full-thickness tear with or without partial-thickness tear</td>
<td>1 (2%)</td>
<td>4 (10%)</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>33</td>
</tr>
</tbody>
</table>

*The values are given as the number, with the percentage of the total in the row given in parentheses. Accuracy = 79/99, or 0.80 (95% confidence interval, 0.71 to 0.87). †For full-thickness tears (with or without a partial-thickness tear), sensitivity = 37/42, or 0.88 (95% confidence interval, 0.74 to 0.96); positive predictive value = 37/47, or 0.79 (95% confidence interval, 0.64 to 0.89); false-positive rate (one minus positive predictive value) = 10/47, or 0.21 (95% confidence interval, 0.11 to 0.36); and negative predictive value = 47/52, or 0.90 (95% confidence interval, 0.79 to 0.97).

### TABLE II Accuracy of Magnetic Resonance Imaging

<table>
<thead>
<tr>
<th>Operative Report</th>
<th>Magnetic Resonance Imaging Findings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Tear</td>
<td>Partial-Thickness Tear Only</td>
</tr>
<tr>
<td>No tear</td>
<td>15 (75%)</td>
<td>4 (20%)</td>
</tr>
<tr>
<td>Partial-thickness tear only</td>
<td>4 (11%)</td>
<td>27 (73%)</td>
</tr>
<tr>
<td>Full-thickness tear with or without partial-thickness tear</td>
<td>0 (0%)</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>33</td>
</tr>
</tbody>
</table>

*The values are given as the number, with the percentage of the total in the row given in parentheses. Accuracy = 82/99 or 0.83 (95% confidence interval, 0.74 to 0.90). †For full-thickness tears (with or without a partial-thickness tear), sensitivity = 40/42, or 0.95 (95% confidence interval, 0.84 to 0.99); positive predictive value = 40/47, or 0.85 (95% confidence interval, 0.72 to 0.94); false-positive rate (one minus positive predictive value) = 7/47, or 0.15 (95% confidence interval, 0.06 to 0.28); and negative predictive value = 47/52, or 0.96 (95% confidence interval, 0.87 to 1.00).
Results

• Office-based U/S led to the correct diagnosis
  – 88% (37/42) of shoulders with full-thickness RTC tear
    • 4/5 were thought to be partial-thickness tear of the tendon
    • All 5 were 1-2 cm in size with < 1 cm retraction
  – 70% (26/37) of shoulders with partial-thickness RTC tear
    • 9/11 thought to be full-thickness tears
  – 80% (16/20) of shoulders with normal tendons

• MRI led to the correct diagnosis
  – 95% (40/42) of shoulders with full-thickness RTC tears
  – 73% (27/37) of shoulders with partial-thickness RTC tears
  – 75% (15/20) of shoulders with normal tendons

P = 0.18
Results

• Accuracy in detection of RTC tear size – within 2 cm of size of tear on operative report
  – In A-P dimension
    • U/S: 86%
    • MRI: 93%
    • $P = 0.26$
  – Medial-lateral dimension
    • U/S: 83%
    • MRI: 88%
    • $P = 0.41$
Additional Results

• U/S diagnosis was more accurate when clinical examination was combined with U/S interpretation compared to blinded U/S interpretation.
Conclusions

• A well-trained office staff and experienced physician can effectively utilize U/S in a typical clinical setting, along with PE and review of radiographs, to accurately diagnose the extent of RTC tear in patients suspected of having a tear.

• Errors – difficult to distinguish between partial and full-thickness tears that are ~ 1 cm in size with U/S (but did not affect the planned surgical approach).
Teefey et al. JBJS 2004

• Detection and quantification of Rotator Cuff Tears. Comparison of U/S, MRI, and arthroscopic findings in 71 consecutive cases
• Direct comparison of accuracy of U/S and MRI for detection and measurement of the size of RTC tears (arthroscopy = gold standard)
• 124 consecutive pts with shoulder pain prospectively studied with U/S and MRI (71 had subsequent surgery)
• Full-thickness tear: 46/71
• Partial-thickness tear: 19/71
• Normal tendon: 6/71
Teefey et al. Results

**U/S**
- Full-thickness RTC tear: 45/46 correctly identified
  - Correct prediction of degree of retraction in 73%
  - Correct prediction of width of tear in 87%
- Partial-thickness: 13/19 correctly identified
  - Correct prediction of length of tear in 85%
  - Correct prediction of width of tear in 54%

