Magnetic resonance imaging of external impingement of the shoulder and rotator cuff disease

Poster No.: C-2397
Congress: ECR 2016
Type: Educational Exhibit
Authors: I. Tsifountoudis\textsuperscript{1}, E. Dionisiadis\textsuperscript{1}, I. Kalaitzoglou\textsuperscript{1}, N. Patsinakidis\textsuperscript{2}, N. Kartalis\textsuperscript{1}, A. Xirokostas\textsuperscript{1}, \textsuperscript{1}Thessaloniki/GR, \textsuperscript{2}Ptolemaida/GR
Keywords: Pathology, Education and training, Imaging sequences, Education, MR, Musculoskeletal joint, Musculoskeletal system
DOI: 10.1594/ecr2016/C-2397

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

To discuss the current trends on imaging diagnosis of rotator cuff (RC) disease, beginning with a discussion of the complex anatomy of the RC, continuing into the normal and pathologic magnetic resonance imaging (MRI) appearances of the RC including tendinopathy and tearing and concluding with the relationship between external shoulder impingement (EI) and RC disease.
Background

Shoulder pain is the third most common complaint made by patients, especially the elderly, to their physicians. The leading causes of this pain diagnosed after clinical examination in the majority of these patients are RC disease and impingement syndromes.

RC muscles perform multiple functions and are often injured during various activities. The anatomy and physiology of the RC is complex and interconnected to adjacent structures in the shoulder. The relationship between RC disease and EI has been the subject of much research. Patients with symptoms of EI are referred for imaging to identify bony abnormalities of the coracoacromial arch and associated bursal and RC disease. Many attempts have been made to identify objective imaging criteria that confirm the diagnosis of impingement, but at present EI remains primarily a clinical diagnosis.
Findings and procedure details

RC ANATOMY

Supraspinatus, infraspinatus, subscapularis and teres minor are the four muscles that contribute to the RC formation (Figure 1). The RC tendons are composed of water, collagen type I and a low amount of proteoglycans and glycosaminoglycan side chains. RC has a complex ultrastructure of five distinct histologic layers with a tendon fascicular orientation that varies according to depth. This layered fiber orientation allows the RC to withstand tensile forces in different directions throughout glenohumeral joint motion. The deep extension of the coracohumeral ligament (CHL) within the RC is called "rotator cable" and it has recently received increasing attention. It has a width of 1 cm and it is located in layer 4 of the RC, directly apposed to layer 5, which is the joint capsule. Another important anatomic element of the RC is the "cable-crescent complex". It is formed by the anterior attachment of the supraspinatus tendon and the posterior attachment of the infraspinatus tendon onto the greater tuberosity. It functions as the supporting limbs of the RC, much like a suspension bridge. Most cuff tears occur in this thinner, crescent portion of the cuff and this possibly explains why some cuff tears may be biomechanically insignificant. On the other hand, tears of the rotator cable itself or of its supporting limbs may have severe biomechanical consequences. A detailed biomechanical study, depicted that the most anterior 8 to 12 mm of the supraspinatus tendon, immediately posterior to the bicipital groove, is the primary load-bearing structure for force transmission within the supraspinatus. It is suggested that tears involving this region should be considered for early surgical repair, whereas repair for crescent tears may be more safely delayed.

Supraspinatus

The supraspinatus muscle arises from the supraspinatus fossa and the superior surface of the scapular spine. It comprises two distinct muscle bellies, the anterior and the posterior. The anterior belly occupies the anterior three-quarters of the fossa and the posterior belly occupies the remainder. The tendon of the anterior belly is cordlike and longer than the posterior tendon, which is quadrangular in shape. The larger volume of the anterior muscle belly suggests that it generates more force than the posterior muscle belly. Coupled with more heterogeneous pennation angles, it may explain the higher incidence of anterior tendon tears due to increased stress.

Infraspinatus
The infraspinatus muscle has two distinct portions, with the larger oblique portion arising from the infraspinatus fossa and the smaller transverse portion arising from the inferior surface of the scapular spine. A morphological and histologic study showed that the tendon of the transverse portion is composed of a thin membrane-like tissue that attaches to the tendon of the oblique portion without reaching the greater tuberosity.

