Shoulder: Rotator Cuff Repair

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1.1 Introduction

Imaging evaluation of the postoperative rotator cuff remains challenging despite advancements in both our understanding of the normal evolution of the postoperative rotator cuff appearance with time and the imaging techniques themselves. It is critical that radiologists and other musculoskeletal care providers understand the normal procedures for operative repair of the rotator cuff, so that they have a baseline of what a "normal" repaired cuff should look like and develop an understanding of when to call a re-tear vs. normal expected postoperative findings. Furthermore, it is important to understand advantages and disadvantages of both MRI and ultrasound for evaluation of the cuff in the normal non-injured state, normal postoperative state, and postoperative state with new injury suspicious for re-tear. This chapter aims to provide such context.

1.2 Operative Management of Rotator Cuff Repairs

Radiologists' familiarity with conventional approaches to operative repair of a rotator cuff tendon or tendons is critical for optimal postoperative evaluation. Before MRI evaluation or live scanning with ultrasound, it is ideal if the operative report for the initial repair can be reviewed, so that any particular modifications or deviations from the standard cuff repair procedure are not misconstrued as new injury. For example, alterations in a patient's anatomy due to tendon transfer procedures (commonly performed with massive rotator cuff tears) can create a perplexing situation for the interpreting radiologist.

Many cases of rotator cuff tear can be managed conservatively, especially in patients with lower demands. However, where patients have persistent symptoms or functional

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deficit or in patients with high level of demand on their shoulder such as athletes, operative repair may be required. While both degenerative and traumatic tears can be repaired, it has been suggested that better results are achieved in younger patients with traumatic tears [1]. Rotator cuff repair is most commonly performed arthroscopically or, if more visualization and access is required, through a mini-open technique requiring a deltoid split. Although subscapularis repair is more technically challenging arthroscopically compared to conventional open repair, recent studies show better patient outcomes in terms of range of motion and pain with arthroscopic approaches. The mini-open repair technique seems to be associated with more postoperative complications and is thus less preferred to fully arthroscopic repair, which is associated with decreased short-term pain and is considered the standard of care for most tears [2].

Typical indications for repair are:

1. Acute full-thickness tendon tears
2. Bursal-sided tears >25% in depth
3. Articular-sided tears >50% in depth
4. Partial articular supraspinatus tendon avulsion (PASTA) lesions with >7 mm of exposed bony footprint between the articular surface and intact tendon

A variety of repair techniques are available to reattach the torn tendon to the bone. Initial open repair techniques used bone tunnels to pass suture material through from the greater tuberosity anchor point to the lateral aspect of the tuberosity where they are tied. This can be a problematic technique when bone quality is poor and currently repair is normally accomplished with suture anchors. These can be placed as a single row or a double row with the intention of recreating the footprint of the tendon. The double row technique is intended to maximize the contact area between the torn tendon and tuberosity, recreating the medial to lateral footprint. While the clinical and functional outcome of the double-row technique over the single row is not clearly shown, there is evidence that the double-row technique speeds up tendon healing and reduces re-tear rates. The majority of available studies in the literature also favor double-row repair vs. single row with regard to tensile strength, construct failure, gap formation, and footprint coverage [3–5].

Another described technique known as the suture bridge technique or transosseous equivalent technique uses a row of medially placed suture anchors at the articular margin to anchor the tendon at a point 10–12 mm medial to the lateral edge of the torn tendon. The suture material is then passed over the bursal surface of the tendon lateral to this anchor point and fastened with a row of anchors lateral to the edge of the torn tendon. The suture material therefore acts to compress the tendon repair against the bone in the footprint area. If this technique is used, the radiologist can expect to see suture anchors lateral to the tendon repair site and this should not be misinterpreted as tendon having pulled away from the anchors.

The typical recovery period takes about 8–12 weeks for adequate healing of the cuff tendon to the greater tuberosity. In the case of massive rotator cuff tears, tendon transfer from the pectoralis major (for chronic subscapularis tendon tears) or latissimus dorsi (for large supraspinatus and infraspinatus tendon tears) may be performed. However, tendon transfer procedures require a longer period of rigid immobilization.

In some centers an augmented repair may be used for the treatment of large rotator cuff tears, particularly if there is substantial retraction of the torn tendon or the tendon is of poor quality. In these cases an allograft or a synthetic graft, made from material such as Teflon, is used to augment the repair. Use of a graft has been shown to reinforce primary repairs in massive rotator cuff tears by enhancing biologic tendon healing and overall biomechanical integrity of the repair [6–8]. This can be achieved through a patch graft augmentation after completion of primary repair of the torn tendon or a patch graft bridge, performed for an irreparable defect >1 cm in size with inadequate excursion of the retracted tendon [9]. In the latter, the graft replaces the native rotator cuff tendon as a bridge between the torn tendon and bony footprint [10].

Other procedures which may be performed in addition to suture anchor placement in a repaired cuff at the time of initial surgery include subacromial decompression and rotator cuff debridement, both performed in patients with low-grade partial articular-sided tears.