**MRI**
- Full-thickness RTC tear: 46/46 correctly identified
  - Correct prediction of degree of retraction in 63%
  - Correct prediction of width of tear in 80%
- Partial-thickness: 12/19 correctly identified
  - Correct prediction of length of tear in 75%
  - Correct prediction of width of tear in 75%
Teefey et al. 2004 - Conclusions

• Overall accuracy of both imaging tests 87%
• No significant difference between U/S and MRI ($p > 0.05$) in identifying and measuring the size of full-thickness and partial-thickness RTC tears

• In experienced hands, choice of imaging study should not be based on accuracy concerns but other factors
  – importance of additional info – labrum, joint capsule, surrounding muscle/bone, implanted device, cost
• Examine accuracy of 143 consecutive U/S scans of patients who subsequently underwent shoulder arthroscopy for rotator cuff disease

• A prospective record was made of all U/S scans performed by one orthopedic surgeon (investigate whether an orthopedic surgeon can develop both the technical skills involved in acquiring U/S images and interpreting pathological findings with a similar degree of accuracy as trained MSK radiologists)

• 364 pts scanned between 2001 and 2004

• 132 had surgical intervention; 11 had MRI (but no surgery) → N = 143
• Results
  – 78 full thickness tears (confirmed by surgery or MRI)
  – Sensitivity = 96.2% (3 moderate sized tears were assessed as partial-thickness by U/S → false negatives)
  – Specificity = 95.4% (one partially torn and 2 intact cuffs were over-diagnosed as small full-thickness tears by U/S → false positives)
  – Estimation of tear size more accurate for large and massive tears than for moderate and small tears
    • Tendency to oversize rather than undersize the tear
• Conclusions
  – U/S imaging of the shoulder performed by a sufficiently-trained orthopedic surgeon is a reliable time-saving practice to identify rotator cuff integrity
  – “Based on our positive experience we recommend this practice to other orthopaedic surgeons”
Meta-Analysis Studies
Objective: To evaluate the evidence for the effectiveness and cost-effectiveness of the newer diagnostic imaging tests as an addition to clinical examination and patient history for the diagnosis of soft tissue shoulder disorders
Executive Summary – Dinnes et al. 2003

• Clinical Examination (10 cohort studies)
  – Full-thickness RTC tear: Sensitivity 90%, Specificity 54%

• U/S (38 cohort studies)
  – Full-thickness RTC tear: Sensitivity 87%, Specificity 96%
  – Partial-thickness: Sensitivity 67%, Specificity “remained high”

• MRI (29 cohort studies)
  – Full-thickness RTC tear: Sensitivity 89%, Specificity 93%
  – Partial-thickness: Sensitivity 44%, Specificity 90%

• MR arthrogram (6 studies)
  – Full-thickness RTC tear: Sensitivity 95%, Specificity 93%
  – Partial-thickness: Results “less consistent”
Dinnes et al. – Conclusions

- Clinical exam by specialists can rule out RTC tear (high sensitivity)
- Either MRI or U/S could equally be used for detection of full-thickness RTC tears
- U/S may be better than MRI at picking up partial-thickness RTC tears
- Given the large differential in the cost of U/S and MRI → U/S is the more cost-effective test for identification of full-thickness RTC tears
• Purpose: Compare diagnostic accuracy of MRI, MR arthrography, and U/S for diagnosis of RTC tears through meta-analysis of the literature

• Identified articles reporting sensitivities and specificities of MRI, MR arthrography, or U/S for diagnosing RTC tears

• Inclusion:
  – Surgical reference standard (open or arthroscopic)
  – U/S imaging performed and interpreted by radiologists only