Subscapularis

The subscapularis muscle arises from the medial two-thirds of the anterior surface of the scapula, passing laterally beneath the coracoid and scapular neck. The superior two thirds of the subscapularis transitions to tendon at the level of the glenoid and blends with the fibers of the joint capsule before insertion onto the lesser tuberosity. The inferior third of the subscapularis is considered to have a "muscular" insertion, attaching onto the surgical neck of the humerus almost directly by way of a thin membranous structure.

Teres Minor

The teres minor muscle, which is narrow in the cranial-caudal dimension and elongated in the medial-lateral dimension, arises from the middle portion of the lateral border of the scapula and the variable dense fascia of the infraspinatus muscle. Absence of this fascia, as described in the literature, does not allow the identification of the border between the infraspinatus and teres minor muscles on MRI. The humeral insertion of the teres minor muscle is composed of an egg-shaped upper portion that attaches to the vertical facet of the greater tuberosity and a band-shaped lower portion attaching onto the surgical neck.

RC PATHOLOGY

The etiology of RC disease is multifactorial including risk factors such as advancing age, smoking, and genetic predisposition. Furthermore, impingement and overload are also implicated as inciting factors in RC disease. The exact role of the RC in the generation of shoulder pain is controversial. Although in most of the cases RC pathology is symptomatic with need of treatment, not all RC abnormalities cause symptoms. What is more, cases of cuff tears in "asymptomatic" patients that may become symptomatic with anatomical deterioration are also described in the literature. The use of the term "RC disease" comprises tendinopathy and tendon tears because these diagnoses are less controversial and have generally accepted histologic and surgical definitions.
Tendinosis

Tendinosis of the RC is caused by tendon degeneration in the setting of overuse. Histopathology demonstrates mucoid, fibrillar, and eosinophilic degeneration and chondroid metaplasia, rather than inflammation. On MRI, tendinosis appears as increased signal on low TE images and intermediate on T2-weighted images (Figure 2). However, this signal is not as bright as fluid.

Partial-thickness tears

A partial RC tear involves only a portion of the tendon. Partial-thickness tendon tears can be classified into articular-sided, bursal-sided, or intrasubstance tears (also referred to as interstitial or intratendinous tears) (Figure 3-5). Intrasubstance tears include both delaminating tears as well as focal tears confined within the footprint of the tendon. According to the literature, partial-thickness tears typically begin 13 to 15 mm posterior to the biceps tendon, near the junction of the supraspinatus and infraspinatus tendons. The typical site of initiation in the medial-lateral dimension may vary depending on the type of partial-thickness tear. Partial-thickness tears should be further characterized as low grade (grade 1, < 3 mm deep), moderate grade (grade 2, 3-6 mm deep), or high grade (grade 3, > 6 mm deep), which is based on the assumption that an average "normal cuff" thickness is 10 to 12 mm. The accuracy of MRI for the detection of partial-thickness cuff tears is lower than that for full-thickness cuff tears, and meta-analyses have shown standard MRI to demonstrate 64% sensitivity and 92% specificity and MR arthrography (MRA) to demonstrate 86% sensitivity and 96% specificity. On MRI, partial tears are seen as a focal fluid signal within the tendon, without complete extension from the bursal to the articular surface. Increased linear fluid-signal intensity that extends along the long axis of the tendon is consistent with an intrasubstance tear, or it can represent delamination when there is communication with the bursal or articular surfaces. If a chronic partial tear has started to develop granulation tissue, the signal may be somewhat hypointense to fluid. Partial tears are seen in patients of all ages, most commonly affecting the supraspinatus tendon. Partial articular-sided tears are more common than bursal-sided tears, occurring in 60% of partial tears. In young patients, partial tears are more commonly associated with trauma or overhead throwing sports. Partial articular-sided tears are the most common partial tear subtype in young athletes. Partial anterior bursal-sided tears occur most commonly in younger patients in the setting of trauma, in the anterior leading edge of the supraspinatus. Partial bursal-sided tears of the posterior supraspinatus tend to be degenerative in origin and occur in the older population. Delaminating or intrasubstance tears occur within the substance of the tendon and may contact the articular surface of the tendon. Delaminating tears may be associated with an intramuscular cyst. A rim-rent tear
is a type of partial tear that extends from the articular surface of the supraspinatus tendon into the footprint on the greater tuberosity (Figure 6). These tears are most commonly seen in young patients and overhead throwing athletes.

