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MRI of Rotator Cuff Tendon Tears – An Introduction

Part 2: Description and Relevant Associated Findings

ABSTRACT

The commonest clinical indication for referring a patient to undergo shoulder magnetic resonance imaging is a suspicion of possible rotator cuff injury. In addition to diagnosing the presence or otherwise of an actual tear and assessing the surrounding soft tissue and skeletal structures, the radiologist's role is to convey diagnostically and prognostically useful information that helps referring clinicians devise optimal management plans for their patients. A short description of how MR imaging of the shoulder is acquired, in addition to relevant MR rotator cuff tendon anatomy, was the focus of part 1, whereas this article shall describe rotator cuff tendon tears in detail.

KEYWORDS

Shoulder, Magnetic resonance imaging (MRI), Radiology, Rotator cuff, Tendon

INTRODUCTION[1,2]

Rotator cuff tendon tears (RCTs) may be either acute or chronic; acute tears are classically seen following a fall or lifting of heavy objects, whereas chronic tears are usually set against a background of intrinsic degeneration and mechanical stresses, with or without adjacent inflammatory changes.

A study performed more than 30 years ago showed that over 95% of torn rotator cuff tendons demonstrated histological evidence of tissue degeneration.[2]

Genetic factors (eg. family history), as well as environmental ones (eg. smoking, hyperlipidaemia), are also thought to play a role, potentially via a deleterious effect on the tendon microvasculature.[3]

CLASSIFICATION – TEARS AND ASSOCIATED FINDINGS

RCTs may also be defined by their thickness and extent.[4-6] A partial-thickness (PT) tear (Fig. 1) may be articular-sided, bursal-sided or interstitial/intrasubstance in nature. By definition, PT tears do not allow communication between the glenohumeral joint space and the subacromial-subdeltoid bursa.

High-grade tears (i.e. those involving greater than 50% of tendon thickness) have a 55% chance to progress to full thickness (FT), whereas low-grade tears (those involving less than 50% of tendon thickness) have only a 14% chance of progression.[7]

Articular-sided tears tend to be commoner with respect to bursal-sided ones (3:1), with recent studies showing that intrasubstance tears may nevertheless be the commonest ones.[4]

Bursal-sided tears also tend to be more painful, thereby tending to present earlier clinically.

ROTATOR CUFF TENDON TEARS (RCTS) MAY BE EITHER ACUTE OR CHRONIC; ACUTE TEARS ARE CLASSICALLY SEEN FOLLOWING A FALL OR LIFTING OF HEAVY OBJECTS, WHEREAS CHRONIC TEARS ARE USUALLY SET AGAINST A BACKGROUND OF INTRINSIC DEGENERATION AND MECHANICAL STRESSES, WITH OR WITHOUT ADJACENT INFLAMMATORY CHANGES