The most common cause of a failed rotator cuff repair is inadequate healing of the cuff tissue to native bone, which results in suture pullout from the repaired tissue. Risk factors for repair failure include:

- Age > 65 years
- Tear size >5 cm in length
- Muscular atrophy
- History of diabetes mellitus
- Retraction of torn tendon medial to the glenoid

Lastly, superior capsular reconstruction (SCR) may be performed in certain cases (Fig. 1.1a, b), indicated in patients with intolerable pain and/or significant functional deficits (based on the patient's lifestyle) who have failed nonoperative therapies and who

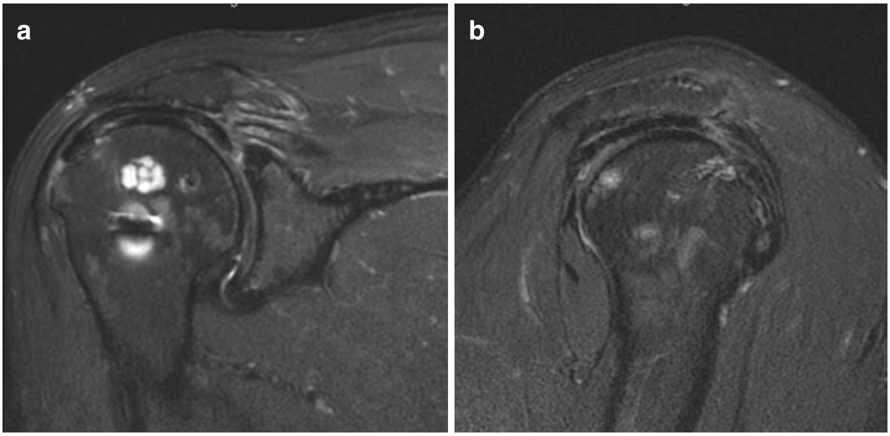

Fig. 1.1 61-year-old male with surgical repair of massive rotator cuff tear involving supraspinatus and a portion of the infraspinatus. Coronal (**a**) and sagittal (**b**) T2-weighted fat-saturated MR images show intact low signal intensity superior capsular reconstruction with dermal allograft. T2 signal hyperintensity at the glenoid attachment represents a suture hole. The sagittal image demonstrates the graft covering the entire superior humeral head. The side-to-side attachment with the infraspinatus tendon is intact

1. have massive, irreparable rotator cuff tears
2. do not have moderate or severe rotator cuff arthropathy
3. have an intact/reparable subscapularis tendon
4. have functional, preserved deltoid musculature [11]

It is contraindicated in patients with moderate to severe rotator cuff arthropathy, patients with glenohumeral osteoarthritis, and in patients with an irreparably torn subscapularis. After successful SCR typically using an acellular dermal allograft, there is passive constraint to superior humeral head translation which helps improve shoulder functionality.

1.3 Imaging Evaluation of the Cuff After Cuff Repair

The mainstays of evaluation of the postoperative rotator cuff are MRI and ultrasound. It is important to note that recurrent tear rates are higher as judged by MRI compared to ultrasound though MRI does offer higher sensitivity [12]. Direct MR arthrography is the most sensitive and specific technique for the diagnosis of partial-thickness or full-thickness rotator cuff tears and post-repair re-tears [13–15], though it may overestimate the failure of healing of repaired cuffs compared to conventional MRI [13].

With optimal protocols and scanning techniques, common re-tear patterns and other complications following rotator cuff repair can be readily identified. In this chapter we will define the expected appearance of the postoperative (i.e., repaired) rotator cuff and the imaging appearance of a range of complications, predominantly focusing on re-tears of a repaired rotator cuff. Both MRI and ultrasound are highly sensitive and specific for detecting rotator cuff tears of the native cuff [15–18], though the sensitivity and specificity drop in the postoperative setting for both modalities.

1.3.1 MRI

Using MRI, the early postoperative period presents a particularly challenging period when evaluating patients with reinjury following rotator cuff repair. This is partly because the repaired tendon(s) can be expected to have a heterogeneous and irregular appearance for a period of about 3–6 months following surgery which can significantly complicate interpretation.

1.3.1.1 Normal Nonoperative RC Tendon

On MRI, the entire length of the supraspinatus and infraspinatus tendons is usually best seen on coronal oblique images, whereas the anterior fibers of the supraspinatus tendon are often best seen on sagittal oblique images. The teres minor tendon is best evaluated on sagittal oblique images, and the subscapularis tendon is best evaluated on axial and sagittal oblique images. The normal tendons should be uniformly hypointense on all pulse sequences on both arthrographic and non-arthrographic MRI exams (Fig. 1.2a, b). Though no strict cutoffs for tendon thickening are routinely used in clinical practice, thickening as well as increased MRI signal are features of tendinosis.