Subscapularis tendon tears have received an increasing amount of attention in the current literature with a prevalence of 6% in a recent study of 244 patients who underwent arthroscopy. Sensitivity of MRI for the diagnosis of partial-thickness subscapularis tears was referred to be 63%, although other authors have found a lower sensitivity of MRI for diagnosing subscapularis tendon tears. These tears are not only difficult in diagnosing with imaging but they can also be missed or underappreciated even on routine arthroscopy. Partial-thickness tears can be diagnosed by thoroughly evaluating the expected footprint of the subscapularis, particularly at the superior aspect, because the vast majority (> 90%) of subscapularis tendon tears begin at the articular-cephalad aspect of the tendon insertion. If the footprint appears narrower than expected on axial images, a partial-thickness articular-sided tear can be diagnosed. The interpreting radiologist should ensure that evaluation is made at the correct axial level of the superior subscapularis tendon and not in the rotator interval by cross-referencing with the sagittal and coronal oblique images (Figure 7).

Full-thickness tears

Full-thickness tears extend between the articular and bursal surfaces of the tendon and may be either focal, involving just one portion of the tendon (Figure 8), or complete (full thickness, full width), involving the entire tendon (Figure 9). Whether the tears are focal or complete, both the anterior-posterior and medial-lateral dimensions of the tears should be measured (Figure 10). If the tear involves a large portion of the tendon, or the entire tendon, the length of tendon retraction should also be reported (Figure 11). In addition to the degree of tendon retraction, the preoperative location of the myotendinous junction (MTJ) in full-thickness RC tears may have prognostic value after RC repair. A recent study showed that if the MTJ was lateral to the glenoid face, there was a > 90% chance of healing in comparison with a MTJ that was medial to the glenoid face where the chances of healing were 50%. Full-thickness cuff tears that are 5 cm in the largest dimension and involve at least two tendons can be considered "massive" (Figure 12). However, accurate measurements may be difficult to ascertain, even at surgery, due to markedly degenerated tissue edges. The presence of delamination should also be reported because this finding may be missed during routine arthroscopy and can lead to lower healing rates. MRI is very accurate for full-thickness cuff tears with meta-analyses showing 92% sensitivity and 93% specificity for standard MRI and 95% sensitivity and 99% specificity with MRA. On MRI, a full-thickness tear is characterized by fluid signal intensity (SI) extending from the bursal to the articular surface on fluid sensitive images. If the tear is chronic, there may be hyperintense granulation tissue interposed between the subacromial-subdeltoid (SASD) bursa and the humeral head. Full-thickness RC tears in
patients < 55 years are most often traumatic. Full-thickness tears in patients > 55 years are usually degenerative; these tears have been shown to occur posteriorly in the RC, at the junction of the posterior supraspinatus and anterior infraspinatus.

ASSOCIATED FINDINGS

Fluid in the SASD bursa is generally seen with full-thickness tears, and this fluid may even extend into and through the acromioclavicular joint (ACJ), a finding referred to as the "Geyser sign" on MRI (Figure 13).

Granulation tissue is frequently seen in chronic full-thickness tears and manifests as fluid or a complex signal that is hypointense to fluid on MRI (Figure 14).

RC assessment should also include the evaluation of RC muscles. The severity of RC muscle fatty degeneration associated with RC tears correlates with poor functional outcome after repair. The five-stage Goutallier grading system is widely used to evaluate the muscles of the RC on MRI, although it was initially introduced using CT. Musculature is evaluated on a 5-point scale, grades 0 to 4. Grade 0 is normal; grade 1 shows some fatty streaks; grade 2 shows more muscle than fat; grade 3 shows equal parts fat and muscle; and grade 4 shows more fat than muscle. On MRI using sagittal images, it may be easier to evaluate the muscle signal with three grades: normal to mild fatty infiltration, moderate fatty infiltration (where there is less fat than muscle), or severe fatty infiltration (where there is greater fat than muscle) (Figure 15).

MR IMAGING PITFALLS

The magic angle artifact is seen on low TE images and occurs when the tendon fibers are oriented at 55 degrees to the body coil causing them to appear with high SI. This artifact most commonly occurs in the critical zone of the distal supraspinatus tendon and may be misdiagnosed as tendinosis. The signal abnormality disappears by changing the imaging protocol parameters.

The rotator cable is a low SI structure that extends from the CHL to the undersurface of the supraspinatus and infraspinatus tendons. It serves to distribute forces about the humeral head.