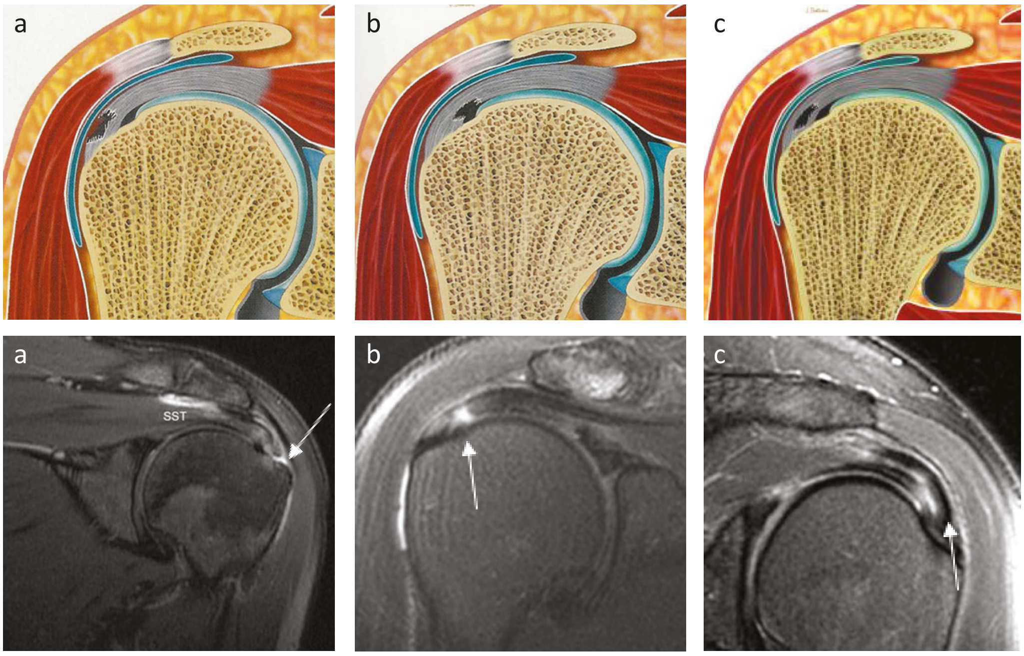


Figure 1. PT tears, diagrammatic (first row) and MRI (second row) representation.
a - bursal-sided,
b - articular-sided,
c - interstitial.[5,8,9]

PT tears may or may not involve the tendon insertion (Fig. 2), leading to various subtypes (eg. PASTA (Partial Articular Supraspinatus Tendon Avulsion)/rim-rent lesion affecting the supraspinatus tendon footplate, whereas a PAINT (Partial Articular-sided tear with INTratendinous extension) lesion affects the non-insertional articular fibres as well as showing an interstitial component).

Classically, PT tears will show up on MRI as fluid-filled foci within tendon tissue.

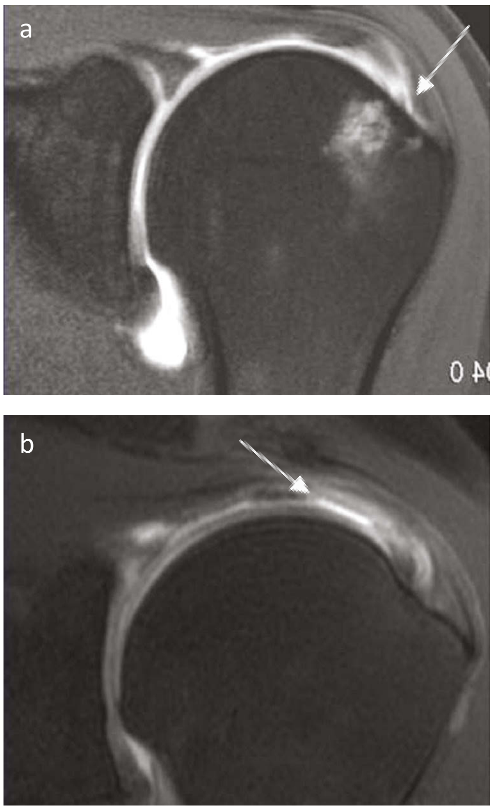
Interstitial tears[10] propagate along the path of least resistance between the collagen fibres (between layers II and III), resulting in cuff delamination. They tend to propagate in a horizontal fashion along the tendon's long axis, and may coexist with a bursal or articular-sided component.

Pure interstitial tears do not communicate with either tendon surface, hence being arthroscopically invisible, leading to the recently coined term 'concealed interstitial delaminating' (CID) lesion.

Overall accuracy of MRI for PT tears is less than that for FT tears. This may be secondary to the formation of granulation/scar tissue within the tendon defect, as well as the relative absence of peritendinous fluid.

Articular-sided, PT tears that coexist with interstitial components may contribute to the development of sentinel cysts.[10-12] These are clinically silent entities, seen in approximately 1% of RCTs, be they PT or FT in nature (Fig. 3).

Figure 2. Examples of PT tendon tears on selected coronal oblique fat-saturated (FS) T1-weighted MR arthrography images.[10]
a – PASTA lesion,
b – PAINT lesion.



Articular fluid enters the delaminating component of the tear via a ball-valve mechanism, leading to cyst development. The cysts tend to be oriented parallel to the long axis of the involved muscle, and may develop within a different, otherwise intact myotendinous unit.

FT tears, by definition, allow communication between the glenohumeral articular and subacromial-subdeltoid spaces. They are best evaluated on fluid-sensitive sequences (with/out fat signal suppression) and evaluated in at least two planes (usually coronal and sagittal, Fig. 4).