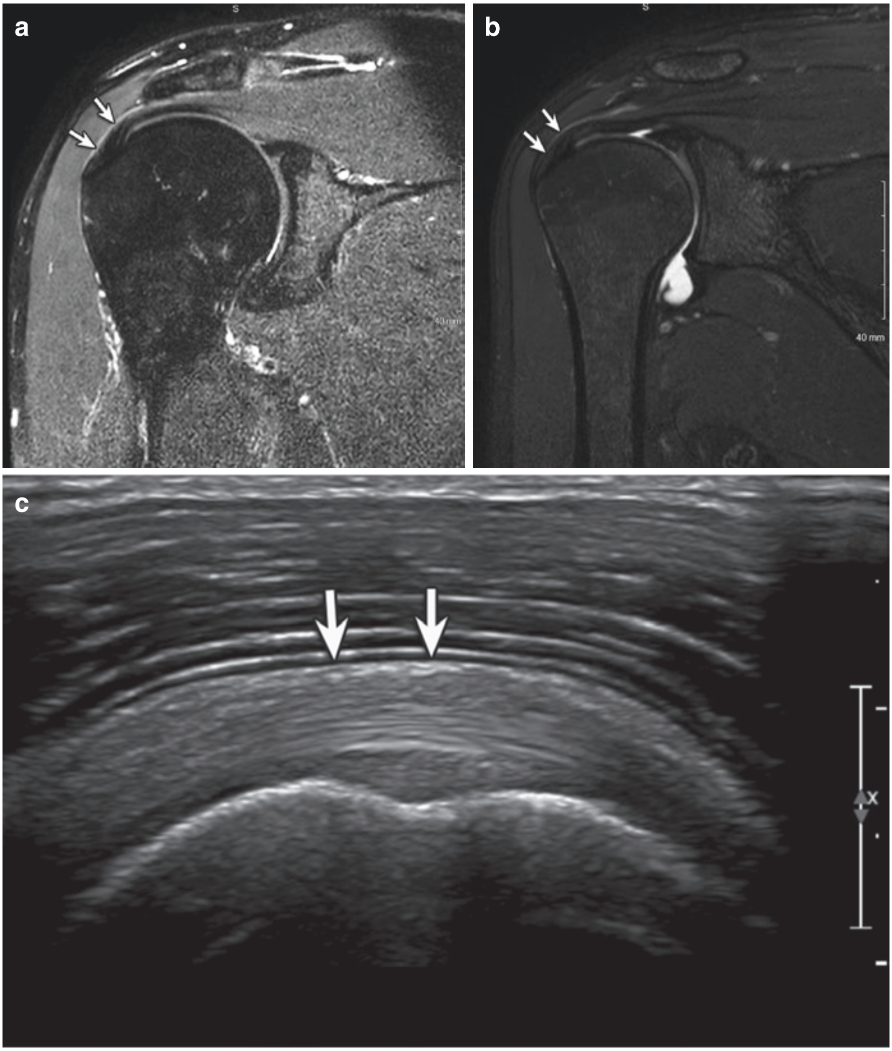

Fig. 1.2 27-year-old male football player with right arm weakness and shoulder pain. The rotator cuff was found to be normal in this patient. (**a**) Coronal T2-weighted fat-saturated MR image shows normal low signal intensity, fibrillar architecture of the supraspinatus tendon (white arrows), with normal appearance of the footprint on the greater tuberosity. (**b**) Coronal T1-weighted fat-saturated MR image after intra-articular injection of gadolinium contrast in this arthrogram shows no penetration of contrast into the supraspinatus tendon (white arrows) to suggest tear. No contrast was seen in the subacromial-subdeltoid bursa to suggest full-thickness rotator cuff tear. (**c**) Long-axis grayscale static ultrasound image of the supraspinatus tendon (white arrows) demonstrates the normal fibrillar and echogenic appearance of a healthy tendon

1.3.1.2 Normal Postoperative (Repaired) RC Tendon

MRI evaluation of the repaired rotator cuff can be inherently challenging due to distortion of normal anatomy and variable degrees of surrounding soft tissue abnormality [19]. In addition, introduced hardware such as suture anchors and, if applicable, graft material may introduce additional artifacts which make interpretation difficult. Fortunately, most implanted rotator cuff hardware used today is made of titanium or plastic and results in minimal metal-related artifact.

The normal MRI appearance of the postoperative rotator cuff (Fig. 1.3) is highly variable, both due to variable healing patterns and due to variations in surgical technique, including a varying number of anchors, number of sutures, and type of sutures used. The factors influencing the postoperative cuff appearance include the extent and chronicity of the native rotator cuff disease, the exact procedure performed, and the time interval between repair and imaging. About 90% of repaired tendons show signal hyperintensity on postoperative MRI [20]. However, there can be significant variability in the postoperative tendon thickness, with tendon thickening due to secondary fibrosis or tendon thinning, as a result of the formation of granulation tissue, both occurring.

Repaired rotator cuff tendon(s) demonstrates intermediate/high signal intensity in the early postoperative period [13, 21]. This appearance reflects postoperative edema, inflammatory change, and/or the formation of granulation tissue. This increased intratendinous signal may persist for several months to years [22] and is considered to be part of the normal spectrum of the postoperative appearance of the rotator cuff tendons [20]. Associated marrow edema may also persist long after rotator cuff repair and should not be routinely interpreted as reflective of fracture [22].

It is critical for radiologists to review operative reports following rotator cuff repairs as operative techniques and thus expected postoperative imaging findings vary considerably, even so much so that in some cases portions of a torn tendon may be left unrepaired due to poor tissue or edge quality or an inadequate length of

Fig. 1.3 56-year-old male with right shoulder pain but no functional deficit following rotator cuff repair 3 months prior. Coronal oblique T2-weighted fat-saturated MR image shows the expected postoperative appearance of the repaired supraspinatus tendon (white arrows). Despite a small amount of signal hyperintensity at the supraspinatus footprint, no tendon fiber discontinuity or clefts were seen, so no tear was called. Incidentally noted were findings of a small glenohumeral joint effusion and small volume subacromial-subdeltoid bursal fluid

tendon to achieve repair. Such diligence can help prevent errors such as unknowingly calling re-tears of intact repairs [23]. Another critical postoperative finding to be aware of reflects the fact that rotator cuff tendon repair procedures do not necessarily produce a "watertight" repair, so postoperative MR arthrography may show contrast material communicating from the glenohumeral joint to the subacromial-subdeltoid bursa without a full-thickness tear present [24, 25]. The radiologist needs to be aware of whether a graft has been used to augment the repair. Graft material will generally show low signal on conventional MRI sequences. There may be an apparent gap at the tendon tear site simulating a re-tear which is in fact bridged by the graft material.

Postoperatively, it is not uncommon to see new T2 signal hyperintensity of the glenohumeral joint capsule and pericapsular soft tissues at the axillary recess [26] which may reflect synovial proliferation and capsular hypervascularity [27]. This new T2 signal hyperintensity in the axillary recess may coincide with limited range of motion of internal and external rotation in some patients at 4-month follow-up [26], findings commonly associated with adhesive capsulitis.