Branches from the anterior and posterior circumflex humeral vessels provide direct blood supply to the humeral head and may be mistaken for subcortical cysts. Prominent-appearing vessels in the distal RC muscles and tendons are normal variants and should not be mistaken for intrasubstance tears or cysts.
EI SYNDROME

Shoulder impingement is one of the most common causes of shoulder pain in adults. While the diagnosis of impingement is primarily clinical, MRI can confirm the clinical suspicion or depict the abnormality. Impingement is typically divided into **external** and **internal** categories. EI is caused by structural changes outside of the joint, and includes **primary**, **secondary**, and **subcoracoid** types.

**Primary and secondary impingement**

Both primary and secondary impingement types are related to narrowing of the supraspinatus outlet, a fibroosseous tunnel created by the humeral head inferiorly and the acromion, ACJ, and the coraco-acromial ligament (CAL) superiorly.

In **primary impingement**, such narrowing is attributable to degenerative changes of the ACJ or acromial morphology, with resultant pathologic involvement of the SASD bursa and the supraspinatus tendon. The patients usually present with pain during overhead or repetitive motion. Secondary impingement has a similar presentation, but in such cases the narrowing is believed to be the result of elevation of the humeral head due to instability from joint laxity, often because of repetitive shoulder abduction and external rotation.

MRI demonstrates both bone and soft tissue abnormalities.

It has been suggested that **variations** in the configuration of the acromion may be responsible for subacromial impingement and RC lesions. Three distinctive acromial types have been described according to the undersurface morphology. A type I acromion with a flat undersurface, a type II acromion with a concave curved undersurface, and a type III acromion with a hooked downward facing leading edge (**Figure 16a-c**). Acromial morphology is best assessed using a combination of at least two MRI sections 4 mm lateral to the ACJ. The highest incidence of RC lesions was observed with Type III acromion and the lowest with Type I. A great majority (87%) of the RC tears were found to be associated with either a type II or a type III acromion. However, other studies have disputed these findings, which may be attributable to the unreliable technical reproducibility and high interobserver variability for performing and interpreting subacromial outlet radiographs and even MR images. A Type IV (inferiorly convex) acromion has also been described in the literature, but showed no association with RC tears (**Figure 16d**). Anterior downsloping of the acromion in the sagittal plane and lateral downsloping in the coronal plane have also been implicated in subacromial impingement syndrome (SIS) (**Figure 17**). Finally, change in acromial shape may also be acquired as a result of RC tearing (**Figure 18**).

An **os acromiale** is a developmental abnormality with failure of ossification of the synchondrosis, which is encountered in 1-8% of the population and may be a contributory
factor to EI in some cases. Several different types of os acromiale have been described, and they are well demonstrated on MR, particularly on the axial sections. The separate ossification center is demarcated from the acromion by a low SI band on T1-weighted and proton-density (PD) images, and high SI on T2-weighted and gradient-echo sequences (Figure 19, 20). An unstable os acromiale may cause impingement on the underlying RC. MRI signs of an unstable os acromiale include bone marrow edema, subchondral cysts, and/or fluid at synchondrosis. It is important to notice that the literature is equivocal as to whether an os acromiale is related to a statistically significant increased risk of a RC tear and the presence of SIS.

The CAL extends from the undersurface of the acromion to the coracoid process and is best seen in the sagittal oblique plane as a thin low SI structure. It has a significant role of transmitting forces from the surrounding musculature by increasing the bending force of the acromion and the coracoid, up to 10 and 3 times, respectively. Bone spur formation can be identified on the inferior surface of the acromion at the origin of the CAL. However, low-SI spurs may be difficult to distinguish from the normal low signal intensity of the thickened CAL, unless the spur has ossified and marrow fat is present (Figure 21-24). The presence of a subacromial spur has been proposed as a potential cause of shoulder impingement syndrome. However, it is not entirely clear whether degeneration of the CAL and spur formation is a predisposing factor for impingement or just mere consequence of supraspinatus tendon degeneration.

Capsular thickening, osteophyte formation and subchondral cysts, edema and sclerosis are features of OA of the ACJ on MRI. Inferior osteophytes may impinge on the RC and SASD bursa, and joint malalignment may also contribute to SIS (Figure 24). However, OA of the ACJ is extremely common and not specific for impingement.