• 65 articles met inclusion criteria
<table>
<thead>
<tr>
<th>Technique</th>
<th>No. of Positive Cases</th>
<th>Sensitivity (%)</th>
<th>CI (%)</th>
<th>No. of Negative Cases</th>
<th>Specificity (%)</th>
<th>CI (%)</th>
</tr>
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<tbody>
<tr>
<td><strong>Full-thickness tear</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>MR arthrography</td>
<td>227</td>
<td>95.4</td>
<td>2.7</td>
<td>879</td>
<td>98.9</td>
<td>0.7</td>
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<tr>
<td>MRI</td>
<td>625</td>
<td>92.1</td>
<td>2.1</td>
<td>1,085</td>
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<td>1.5</td>
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<tr>
<td>Ultrasound</td>
<td>639</td>
<td>92.3</td>
<td>2.1</td>
<td>674</td>
<td>94.4</td>
<td>1.7</td>
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<td><strong>Partial-thickness tear</strong></td>
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<tr>
<td>MR arthrography</td>
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<td>4.9</td>
<td>875</td>
<td>96.0</td>
<td>1.3</td>
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<td>916</td>
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<td>1.8</td>
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<tr>
<td>Ultrasound</td>
<td>249</td>
<td>66.7</td>
<td>5.9</td>
<td>790</td>
<td>93.5</td>
<td>1.7</td>
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<td><strong>Full- or partial-thickness tear</strong></td>
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<tr>
<td>MR arthrography</td>
<td>485</td>
<td>92.3</td>
<td>2.4</td>
<td>869</td>
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<td>1.5</td>
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<tr>
<td>MRI</td>
<td>667</td>
<td>87.0</td>
<td>2.6</td>
<td>463</td>
<td>81.7</td>
<td>3.5</td>
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<tr>
<td>Ultrasound</td>
<td>915</td>
<td>85.1</td>
<td>2.3</td>
<td>481</td>
<td>86.1</td>
<td>3.1</td>
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<td><strong>All tears</strong></td>
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<td>MR arthrography</td>
<td>907</td>
<td>91.7</td>
<td>1.8</td>
<td>2,623</td>
<td>96.5</td>
<td>0.7</td>
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<tr>
<td>MRI</td>
<td>1,528</td>
<td>85.5</td>
<td>1.8</td>
<td>2,464</td>
<td>90.4</td>
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<td>Ultrasound</td>
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<td>85.1</td>
<td>1.6</td>
<td>1,945</td>
<td>92.0</td>
<td>1.2</td>
</tr>
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</table>
• Results
  – MR arthrography more sensitive and specific in diagnosing a full- or partial-thickness RTC tear than either MRI or U/S ($p < 0.05$)
  – No significant difference between MRI and U/S
• Conclusion
  – MR arthrography is the most sensitive and specific technique for diagnosing both full- and partial-thickness RTC tears
  – U/S and MRI are comparable in sensitivity and specificity
    • U/S more cost-effective
    • If inexperienced ultrasonographer – MRI better
• Purpose: To determine the diagnostic accuracy of U/S for detecting subacromial disorders in pts presenting in primary and secondary care settings
• Criteria: U/S frequency ≥ 7.5 MHz; surgery, MRI, and/or radiography as reference standards; subacromial disorders as target conditions
• 23 studies included – full-thickness RTC tear, partial-thickness RTC tear, subacromial bursitis, tendinopathy, calcific tendonitis
## Table 4: Pooled Results for Full-Thickness and Partial-Thickness Tears