1.3.1.3 Torn Postoperative RC Tendon

Re-tear after surgical repair of the rotator cuff remains a significant problem [28, 29] despite advances in surgical approaches, technique, instrumentation, and imaging techniques. Re-tear rates are reported in the range of 11–68% [30, 31]. The significance of a re-tear is determined by considering the type of surgical repair undertaken, imaging findings, and clinical assessment. Taken together, this information may inform whether further surgery is likely to be successful. Symptomatic smaller partial-thickness tears are sometimes debrided without repair, whereas higher-grade partial-thickness (>50%) and full-thickness tears are commonly repaired with either a single or double row of suture anchors at the greater tuberosity footprint [32]. The double-row suture anchor technique and the suture bridge technique have been reported as having lower tendon re-tear rates [33–36]. Despite these and other advancements in surgical technique for rotator cuff repair over many years, a certain percentage of patients will inevitably succumb to structural failure of the repair [28, 37–40].

Risk factors for rotator cuff tendon re-tear following surgical repair include advanced age, smoker status, longer time interval between initial tear and surgical repair, larger tear size, poor tendon quality, and muscle atrophy [41–43]. It should be noted that MR arthrography performed after rotator cuff repair is thought to result in overcalling of re-tears due to the appearance of pseudo-tears that are a part of the normal healing process [13]. Timing of MRI after rotator cuff repair strongly influences the expected appearance of the repair, and recent data suggest that 6 months postoperatively may be the ideal time to assess and predict for future structural failure after arthroscopic rotator cuff repair [44]. The quality of the underlying bone, repaired tendon, and the muscle must all be considered when assessing the potential for a successful re-operation.

A re-tear of a repaired rotator cuff will typically show a fluid signal intensity cleft at the repair site (Fig. 1.4), along with absence of the heterogeneous repaired tendon at the expected site. As with the native cuff, a re-tear of a repaired rotator cuff may be partial-thickness (Fig. 1.5a, b) or full-thickness or, if involving multiple tendons, may be described as a massive re-tear (Fig. 1.6a–c). The stump of re-torn tendon is typically visible and is often proximally retracted to a variable degree. It is critical to note the absence of tendon bulk (Fig. 1.7a–d) at the expected tendon footprint on the greater tuberosity, as intervening intermediate-signal granulation tissue and scar may create the appearance of a partial-thickness or incomplete re-tear. It is critical to assess both the repair site and the musculotendinous junction in all available planes to assess for changes in the configuration of the repaired tendon which may provide a subtle indication that a re-tear has occurred.

When examined in the early postoperative period after surgery (e.g., 3 months), the repaired rotator cuff typically appears disorganized and heterogeneous on MRI, though this appearance gradually improves and becomes more homogeneous through remodelling and repair from 3 to 12 months [13, 45]. Hyperintense granulation tissue may mimic a re-tear of a repaired rotator cuff tendon, and though these changes tend to decrease with time, they can persist for several months to years and create challenges in interpretation of postoperative MR imaging [46].

A systematic review by Saccomanno and colleagues in 2015 showed that structural integrity of the repaired rotator cuff, dichotomized by the Sugaya classification [40] into intact versus re-tear, was the only one of many variables measured in 120 different analyzed studies that showed good intra- and inter-observer reliability [47]. Other variables analyzed included footprint coverage, tendon thickness, tendon signal intensity, partial re-tear, full-thickness re-tear location, tear size, number of tendons involved, tendon retraction, fatty infiltration, marrow edema and/or cysts in the humeral head, presence of a glenohumeral joint effusion, and the acromiohumeral (AH) interval.

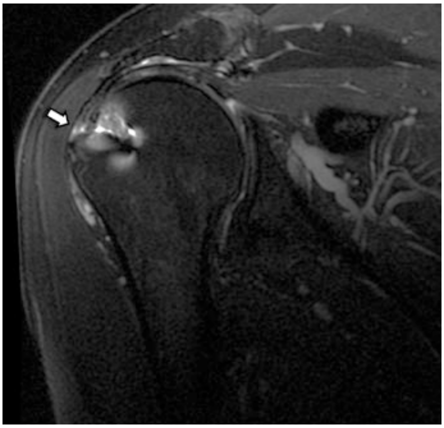

Fig. 1.4 42-year-old male with persistent right shoulder pain, now 1.5 years status-post rotator cuff repair. Coronal T2-weighted fat-saturated MR image shows a focal bursal-sided re-tear (white arrow) at the supraspinatus footprint with mild diffuse thinning/attenuation of the tendon. A small amount of fluid is also noted in the subacromial-subdeltoid bursa

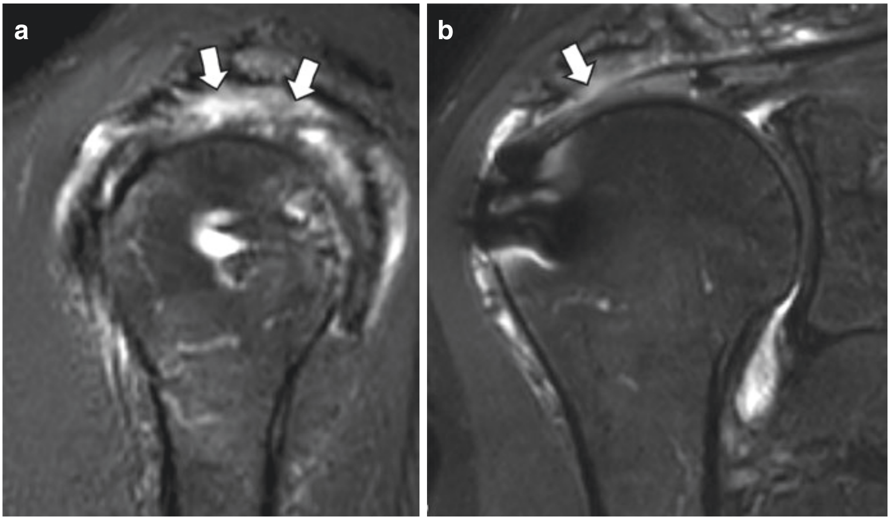

Fig. 1.5 65-year-old female with left shoulder pain and weakness 5 months after rotator cuff repair. (**a**) Sagittal T2-weighted fat-saturated MR image shows marked heterogeneity in the region of both the supraspinatus and anterior infraspinatus tendons (white arrows) without discernible tendon fibers, suggestive of at least a partial re-tear. (**b**) Coronal T2-weighted fat-saturated MR image shows a high-grade bursal-sided rotator cuff re-tear (white arrows) involving the supraspinatus tendon several centimeters medial to the footprint. There is fluid in the glenohumeral joint as well as in the subacromial-subdeltoid bursa