**Secondary impingement** is related to glenohumeral or scapulothoracic instability. Abnormal superior migration of the humeral head may lead to narrowing of the supraspinatus outlet. This form of impingement more commonly occurs in younger patients and athletes who perform repetitive overhead or throwing activities. Weakening of the anterior capsule and glenohumeral ligaments results in chronic shoulder instability. Damage to the static stabilizers of the joint, increases the workload over the RC muscles (dynamic stabilizers) and as a consequence of the fatigue of the RC excessive superior humeral head translation and dynamic narrowing of the coracoacromial outlet may take place. Finally, this condition results in undersurface impingement of the RC with subsequent degeneration and tear.

**Subcoracoid impingement**

Subcoracoid impingement occurs as a result of compression of the subscapularis tendon, the subcoracoid bursa, and the anterior joint capsule between the coracoid process and the lesser tuberosity. It is thought to be related to narrowing of the coracoacromial interval, which may be congenital, post-traumatic, or iatrogenic. Patients present with
anteromedial shoulder pain and tenderness of the anterior shoulder over the coracoid process and making the diagnosis is important since overlooking it can result in failed RC repair surgery. Attempts have been made to characterize and measure the coracohumeral interval in order to predict the diagnosis of subcoracoid impingement, but no definitive consensus on this issue has been achieved. Subcoracoid stenosis has been defined as coracohumeral interval of less than 5.5-6mm (Figure 25). However, imaging finding of subcoracoid stenosis is insufficient to establish the diagnosis of impingement in cases of absence of associated pathology or physical exam findings. Usually subcoracoid impingement is diagnosed when direct contact of the coracoid process against the lesser tuberosity of the humerus is observed arthroscopically.

CALCIUM HYDROXYAPATITE DEPOSITION

Calcium hydroxyapatite deposition, calcific tendinosis, or calcific tendinopathy of the shoulder is a painful condition caused by deposition of calcium within or about the RC tendons. Although it occurs most commonly in the supraspinatus tendon, it can occur elsewhere in the body. In the latent and resting phases, patients are asymptomatic. However, in the resorptive phase, patients often develop extreme pain with acute onset. One study showed an incidence of 2.7% in a survey of 6,000 radiographs of the shoulder, with 51.5% of cases involving the supraspinatus tendon. Of these, 35% were symptomatic at some point. Large calcifications may cause impingement on the acromion when the arm is abducted. On radiographs, calcific tendinosis appears as amorphous to well-circumscribed calcification within the tendons. Amorphous calcifications are less well seen on radiographs than well-defined calcifications. On MRI, the deposits are low SI on all pulse sequences, and there is usually edema within the tendon and occasionally within the subjacent bone (Figure 26). Erosive changes at the tendon insertion are occasionally seen.
Images for this section:

**Fig. 1:** Normal MR anatomy of the RC. (a) Coronal T1-weighted image showing subscapularis tendon inserting onto the lesser tuberosity (arrows); (b, c) coronal T1-weighted images showing supraspinatus and infraspinatus tendons inserting onto the greater tuberosity (arrows); (d) sagittal PD image with fat saturation showing RC tendons (arrows) and long head of biceps tendon (long arrow); (e) axial gradient echo image showing subscapularis and infraspinatus tendons inserting onto the lesser and greater tuberosity respectively and long head of biceps tendon located into the bicipital groove (long arrow). (Sub: subscapularis; Sup: supraspinatus; Inf: infraspinatus; Ter: teres minor).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 2: Tendinosis. (a) Coronal T1-weighted image, (b) coronal PD-weighted image with fat saturation and (c) sagittal PD-weighted image with fat saturation demonstrate thickening of and increased intermediate signal within the supraspinatus tendon insertion, consistent with tendinosis (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 3:** Articular-sided partial-thickness tear of the supraspinatus tendon. (a) Coronal PD-weighted image with fat saturation and (b) sagittal PD-weighted image with fat saturation show discontinuity of the articular fibers and intact bursal fibers (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 4: Bursal-sided partial-thickness tear of the supraspinatus tendon. (a) Coronal PD-weighted image with fat saturation and (b) sagittal PD-weighted image with fat saturation show discontinuity of the bursal fibers (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 5:** Intratendinous partial-thickness tear of the supraspinatus tendon. (a) Coronal PD-weighted image with fat saturation and (b) sagittal PD-weighted image with fat saturation show high signal within the tendon, consistent with an intrasubstance tear (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 6:** Rim-rent partial-thickness tear. (a) Coronal PD-weighted image with fat saturation, (b) sagittal PD-weighted image with fat saturation and (c) axial PD-weighted image with fat saturation show a small articular-sided tear involving the insertional fibers of the anterior most aspect of the supraspinatus (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 7: Partial subscapularis tendon tear. (a) Axial gradient echo image and (b) sagittal PD-weighted image with fat saturation show a partial tear of the subscapularis tendon (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 8:** Focal full-thickness supraspinatus tear. (a) Coronal PD-weighted image with fat saturation and (b) sagittal PD-weighted image with fat saturation demonstrate a small focal full-thickness tear, extending from the bursal surface to the articular surface (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 9:** Near-complete supraspinatus tear. (a) Coronal T2-weighted fat-saturated and (b) corresponding sagittal T2-weighted fat-saturated image show fluid signal extending from bursal to articular surface with retraction of the supraspinatus to the acromion (arrows). A small remnant of supraspinatus tendon remains attached to the footprint (long arrow).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 10:** Focal full-thickness supraspinatus tendon tear. (a) Coronal oblique and (b) sagittal fat-saturated T2-weighted images of the same patient show focal full-thickness tear of the supraspinatus tendon. Double-headed arrows indicate the greatest dimension of the tear.

