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*This modality offers a high degree of sensitivity and specificity*

# Effective use of MRI: Scanning the shoulder

*ABSTRACT: Baby boomers often exercise to fight disease and have soft tissue injuries that result from age-related compromise of their musculoskeletal system. MRI can serve as a powerful evaluation tool for shoulder and knee injuries. A good command of anatomic knowledge of these sites is needed. The major plane of interest in evaluation of rotator cuff abnormalities is the coronal plane. T2-weighted MRI scans demonstrate high signal intensity at the site of a partial-thickness tear. In full-thickness tears, T2-weighted images demonstrate bright fluid extending through the tendon. Although impingement syndrome is primarily a clinical diagnosis, MRI may help rule out other pathology. The major plane of interest in evaluation of shoulder instability is the transaxial plane.*
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As the early baby boomers cross the threshold of age 60 years and the younger boomers enter their 50s, a new epidemic is occurring in the United States. Middle-aged Americans are continuing their exercise regimens to combat diabetes mellitus, hypertension, and heart disease, but in the process they often compromise their musculoskeletal system by unknowingly exceeding its diminishing capabilities. The resulting increase in exercise- and sports-related injuries—nicknamed "boomeritis"—has become the number 2 reason for doctor visits across the nation, according to a 2003 National Ambulatory Medical Care Survey.

To meet the increasing demands of these injuries in a growing population of baby boomers, physicians need some proficiency in soft tissue damage evaluation. MRI can serve as a powerful evaluation tool, especially for injuries in commonly involved joints, such the shoulder and knee. The high anatomic resolution of MRI, combined with a good command of anatomic knowledge of these sites, rewards diligent physicians with a high degree of sensitivity and specificity. For more discussion, see the Box, "The clinical utility of MRI," on page 846.

This 2-part article reviews the preoperative use of MRI for making the diagnosis of soft tissue injuries of the shoulder and knee. In this first part, we discuss the anatomy of the shoulder joint and optimal MRI scanning procedures for detecting rotator cuff tears, impingement syndrome, and shoulder instability. The second part, to appear in a later issue of this journal, will describe MRI scanning techniques for knee injuries, as well as cartilage injury.

## ROTATOR CUFF

### The muscles

The muscles and tendons of the rotator cuff are important for glenohumeral joint stability and essential for synchronous motion of the shoulder girdle. The subscapularis muscle, which is essential for internal rotation, has a broad origin site on the anterior scapula and inserts onto the lesser tuberosity of the humerus. The most superior portion of the posterior scapula contains the origin of the supraspinatus muscle, which has its insertion site on the greater tuberosity of the humeral head. The supraspinatus muscle

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## The clinical utility of MRI

Appropriate and cost-effective use of MRI of the shoulder must be considered in the context of the clinical skills and experience of the clinician, the index of suspicion for various diagnoses, and the expectations and needs of the patient. In some cases, MRI may be used as a triage tool, whereby decisions can be made about the need and urgency for referral to an orthopedic surgeon. For example, distinguishing full-thickness tears of the supraspinatus from subacromial bursitis may be quite difficult on physical examination, but a high-quality MRI scan has excellent sensitivity for rotator cuff tears. Cuff tears, especially those in physiologically young patients, should be referred for surgical consultation.

In contrast, other shoulder disorders are not particularly well seen by MRI. For example, chondral injuries are easy to miss with use of the current shoulder MRI routines, but they are easy to visualize arthroscopically.

For the most efficient approach, first develop a good clinical differential diagnosis. Then establish the effect of MRI information on the triage or treatment of each individual patient.

and tendon are involved in shoulder abduction; the supraspinatus tendon is the most commonly injured structure of the rotator cuff.

Posterior to the supraspinatus and the spine of the scapula is the origin of the infraspinatus muscle. Inferior to this is the origin of the teres minor muscle. Both insert onto the greater tuberosity of the humerus and provide external rotation force for the humerus.