Independent predictive factors for re-tear after rotator cuff repair include the degree of tendon retraction [48–50] and the degree of narrowing of the AH interval preoperatively [50]. Specifically, patients who experienced re-tears tended to have narrower AH intervals (6.8 ± 2.1 mm) compared to those without re-tears (8.7 ± 1.2, $p = 0.000$). This same study [50] of predictive factors of re-tear after repaired full-thickness supraspinatus tendon tears showed the following variables to not be independent predictive factors for re-tear: the type of rotator cuff tear (e.g., full-thickness full-width versus full-thickness partial-width), presence of signal intensity near the tear edge, degree of supraspinatus muscle fatty infiltration, and the anteroposterior (AP) dimension of the torn tendon. However, it is important to note that other studies have shown the AP dimension of rotator cuff tears and fatty infiltration of the rotator cuff musculature predispose patients to greater re-tear rate [28, 51, 52].

1.3.2 Ultrasound

As is the case with MRI, the postoperative cuff presents a challenge for ultrasound evaluation given the expected heterogeneity seen in the postoperative state, especially in the first 6 months. Ultrasound faces additional challenges as well—that the sound beam must travel through superficial soft tissues to reach the deeper cuff

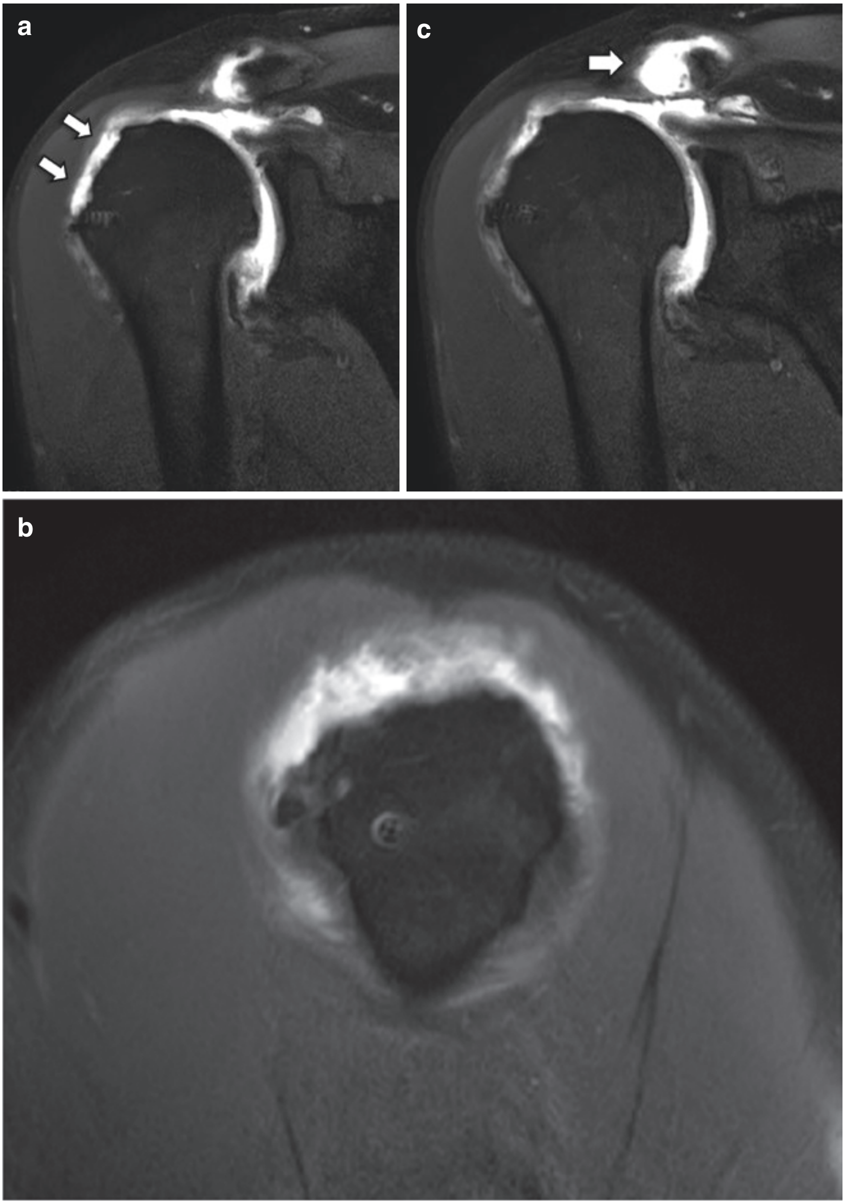

Fig. 1.6 44-year-old male with severely limited motion and pain since an injury to his shoulder at work 4 months prior. History of rotator cuff repair. (**a**) Coronal T2-weighted fat-saturated MR image shows no discernible tendon fibers attaching at the greater tuberosity. There is free communication of fluid from the glenohumeral joint into the subacromial-subdeltoid bursa through the large full-thickness rotator cuff rear. The torn tendon edge/stump (white arrows) is seen retracted to the level of the glenoid. (**b**) Sagittal T2-weighted fat-saturated MR image shows no discernible tendon fibers attaching at the greater tuberosity. (**c**) Coronal T2-weighted fat-saturated MR image again shows no discernible tendon fibers attaching at the greater tuberosity. Also depicted here is the classic "geyser sign" (white arrow), an eruption of synovial fluid through this chronic full-thickness rotator cuff tear and through the degenerated acromioclavicular joint. This often results in a palpable lump