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 11:** Full-thickness supraspinatus tear with medial tendon retraction. (a) Coronal oblique T2-weighted fat-saturated image shows medial retraction of the stump of the supraspinatus tendon almost to the glenoid fossa (arrow). (b) Axial gradient echo image in the same patient shows depositions of hemosiderin with very low signal intensity within the joint capsule and the periarticular tissues, which is consistent with pigmented-villonodular synovitis (PVNS) (arrows). (c) Axial T1-weighted fat-saturated image after intravenous administration of contrast medium demonstrates pathologic enhancement of the synovium (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 12: Massive full-thickness RC tear. (a) Coronal oblique T2-weighted fat-saturated image shows medial retraction of the stump of the subscapularis tendon (arrows) with dislocation of the biceps tendon outside from bicipital groove (black arrows). (b) Coronal oblique T2-weighted fat-saturated image shows medial retraction of the stump of the supraspinatus tendon to the glenoid fossa (arrow). (c) Coronal oblique T2-weighted fat-saturated image shows medial retraction of the stump of the infraspinatus tendon almost to the glenoid fossa (arrows). (d) Axial gradient echo image shows medial retraction of the stumps of subscapularis and infraspinatus tendons (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 13: "Geyser" sign on MRI in a patient who presented with a palpable ACJ mass. (a) Coronal T2-weighted fat-saturated, (b) coronal T1-weighted and (c) sagittal T2-weighted images show a complete supraspinatus tear with retraction of the tendon (long arrow). Fluid is seen extending from the glenohumeral joint, through the ACJ and into the overlying soft tissues (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 14:** Full-thickness supraspinatus tendon tear. (a) Coronal T2-weighted fat-saturated image and (b) corresponding sagittal T2-weighted fat-saturated image show the tear with granulation tissue in the tendon defect (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 15: Muscle fatty degeneration and volume loss in the supraspinatus muscle. (a) Coronal oblique T1-weighted image shows a full-thickness tear of the supraspinatus tendon with retraction of the tendon (arrow). The supraspinatus muscle belly appears to be markedly decreased in size. (b) Sagittal T1-weighted image shows severe fatty degeneration and volume loss in the supraspinatus muscle belly. The volume of the subscapularis and infraspinatus muscle bellies appears to be unchanged (Sub: subscapularis; Sup: supraspinatus; Inf: infraspinatus).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 16: Acromial morphology. Sagittal PD-weighted images with fat saturation show Type I (a), Type II (b), Type III (c) and Type IV (d) types of acromia.

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 17: Acromial morphology. (a) Coronal oblique T1-weighted image and (b) coronal oblique T1-weighted image adjacent to (a) show lateral acromial slanting. (c) Coronal oblique T1-weighted image and (d) coronal oblique T2-weighted fat-saturated image demonstrate lateral downsloping of the acromion with a tiny undersurface spur, which impinges on the supraspinatus tendon. Associated fluid collection within the SASD bursa is also present.