<table>
<thead>
<tr>
<th>Outcome Subgroup</th>
<th>No. of Studies</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>LR+ (95% CI)</th>
<th>LR- (95% CI)</th>
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</thead>
<tbody>
<tr>
<td><strong>Full-Thickness Tears</strong></td>
<td></td>
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</tr>
<tr>
<td>All studies</td>
<td>22</td>
<td>0.95 (0.90–0.97)</td>
<td>0.96 (0.93–0.98)</td>
<td>24.20 (12.85–45.63)</td>
<td>0.05 (0.03–0.11)</td>
</tr>
<tr>
<td>Prospective design</td>
<td>8</td>
<td>0.89 (0.80–0.95)</td>
<td>0.94 (0.84–0.98)</td>
<td>15.47 (5.60–42.76)</td>
<td>0.11 (0.06–0.22)</td>
</tr>
<tr>
<td>Frequency ≥10MHz</td>
<td>7</td>
<td>0.98 (0.93–1.00)</td>
<td>0.94 (0.87–0.97)</td>
<td>15.72 (7.74–31.95)</td>
<td>0.02 (0.01–0.08)</td>
</tr>
<tr>
<td>Age (y)</td>
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<td></td>
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</tr>
<tr>
<td>≤50</td>
<td>6</td>
<td>0.93 (0.80–0.98)</td>
<td>0.96 (0.92–0.98)</td>
<td>22.06 (10.75–45.24)</td>
<td>0.08 (0.03–0.23)</td>
</tr>
<tr>
<td>50+</td>
<td>13</td>
<td>0.97 (0.93–0.99)</td>
<td>0.96 (0.90–0.98)</td>
<td>22.75 (10.00–51.75)</td>
<td>0.03 (0.01–0.08)</td>
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<tr>
<td>Prevalence (%)</td>
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<tr>
<td>≤40</td>
<td>5</td>
<td>0.91 (0.80–0.96)</td>
<td>0.99 (0.96–1.00)</td>
<td>144.03 (21.00–987.62)</td>
<td>0.09 (0.04–0.22)</td>
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<tr>
<td>41–60</td>
<td>12</td>
<td>0.92 (0.84–0.97)</td>
<td>0.96 (0.91–0.98)</td>
<td>22.45 (10.73–46.96)</td>
<td>0.08 (0.03–0.18)</td>
</tr>
<tr>
<td>Bias avoided</td>
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<tr>
<td>Partial verification</td>
<td>12</td>
<td>0.97 (0.90–0.99)</td>
<td>0.95 (0.90–0.97)</td>
<td>18.85 (9.42–37.72)</td>
<td>0.03 (0.01–0.11)</td>
</tr>
<tr>
<td>Index test blind</td>
<td>18</td>
<td>0.96 (0.93–0.98)</td>
<td>0.96 (0.91–0.99)</td>
<td>21.61 (11.20–41.70)</td>
<td>0.04 (0.02–0.08)</td>
</tr>
<tr>
<td><strong>Partial-Thickness Tears</strong></td>
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<tr>
<td>All studies</td>
<td>15</td>
<td>0.72 (0.58–0.83)</td>
<td>0.93 (0.89–0.96)</td>
<td>10.91 (6.26–19.02)</td>
<td>0.30 (0.19–0.48)</td>
</tr>
<tr>
<td>Prospective design</td>
<td>6</td>
<td>0.70 (0.50–0.85)</td>
<td>0.93 (0.85–0.97)</td>
<td>10.36 (3.58–29.96)</td>
<td>0.32 (0.17–0.61)</td>
</tr>
<tr>
<td>Frequency ≥10MHz</td>
<td>6</td>
<td>0.74 (0.60–0.85)</td>
<td>0.97 (0.94–0.98)</td>
<td>21.62 (11.73–39.86)</td>
<td>0.26 (0.16–0.43)</td>
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<tr>
<td>Age (y)</td>
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<tr>
<td>≤50</td>
<td>5</td>
<td>0.64 (0.38–0.84)</td>
<td>0.95 (0.86–0.98)</td>
<td>13.06 (5.75–29.63)</td>
<td>0.38 (0.19–0.73)</td>
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<td>50+</td>
<td>8</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>Prevalence (%)</td>
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<td></td>
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<tr>
<td>≤20</td>
<td>5</td>
<td>0.60 (0.37–0.80)</td>
<td>0.88 (0.75–0.95)</td>
<td>4.96 (1.78–13.84)</td>
<td>0.45 (0.24–0.86)</td>
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<tr>
<td>21–30</td>
<td>7</td>
<td>0.77 (0.56–0.90)</td>
<td>0.96 (0.93–0.98)</td>
<td>19.80 (10.94–35.86)</td>
<td>0.24 (0.11–0.50)</td>
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<tr>
<td>Bias avoided</td>
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<td></td>
</tr>
<tr>
<td>Partial verification</td>
<td>7</td>
<td>0.72 (0.50–0.87)</td>
<td>0.92 (0.85–0.96)</td>
<td>8.76 (3.78–20.32)</td>
<td>0.30 (0.15–0.62)</td>
</tr>
<tr>
<td>Index test blind</td>
<td>13</td>
<td>0.75 (0.61–0.85)</td>
<td>0.94 (0.91–0.96)</td>
<td>12.73 (7.96–20.34)</td>
<td>0.27 (0.17–0.43)</td>
</tr>
</tbody>
</table>
Ottenheijm et al. 2010