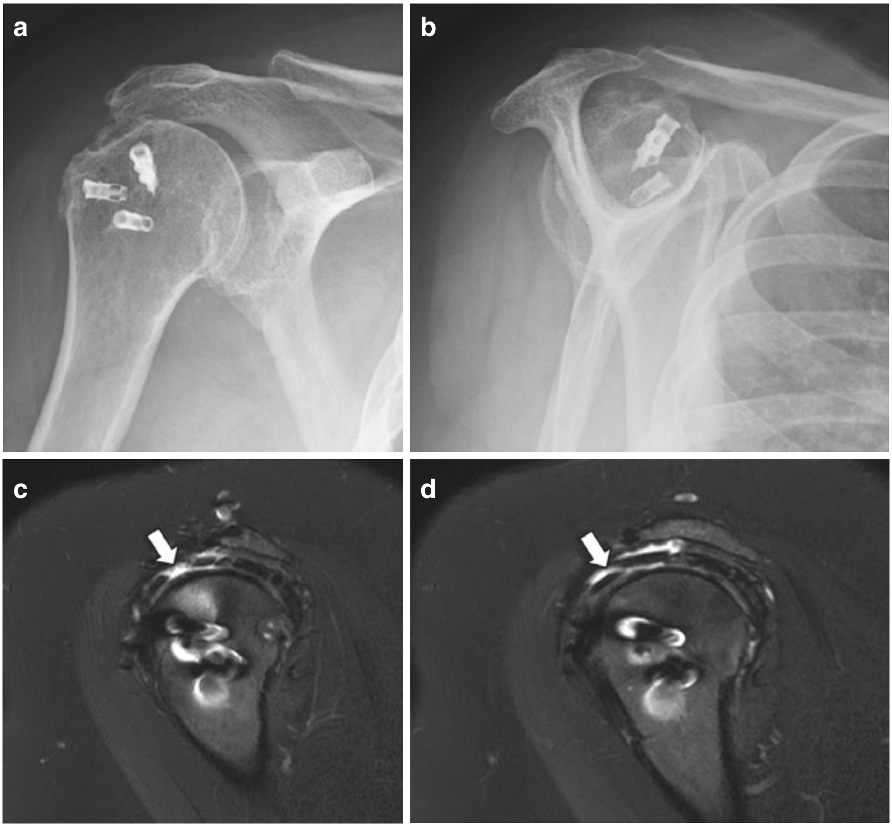

Fig. 1.7 64-year-old female with prior rotator cuff repair, now with 12-month follow-up evaluation for progressive weakness and loss of range of motion. (**a**) External rotation radiographic view of the right shoulder shows three suture anchors in the right humeral head, significant cortical irregularity at the greater tuberosity, and a high-riding humeral head. The patient has also undergone prior distal clavicular resection. (**b**) Scapular Y radiographic view of the right shoulder shows congruency of the humeral head with the glenoid. (**c**, **d**) Sagittal T2-weighted fat-saturated MR images show a discontinuous rotator cuff with a prominent fluid-filled gap where the anterior supraspinatus tendon should reside (white arrow)

tendons and musculature means that if there is any fatty infiltration of the deltoid or other echogenic soft tissue overlying the rotator cuff, visualization of the cuff is limited. In some cases, artifact from suture material may obscure areas of interest to a greater extent than on MRI.

Some of the advantages of ultrasound evaluation of the postoperative rotator cuff include dynamic assessment, fast execution, low cost, and less artifact associated with sutures, suture anchors, micrometallic debris (which may cause obscuring blooming artifact on MRI), and knots [53]. Several studies suggest that ultrasound may be the preferred modality to evaluate for repair integrity in the early postoperative period (e.g., 3 months postoperatively) due to its high sensitivity and specificity [28, 39, 54, 55]. However, ultrasound is operator-dependent and offers only a limited field of view, necessitating knowledge of anatomic landmarks to a greater extent than MRI [56, 57]. It has been reported that assessing rotator cuff repairs in patients serially at 3 months and then at 6 months has a high sensitivity and specificity for predicting future structural failure [44]. These authors concluded that all patients, even those who are asymptomatic at 6 months, should undergo ultrasound at 6 months because of the utility of predicting future functional outcomes based on these imaging findings and to provide a baseline for future studies.

1.3.2.1 Normal Nonoperative RC Tendon

Ultrasound evaluation of the intact native rotator cuff requires knowledge of the detailed anatomy of the various structures of the rotator cuff. The supraspinatus tendon typically measures 23 mm in anterior-to-posterior width and inserts onto both the superior and middle facets of the greater tuberosity [58]. The infraspinatus tendon measures approximately 22 mm in anterior-to-posterior width and inserts onto the middle facet of the greater tuberosity, its anterior fibers overlapping with the supraspinatus tendon's posterior fibers at a junctional zone measuring about 10 mm. The supraspinatus footprint, a common site for rotator cuff tears, measures approximately 12 mm in medial to lateral dimension. The teres minor tendon attaches onto the inferior facet of the greater tuberosity, located posteriorly. The subscapularis tendon attaches to the lesser tuberosity.