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 18: Acromial morphology in a patient with full-thickness supraspinatus tear. (a) Coronal oblique T1-weighted image and (b) corresponding T2-weighted fat-saturated image. The acromial shape has been modified due to bony eburnation as a result of chronic superior subluxation and impingement of the humeral head on the undersurface of the acromion (arrows). Secondary osteoarthritic changes are also evident in the glenohumeral joint with osteophyte formation (arrows). The stump of the torn supraspinatus tendon is medially retracted to the glenoid fossa (long arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 19: Os acromiale. (a) Axial T1-weighted, (b) corresponding axial gradient echo image, (c) coronal oblique T1-weighted image and (d) corresponding coronal PD-weighted fat-saturated image demonstrate an os acromiale with osteophyte formation (arrows). The ununited ossification center is separated from the remainder of the acromion by a low SI line on the T1-weighted images and a bright SI line on the gradient-echo image.

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 20:** Os acromiale. (a, b) Axial CT images demonstrate a case of bilateral os acromiale with osteophyte formation (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 21: Thickened CAL. (a, b) Sequential coronal oblique T2-weighted fat-saturated images and (c) sagittal oblique T2-weighted fat-saturated image show a prominent CAL (arrows) associated with edema in the SASD bursa (long arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 22:** Thickened CAL. (a, b) Coronal oblique T1-weighted and corresponding T2-weighted fat-saturated images and (c) sagittal oblique T2-weighted fat-saturated image show a prominent CAL (arrows) associated with subtle edema in the SASD bursa and tendinosis of the supraspinatus tendon (long arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 23:** Subacromial spur. (a) Coronal oblique T1-weighted image and (b) corresponding T2-weighted fat-saturated image in a patient with subacromial enthesophyte formation on the undersurface of the acromion (long arrows). There is fat marrow signal intensity within the bony spur, which impinges the supraspinatus tendon, and associated tendinosis (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Fig. 24: Osteoarthritic changes within the ACJ and subacromial spur. (a, b) Coronal oblique T1-weighted and corresponding T2-weighted fat-saturated images and (c) sagittal oblique T2-weighted fat-saturated image demonstrate osteoarthritic changes within the ACJ with bone marrow edema and inferior osteophyte formation (arrows) and a subacromial spur (black arrows). The osteophytes impinge on the supraspinatus tendon, and there is tendinosis and associated bursitis (long arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 25:** Subcoracoid impingement. Axial gradient echo image in the same patient with figure 7 at the level of the coracohumeral interval depicts that in this case of clinically suspected subcoracoid impingement, a narrowed coracohumeral interval (4.8mm) and a partial tear of subscapularis tendon were observed, supporting the diagnosis (arrow).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
**Fig. 26:** Calcific tendinitis of the RC tendons. (a, b, c) Coronal oblique T2-weighted fat-saturated images and (d, e) axial gradient echo images show the deposits of calcium hydroxyapatite within subscapularis, supraspinatus and infraspinatus tendons presenting with low SI on both sequences (arrows).

© Radiology, 424 General Military Hospital - Thessaloniki/GR
Conclusion

Diagnostic imaging of the RC and EI, performed by MRI, provides valuable information about the nature of the injury and is essential for optimal treatment planning and prognostic accuracy.
References


Chard MD, Hazleman BL. Shoulder disorders in the elderly (a hospital study). Ann Rheum Dis 1987;46(9):684-687


Vahlensieck M, an Haack K, Schmidt HM. Two portions of the supraspinatus muscle: a new finding about the muscles macroscopy by dissection and magnetic resonance imaging. Surg Radiol Anat 1994;16(1):101-104


Löhr JF, Uhthoff HK. Epidemiology and pathophysiology of rotator cuff tears [in German]. Orthopade 2007;36(9):788-795


Adams CR, Schoolfield JD, Burkhart SS. Accuracy of preoperative magnetic resonance imaging in predicting a subscapularis tendon tear based on arthroscopy. Arthroscopy 2010;26(11):1427-1433


Bigliani LU, Morrison DS, April EW. The morphology of the acromion and its relationship to rotator cuff tears. Orthop Trans 1986;10:228


Nakagawa S, Yoneda M, Hayashida K, et al. The posterior rotator interval may be the initial site of rotator cuff tears in baseball players. J Shoulder Elbow Surg 1997;6:S246


Lo IKY, Parten PM, Burkhart SS. Combined subcoracoid and subacromial impingement in association with anterosuperior rotator cuff tears: an arthroscopic approach. Arthroscopy 2003;19(December (10)):1068-78

Friedman RJ, Bonutti PM, Genez B. Cine magnetic resonance imaging of the subcoracoid region. Orthopedics 1998;21(5):545-548