The most common appearance of a FT tear is high signal intensity on a fluid-sensitive sequence that extends from the articular surface of the rotator cuff to the subacromial-subdeltoid space. This is the finding observed in approximately 90% of FT tears proven at surgery.[13]

In chronic RCTs in which the shoulder joint has little or no effusion, the humeral head may be high-riding, with not much high signal being identified at the tear site. Fibrous thickening of the subacromial-subdeltoid bursa may develop in a few patients with chronic tears. This may mimic an intact tendon in the absence of an effusion and may lead to misdiagnosis. In the case of acute RCTs, blood products principally platelet-rich plasma may sometimes mimic some intact fibers, another potential diagnostic pitfall.

FT tears don't heal on their own: without treatment, they tend to progress, causing fatty infiltration and atrophy of the corresponding muscle bellies, altered shoulder dynamics and ultimately osteoarthritis.[13]

The sagittal plane dimensions of RCTs determine whether they are small (<1cm), medium sized (1-3cm), large (>3-5cm), or massive (>5cm).[14,15] It is very important to assess for integrity or otherwise of the overlying deltoid musculotendinous unit, with injuries of the latter entity being associated with massive, FT RCTs.[16]

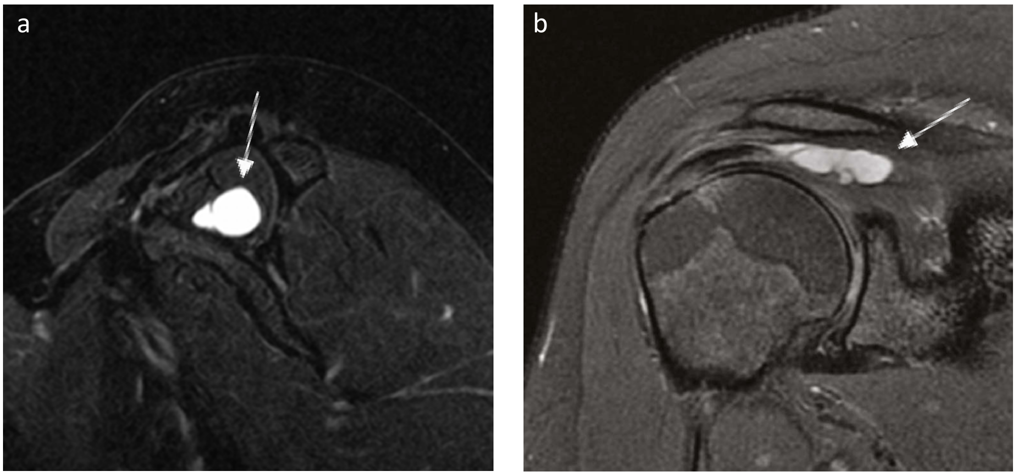


Figure 3. Sagittal (a) and coronal (b) oblique images showing a lobulated intramuscular cyst within the supraspinatus muscle belly.[11,12]

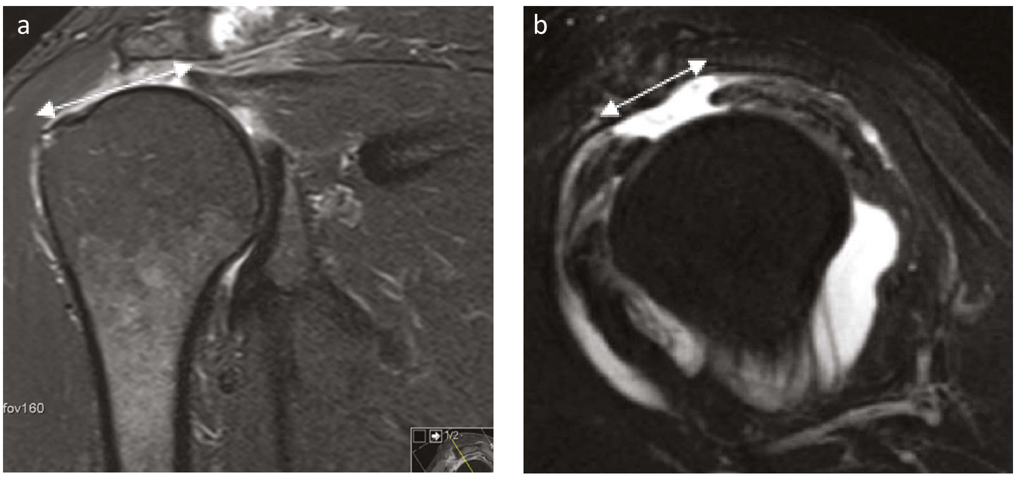


Figure 4. Two-plane evaluation (a-coronal, b-sagittal) of a FT supraspinatus insertional tendon tear (double-headed arrows).[11]