• Results
  – Subacromial bursitis (3 studies)
    • Sensitivity 79-81%; Specificity 94-98%
  – Tendinopathy (2 studies)
    • Sensitivity 67-93%; Specificity 88-100%
  – Calcific tendonitis (2 studies)
    • Sensitivity 100%; Specificity 85-98%
Full-thickness tear

<table>
<thead>
<tr>
<th>Study</th>
<th>TP</th>
<th>FP</th>
<th>FN</th>
<th>TN</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martin-Hervas 2001</td>
<td>15</td>
<td>0</td>
<td>11</td>
<td>35</td>
<td>0.58 [0.37, 0.77]</td>
<td>1.00 [0.90, 1.00]</td>
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<tr>
<td>Paavolainen 1994</td>
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<td>1</td>
<td>7</td>
<td>21</td>
<td>0.74 [0.54, 0.89]</td>
<td>0.95 [0.77, 1.00]</td>
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<tr>
<td>Takagishi 1996</td>
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<td>0</td>
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<td>84</td>
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<td>1.00 [0.96, 1.00]</td>
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<td>Roberts 2001</td>
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<td>0.82 [0.70, 0.91]</td>
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<td>18</td>
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<td>0.80 [0.59, 0.93]</td>
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<td>94</td>
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<td>1.00 [0.78, 1.00]</td>
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Partial-thickness tear
### Calcifying tendonitis

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<tr>
<th>Study</th>
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<th>TN</th>
<th>Sensitivity</th>
<th>Specificity</th>
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<td>6</td>
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<td>0.67 [0.41, 0.87]</td>
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<td>1</td>
<td>22</td>
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<td>1.00 [0.85, 1.00]</td>
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### Tendinopathy

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<th>TN</th>
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<td>0.98 [0.95, 0.99]</td>
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<td>Naredo 1999</td>
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<td>0.81 [0.65, 0.92]</td>
<td>0.95 [0.87, 0.99]</td>
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</tbody>
</table>

### Subacromial bursitis
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• Conclusions
  – “We strongly recommend ultrasound in patients for whom conservative treatment fails...
    • to rule in or out full-thickness tears
    • to rule in partial-thickness tears
    • and to a lesser extent to diagnose tendinopathy, subacromial bursitis and calcific tendonitis
    • ...to help physicians tailor treatment”
Wrap up - Conclusions

• U/S provides similar sensitivity and specificity with regard to diagnosis of rotator cuff tears (full- and partial-thickness) compared to MRI – and may be better than MRI for partial-thickness.

• U/S has several benefits – including patient preference and cost – but is very operator dependent.
When U/S is preferred

- Experienced operator/interpreter
- Contraindication to MRI (absolute and relative)
  - Implanted devices (pacemaker, insulin pump, baclofen pump, neurostimulator, cochlear implant)
  - Metallic fragments, clips, or devices in the brain, spinal canal, eye, etc. (aneurysm clip)
  - Severe claustrophobia
- Evaluation of soft tissue adjacent to metal implant
- Cost (Jon A. Jacobson 2009 review article in AJR)
  - Diagnostic U/S of an extremity with image documentation – Medicare physician fee schedule payment ~ $101 for technical fee and $31 for professional fee
  - MRI of upper extremity joint without contrast - $371.00 for technical fee and $73.00 for professional fee
When MRI is preferred

- Additional clinical information is needed that is not as readily available with U/S examination
  - Glenoid labrum
  - Joint capsule
  - Articular cartilage
  - Surrounding muscle or bone
- Lack of availability of expertise in MSK U/S
- If patient fails to improve with conservative treatment and U/S was thought to be normal or uncertain
- No contraindications to MRI
- Surgeon preference
References

References

Accuracy of MRI, MR Arthrography, and Ultrasound in the Diagnosis of Rotator Cuff Tears: A Meta-Analysis

Joseph O. de Jesus1
Laurence Parker
Andrea J. Frangos
Levon N. Nazarian

Accuracy of Diagnostic Ultrasound in Patients With Suspected Subacromial Disorders: A Systematic Review and Meta-Analysis

Ramon P. Ottenheijm, MD, Mariëtte J. Jansen, MSc, J. Bart Staal, MSc, PhD, Ann van den Brul, MD, PhD, René E. Weijers, MD, PhD, Rob A. de Bie, MSc, PhD, Geert-Jan Dinant, MD, PhD