**Figure 1 –** *This coronal cross section of a patient's right shoulder demonstrates a bursal-sided high-grade partial-thickness rotator cuff tear. The red arrow points to the region of high signal intensity.*

### Evaluating abnormalities

The major plane of interest in the evaluation of rotator cuff abnormalities is the coronal. T1-balanced and T2-weighted images should be used in the coronal plane.[1] In addition, a transaxial T1-weighted series or gradient echo sequence is useful for evaluating abnormalities of the subscapularis tendon.[2]

Because tendons are composed of a dense collagenous material, they usually produce no signal when the rotator cuff is in a healthy state. A high-intensity signal that originates from the tendon is associated with pathology, such as tendinosis, inflammation, or a tendon tear.[1,2] A normal, healthy rotator cuff tendon appears as a black line in coronal section.[3]

### Partial-thickness tears

This kind of tear is a lesion that extends partway through the thickness of the tendon from superior to inferior; it may be further classified as involving the articular or the bursal surface (Figure 1). T2-weighted MRI scans demonstrate high signal intensity at the site of the lesion because of the presence of fluid. The fluid may involve the articular surface, bursal surface, or interstitial portions of the tendon.

Surgical management of partial-thickness rotator cuff tears involves either debridement or tendon repair, depending on the degree of tendon involvement. Partial-thickness tears do not require urgent surgical intervention because the tendons are still attached to the tuberosity—in contrast to full-thickness tears, concerns about tendon retraction and muscle atrophy and fatty infiltration are minimized with partial-thickness tears.

### Full-thickness tears

This kind of lesion is defined as a tear that extends all the way through the tendon from superior to inferior; however, it does not necessarily extend all the way through the tendon from anterior to posterior. T2-weighted images demonstrate bright fluid extending through the entire thickness of the tendon from superior to inferior. Retraction of the tendon because of muscle atrophy may be present. A massive tear of the rotator cuff, including disruption of the supraspinatus and infraspinatus and portions of the subscapularis tendons, may lead to a high-riding humeral head that may articulate with the undersurface of the acromion.

Muscle atrophy and fatty infiltration are important prognostic indicators for surgical intervention. When these findings are advanced, the probability of successful tendon healing and restoration of power is decreased markedly.

### Sensitivity and specificity

MRI has demonstrated high sensitivity and specificity in the diagnosis of rotator cuff injury. The sensitivity and specificity of MRI are about 0.9 for both partial- and full-thickness tears.[4]

Although MRI is useful for picking up partial-thickness cuff tears and tendinosis, imaging alone usually is not sufficient for making surgical decisions about rotator cuff repair versus debridement. These decisions must be made at the time of arthroscopic evaluation.

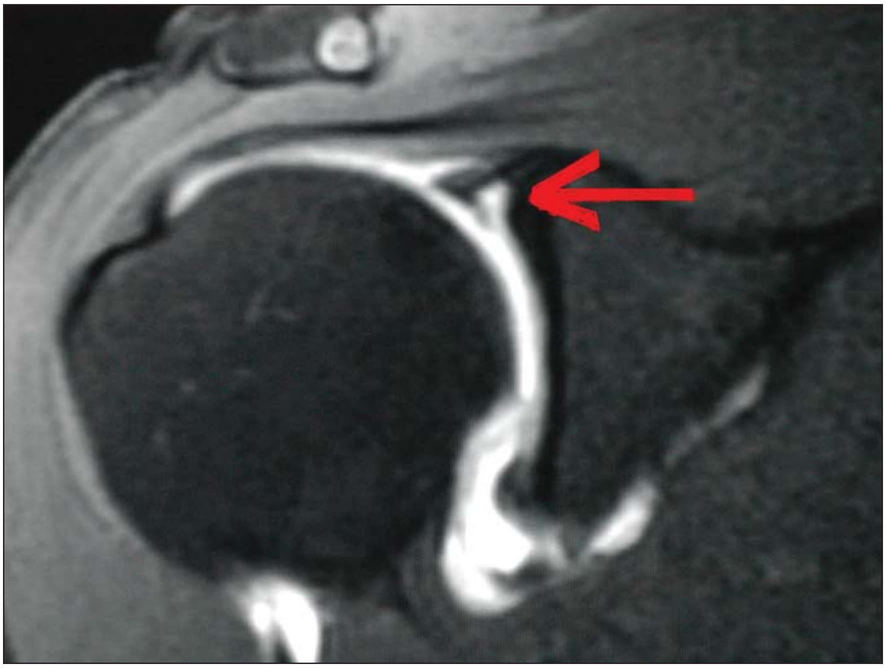

**Figure 2 –** *In this coronal cross section of a patient's right shoulder, the red arrow indicates a region of high signal intensity in the superior labrum, indicative of a superior labral anterior posterior lesion.*