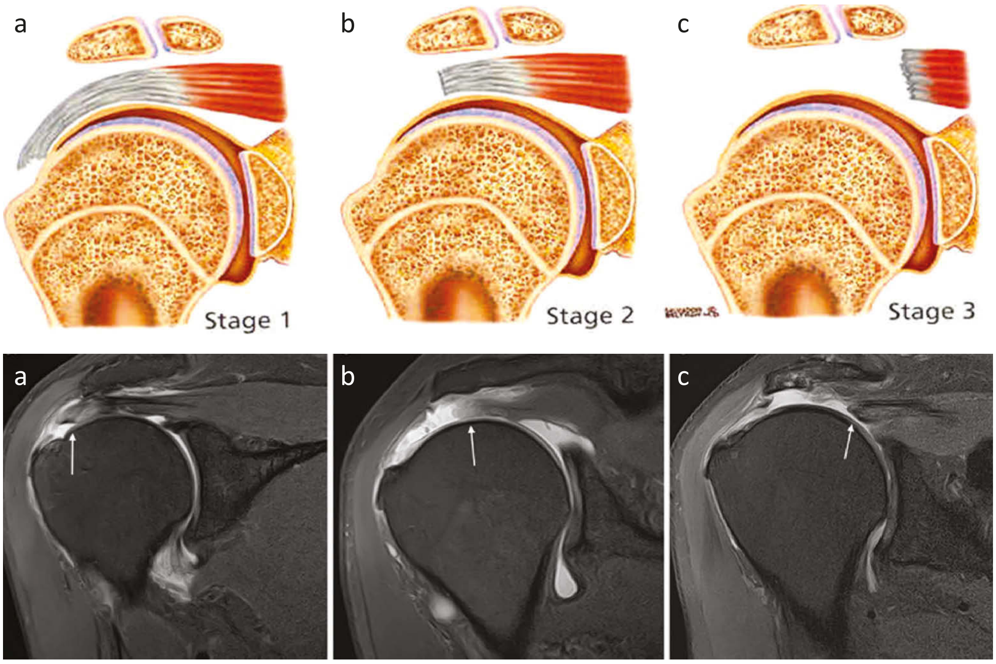


Figure 5. Supraspinatus FT tendon tears, different stages of retraction. Diagrammatic representation (first row), and coronal oblique MR arthrography images (second row).[6,17]

Stage 1, minor retraction;

Stage 2, retraction up to the vertex of the humeral head;

Stage 3, retraction over the superior glenoid margin.

Figure 6. Different stages of muscle volume/fatty infiltration seen on sagittal oblique T1-weighted imaging, as per Goutallier classification.[21]

Normal | Stage 1 | Stage 2 | Stage 3 | Stage 4

The degree of tendon retraction in the coronal plane (Fig. 5) also needs to be determined:[17]

Stage I - little retraction of the proximal tendon stump.

Stage II - retraction of the stump up to the apex of the humeral head.

Stage III -retraction of the tendon to the level of the glenohumeral joint line.