In the healthy state, rotator cuff tendons appear fibrillar and hyperechoic on ultrasound (Fig. 1.2c) and demonstrate anisotropy. In addition, for example with the supraspinatus tendon, the superior (bursal-sided) surface of the tendon should be convex without areas of discontinuity or concavity. The tendons should be smooth and without hypoechoic or anechoic defects. Care must be taken during ultrasound examination of the cuff to ensure the entire width of each tendon is evaluated (for example, the full anterior to posterior width of the supraspinatus tendon and the full craniocaudal extent of the subscapularis tendon anteriorly). In short-axis evaluation, the multiple tendon slips of the subscapularis tendon should be visible as discrete hyperechoic bundles, each demonstrating the expected sonographic features of tendons described above.

1.3.2.2 Normal Postoperative (Repaired) RC Tendon

Ultrasound evaluation of the postoperative cuff allows for excellent dynamic assessment of the repaired cuff's continuity, tendon position and thickness, and for the presence of secondary complications such as bursitis or infection [23]. The normal early postoperative (i.e., first 6 months after surgery) repaired cuff typically shows hypoechogenicity with loss of normal fibrillar tendon architecture (Fig. 1.8a, b). Most commonly, echogenicity of repaired tendons increases with time as healing continues. Suture anchors may be seen as hyperechoic foci with associated reverberation artifact, and there is often cortical irregularity of the greater tuberosity at the tendon reattachment site. If subacromial decompression was performed, cortical irregularity may also be seen at the lateral acromial undersurface.

It is critical for interpreting radiologists to know that it is not uncommon to see an apparent full-thickness defect or focal clefting at a repair site in the early postoperative period. This is hypothesized to reflect reparative scar formation rather than a true re-tear [59] and has been corroborated by histological studies [45, 60]. Serial

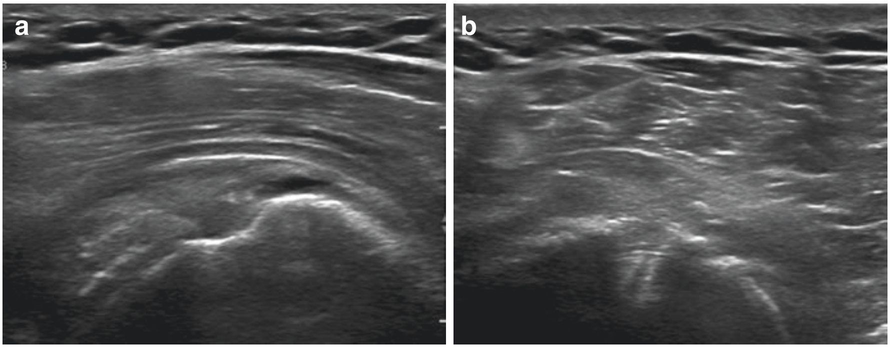

Fig. 1.8 50-year-old male with history of rotator cuff repair 6 months prior. Patient is currently asymptomatic. (**a**) Long-axis ultrasound image of the supraspinatus tendon demonstrates heterogeneous diffuse hypoechogenicity with hyperechoic suture material and minimal anechoic fluid in the subacromial-subdeltoid bursa. (**b**) Short-axis ultrasound image of the supraspinatus tendon demonstrates heterogeneity of the postoperative supraspinatus and infraspinatus tendons. Postoperative changes in the humeral head at the site of suture anchor insertion are also seen

imaging by ultrasound will often show fill-in of these apparent clefts and irregular areas of the repaired cuff. It is therefore critical to dynamically assess the repaired tendons during postoperative sonographic evaluation to look for true gapping at a suspected tear site.

The variable and heterogenous ultrasound appearance of the repaired cuff may persist for years after surgery [58, 61, 62]. Interestingly, up to 20–50% of repaired cuffs may show postoperative cuff defects even up to 5 years after surgery [63]. Other findings such as subacromial-subdeltoid bursitis and increased vascularity of the repaired tendon have been shown to decrease serially over time [64].

1.3.2.3 Torn Postoperative RC Tendon

Sonographic evaluation of a potentially re-torn rotator cuff offers advantages of dynamic imaging properties, easy accessibility, high spatial resolution, and high sensitivity, specificity, and accuracy, measuring 91%, 86%, and 89% in one study, respectively [62].

Most structural failures after arthroscopic rotator cuff repair, up to 74% [65], occur within the first 3 months postoperatively [39]. Few tears occur after 26 weeks post-repair [66].

The ultrasound appearance of a rotator cuff re-tear after initial repair shows a tendon defect or tendon non-visualization at its expected location (Fig. 1.9). These re-tears usually occur at the site of repair on the greater tuberosity. Indirect ultrasound findings of a tear in the native rotator cuff, such as tendon thinning and cortical irregularity at the supraspinatus tendon footprint, cannot be applied after surgical repair. In addition, small or equivocal tendon defects may become less apparent over time. A follow-up ultrasound examination should be considered with any equivocal tendon finding to help determine its significance and whether its appearance on initial postoperative scan may reflect normal evolution of the healing process.

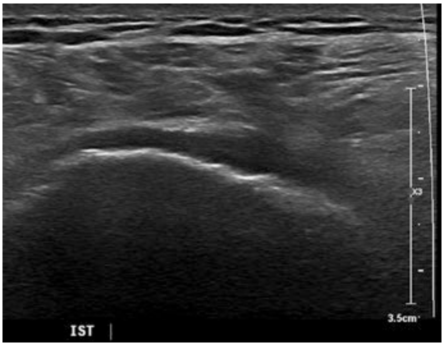

Fig. 1.9 61-year-old female with limited range of motion of her left shoulder. Longitudinal ultrasound image of the posterior aspect of the humeral head shows no discernible tendon fibers at the infraspinatus footprint on the middle facet of the greater tuberosity

1.4 Displacement of Suture Anchors

The majority of rotator cuff repairs involve the placement of suture anchors and these can dislodge (Fig. 1.10a–d). While this may or may not result in failure of the cuff repair, the displaced anchor in itself can generate synovitis and become a cause of pain or chondral damage. The displaced anchor may also lead to catching or locking of the joint [67]. One study has suggested that pain following rotator cuff repair is not uncommonly associated with dislodged suture anchors [68]. In this small study all cases presented within the first 6 months after surgery. While dislodged metallic suture anchors may be readily visualized on conventional radiographs (Fig. 1.10c), bioabsorbable anchors are not easily seen. However, MRI can identify the displacement and location of any displaced anchor which can help with surgical planning (Fig. 1.10a, b). Ultrasound is also able to identify anchor displacement and has the ability to demonstrate suture material as well (Fig. 1.10d). The latter when seen unrelated to the cuff may in itself indicate breakdown of the repair.