## IMPINGEMENT SYNDROME

This is shoulder pain caused by acromial compression of the rotator cuff tendons that results in damage to the tendons. Although impingement syndrome is primarily a clinical diagnosis and its presence may be confirmed by intrabursal lidocaine injection, MRI may help rule out rotator cuff–associated and other periarticular pathology.

The same series of images that are used for rotator cuff abnormalities may be used here. In addition, a sagittal T1-weighted series may be useful for evaluating the coracoacromial arch.

MRI examination may be used to evaluate acromial morphology.[5] Type 1 acromions have a flat undersurface; type 2, a curved undersurface; and type 3, a hooked undersurface. Types 2 and 3 acromions predispose patients to impingement. Secondary signs of impingement syndrome are a thickened coracoacromial ligament and a thickened subacromial bursa.

## GLENOHUMERAL JOINT MOBILITY AND INSTABILITY

The glenohumeral joint of the shoulder provides the highest degree of movement of any joint in the body because the surface area of the humeral head is 4 times as large as that of the glenoid cavity and very few bony or ligamentous structures restrict joint movement. Many mechanisms compensate for the inherent instability of the shoulder that is associated with its wide range of motion. Again, the muscles and tendons of

## Practice Points

- The coronal plane is the major plane of interest in MRI evaluation of rotator cuff abnormalities. Tendons usually produce no signal when the rotator cuff is in a healthy state.
- In partial-thickness rotator cuff tears, T2-weighted MRI scans demonstrate high signal intensity at the site of the lesion.
- In full-thickness tears, T2-weighted images demonstrate bright fluid through the entire thickness of the tendon.

the rotator cuff play an important role in keeping the humeral head apposed to the glenoid bone, but many other structures help.

The fibrocartilaginous glenoid labrum that surrounds the glenoid bone increases the surface area between the glenoid and humeral head and deepens the glenoid fossa. An articular capsule surrounds the joint, and ligaments reinforce it.

The superior, middle, and inferior glenohumeral ligaments add joint stability, although they vary in size and orientation. This anatomic variability is important in the context of MRI interpretation.[6] The glenohumeral ligaments are found on the anterior surface of the glenoid labrum and connect to the humerus. The inferior glenohumeral ligament is the most important structure that provides anterior shoulder instability.[7]

### Evaluation of instability

The major plane of interest in evaluation of shoulder instability is the transaxial plane. Therefore, T1-weighted, balanced, and T2-weighted sequences are used in this plane. In addition, a T1-weighted coronal (oblique) sequence is added to this series gradient; echo sequences also may be used.

Defects of the superior labrum (superior labral anterior posterior [SLAP] lesions) most often result from a fall onto an outstretched arm or from repetitive stress on the superior labrum caused by an overhead throwing motion. The trauma may cause fraying of the labrum or detachment of the fibrocartilaginous labrum from the osseous glenoid. The superior labrum is best visualized with a coronal cross section (Figure 2). It normally appears as a dark triangular structure. Evaluation of the labrum for SLAP lesions may be improved with injection of intraarticular gadolinium before MRI scanning (MR arthrography).

Perilabral cysts often are associated with labral tears, but the diagnosis is quite difficult to make on physical examination. MRI is exquisitely sensitive for cystic structures because they are filled with fluid.

Defects of the anterior glenoid labrum are associated with anterior shoulder dislocation. In transaxial cuts, a normal anterior glenoid labrum appears to have a triangular shape and usually is dark.

MRI is also useful for picking up humeral avulsion of the glenohumeral ligaments (the so-called HAGL lesion). The presence of avulsion may affect whether an arthroscopic or open repair surgical strategy is used. Images also should be scrutinized for a bony avulsion injury, particularly at the anteroinferior corner of the glenoid, because its presence may affect surgical management decisions. If better bony detail is required for decision making, CT scanning is the preferred imaging modality. ■

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