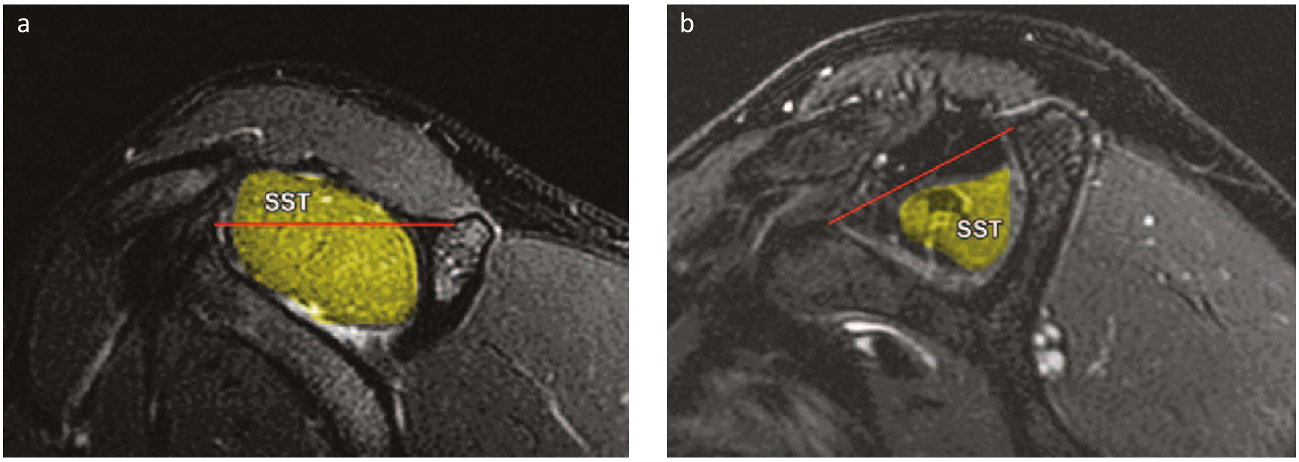
Longstanding FT RCTs can result in muscle atrophy and fatty infiltration, thereby preventing successful surgical repair. Various methods for muscle atrophy evaluation on MRI have been described in the radiology literature, in view of the fact that fatty degeneration is an important predictive factor for surgical outcome, especially at the infraspinatus level.[18-20] This tends to develop more quickly and more severely in larger, FT tendon tears.

The Goutallier classification system, originally utilized for CT imaging[19] and then validated for MRI,[20] is universally utilised for staging (Fig. 6):

Stage 0 Normal
Stage 1 Minimal fatty streaking
Stage 2 Muscle>fat
Stage 3 Muscle=fat
Stage 4 Fat>Muscle

The 'tangent' sign[22-24] and 'occupation ratio'[23] are amongst the most commonly used methods that help quantify the degree of atrophy and fatty degeneration present in muscles. A positive tangent sign (Fig. 7) is present when a line drawn across the roof of the supraspinous fossa fails to intersect through the supraspinatus muscle belly.[24] This tends to be seen

Figure 7. Selected sagittal oblique proton density FS (PD-FS) images.[22]
a - Negative tangent sign: red line drawn across the roof of the supraspinous fossa intersects a normal-volume supraspinatus muscle belly,
b - Positive tangent sign: red line drawn across the roof of the supraspinous fossa fails to intersect an atrophic supraspinatus muscle belly.[2]



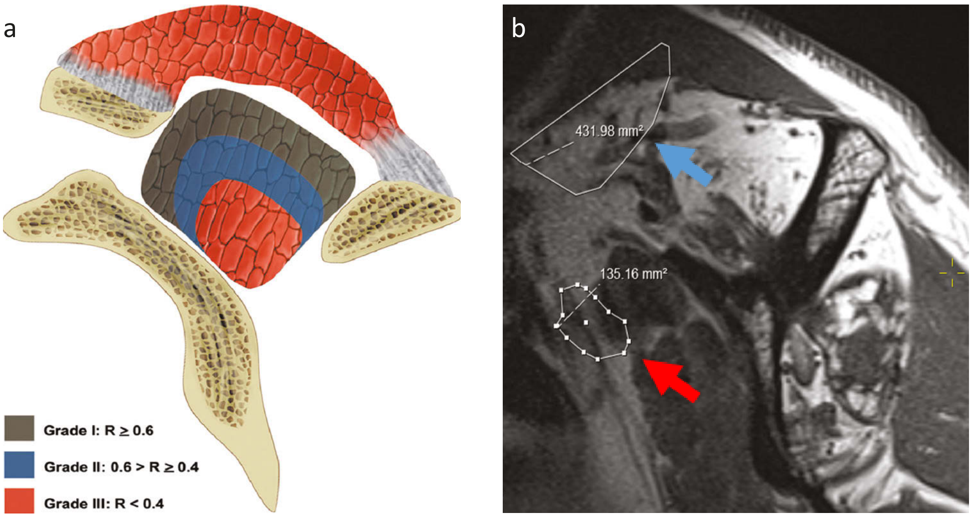


Figure 8.
a - Diagrammatic representation of the occupation ratio.
b - Significant atrophy of the supraspinatus muscle belly (red arrow), relative to the supraspinous fossa cross-sectional area (blue arrow).[23]

between 4-5 years after a FT RCT, and is a useful predictor of whether a tear is surgically repairable or not.