1.5 Other Complications

As noted above, subacromial bursitis is a frequent finding in the immediate postoperative period and may be seen in asymptomatic individuals [20]. However, when a large bursal collection is seen in a symptomatic patient, consideration should be given to the possibility of infection or a reaction to suture anchors [69].

In patients who undergo open rotator cuff repair or mini-open technique, the deltoid muscle is divided to access the joint. Although rare, deltoid dehiscence as a result of failure of the closing sutures can be difficult to manage and is often associated with a poor outcome [70]. A similar problem can also occur as a complication of acromioplasty and arthroscopic decompression. The dehiscence can be detected on MRI and ultrasound by the presence of retraction of the deltoid at the site of

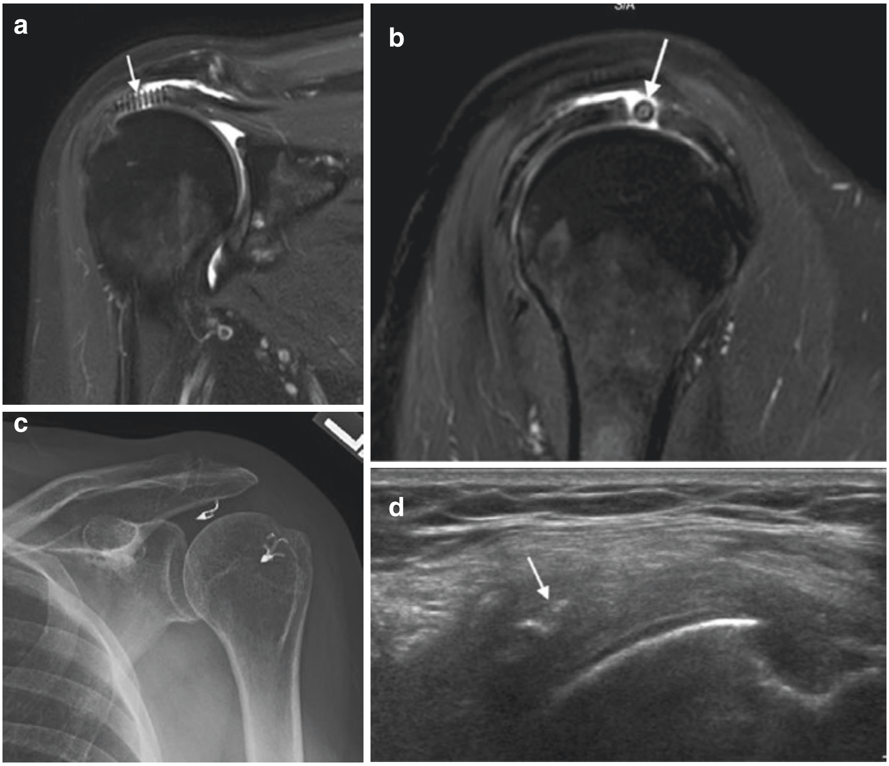

Fig. 1.10 Case 1 (**a**, **b**) 61-year-old female with prior arthroscopic rotator cuff repair 11 months ago. Case 2 (**c**, **d**) 78-year-old female with prior arthroscopic rotator cuff repair 4 months ago. Coronal (**a**) and sagittal (**b**) T2-weighted fat-saturated MR images show medial displacement of a suture anchor previously embedded in the humeral head at the supraspinatus footprint. The suture anchor is now seen oriented horizontally above the humeral head and is seen in the region of the supraspinatus/infraspinatus overlap on sagittal images, clearly displaced from its insertion site (arrows). Frontal neutral radiograph (**c**) of the left shoulder and long-axis ultrasound image of the supraspinatus tendon (**d**) demonstrate a displaced metallic suture anchor projecting in the subacromial space above the humeral head (arrow). An additional metallic anchor is seen on the radiograph at the greater tuberosity

breakdown, with the gap being filled with fluid. Depending on the chronicity there may also be associated atrophy and fatty infiltration of the deltoid musculature [67].

Other postoperative complications following rotator cuff repair include acromial fracture, injury to the suprascapular or axillary nerve and biceps tendon subluxation or rupture. When imaging the shoulder following rotator cuff repair in patients with ongoing pain, careful inspection of the biceps tendon should be made. However, as ever it is important to review the operative notes as surgery may have also involved biceps tenotomy or tenodesis [67].

1.6 Conclusion

MRI and ultrasound are both effective imaging modalities for evaluating a repaired rotator cuff tendon for potential re-tear. In the early postoperative period (less than 6 months), the repaired tendon often has a heterogeneous appearance, and it evolves in a predictable manner with time. Serial imaging is very helpful to evaluate for re-tears after a new injury or new symptom development. The diagnosis of a tendon re-tear should rely on the unequivocal identification of a tendon defect rather than simply heterogeneity or small cleft. Since small tendon defects may disappear over time, any equivocal imaging finding of the rotator cuff after repair can be followed up with imaging to determine its clinical significance.

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