Thomazeau and colleagues[23] proposed the occupation ratio (Fig. 8), whereby the cross-sectional area of the muscle is divided by the cross-sectional area of the supraspinous fossa. A normal value is a ratio of 0.6 or above, with one that is less than 0.4 signifying severe atrophy.

Both of these two methods need to be carried out medially, because of possible significant medial muscle belly retraction following a FT tear, leading to potential errors.[22]

A NORMAL [OCCUPATION RATIO] VALUE IS A RATIO OF 0.6 OR ABOVE, WITH ONE THAT IS LESS THAN 0.4 SIGNIFYING SEVERE ATROPHY

OTHER FACTORS TO CONSIDER WHEN REPORTING RCTS

Humeral head migration/acromiohumeral interval (AHI, Fig. 9)[25]

Acromial morphology (Fig. 10):[26] downsloping (coronal images) or inferiorly hooking (sagittal images); lateral subacromial bony spurs measuring > 5mm in size have been associated with tear development.

Persistent os acromiale (Fig. 10):[27] relevant in the adult population, given the associated dynamic instability as well as the development of underlying bony spurs.

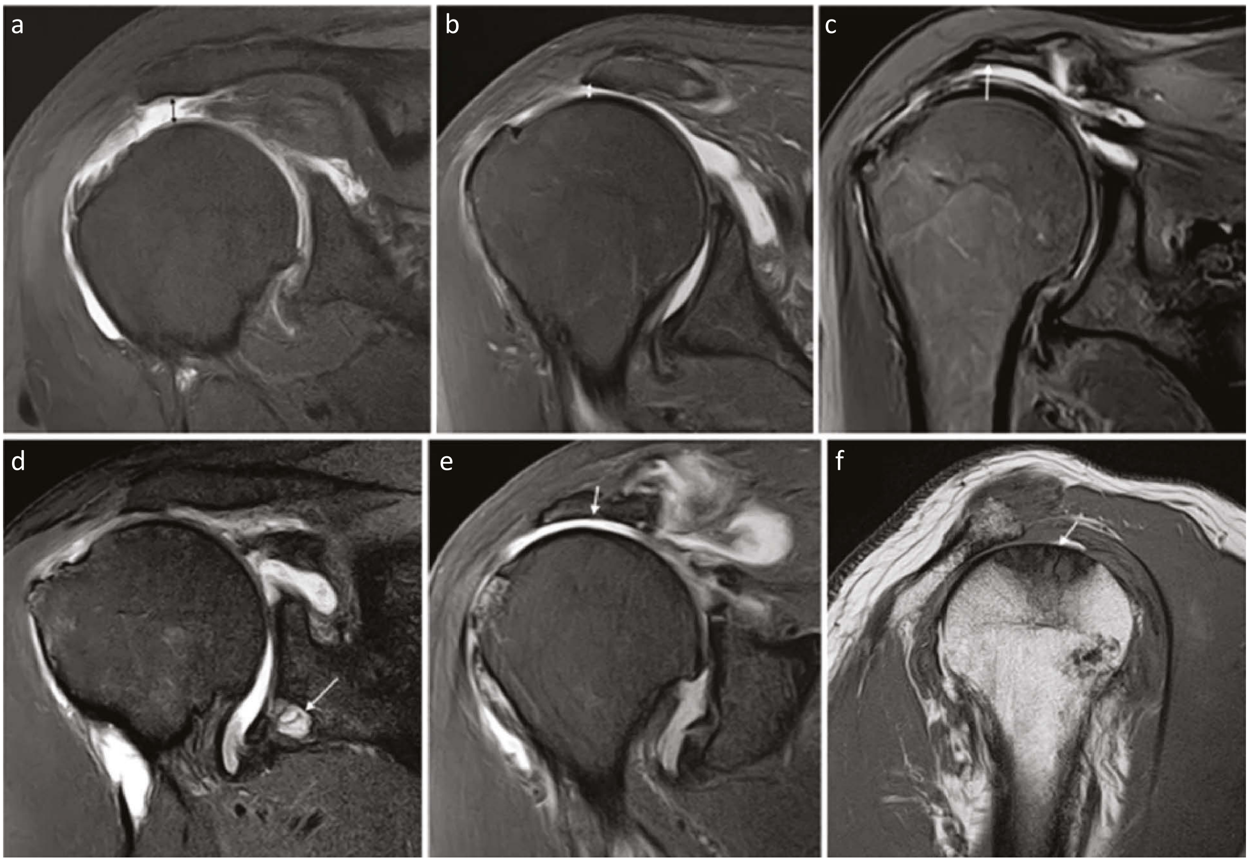
Acromioclavicular (AC) joint morphology - undersurface marginal osteophytes may contribute towards mechanical impingement.[28]

Labral morphology/tears- paralabral pseudocysts arising from glenoid labral tears may contribute to cuff muscle denervation and potential instability, in addition to clinical weakness.

Long head of biceps (LHB) tendon – location (medialisation relative to the subscapularis footplate) and morphology (may be torn in conjunction with large/ massive RCTs).[28]

Figure 9. Hamada rotator cuff arthropathy stages of evolution.[18,25] Coronal oblique PD-FS (a-e), sagittal oblique T1-weighted (f) images.
a - Stage 1 AHI>5mm (double-headed arrow).
b - Stage 2 AHI <5mm (double-headed arrow).
c - Stage 3 AHI plus acetabularised acromial undersurface (arrow).
d - Stage 4a - same as stage 2 but with accompanying glenohumeral degeneration (arrow).
e - Stage 4b - as 4a plus acetabularised acromial undersurface (arrow).
f - Stage 5 - osteonecrosis at the humeral head apex (arrow).

The term 'acetabularization', as described by Hamada et al., refers to an excavating deformity of the acromion undersurface or an excessive spur deformity along the coracoacromial ligament.



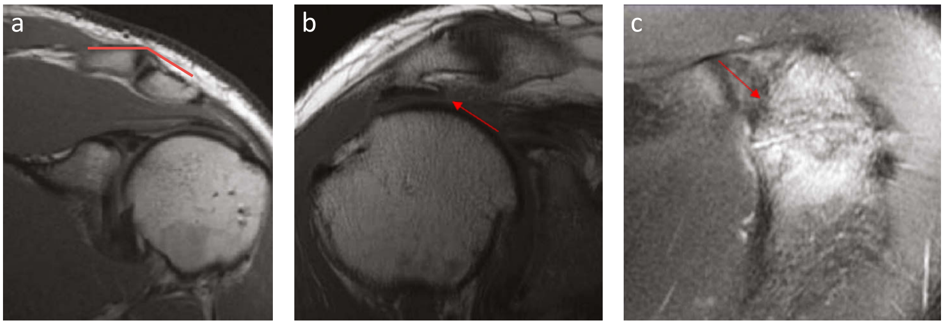


Figure 10[5,12]**.**
a - Laterally downsloping acromion.
b - Prominent subacromial ' keel' osteophyte (red arrow).
c - Os acromiale with florid subarticular marrow oedema-like signal changes (red arrow).

SUMMARY: WHAT THE SURGEON NEEDS TO KNOW[29]

- Type, Location of tear
- Size (2 planes)
- Muscle Atrophy/fatty infiltration
- Chronicity (implies the presence of a less compliant tendon)
- Quality of tissues (tendon stump resorption; fibrillated tendon edges)
- Elevation of Humeral Head/? cuff arthropathy
- Acromial Morphology
- Status of LHB Tendon

CONCLUSION

RCTs are a common, significant cause of pain and reduced mobility, varying in size, location, pattern, functional impairment, and potential repairability. Radiological findings of RCTs have a decision-making impact on patients, depending on the factors outlined above. It is therefore up to the radiologist to deliver a meaningful report that is useful to the referring clinician, thereby assisting in optimal treatment selection.

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