Failed rotator cuff repair may be caused by surgical complications, diagnostic errors, technical errors, failure to heal, and traumatic failure. Revision rotator cuff repair is made technically more difficult by poor tissue quality, tissue adhesions, and retained suture and suture anchor material. Historically, open revision rotator cuff repair yields inferior results compared with primary rotator cuff repair; however, more recent studies show 52% to 69% satisfactory results in small-sized or medium-sized tears. Arthroscopic revision rotator cuff repair yields greater than 60% good or excellent results. Poor tissue quality, detachment of the deltoid origin, and multiple previous surgeries are risk factors for poor results in revision rotator cuff repair.

Level of evidence: Review Article.
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Keywords: Revision rotator cuff repair; failed rotator cuff; rotator cuff re-tear; arthroscopic rotator cuff repair; revision shoulder; causes of rotator cuff failure; rotator cuff repair; rotator cuff tear

The healing rates of primary rotator cuff repair (RCR) are variable. As RCR becomes more commonly performed, more failures will require surgical revision. Revision RCR is a more complicated process than primary RCR due to poor tissue quality, retained hardware, patient factors and expectations, and the sequelae of postoperative complications. Successful revision RCR requires a complete understanding of the anatomy of the rotator cuff, diagnosis of failed RCR, causes of failure, indications for operative intervention, and unique technical factors of surgical revision.

Causes of failed RCR

Causes of failed RCR can be categorized as surgical complications, diagnostic errors, technical errors, failure to heal, and traumatic failure (Table I). Failed RCR is often multifactorial, and these factors have significant overlap. Determining the causes of failure and correcting these factors, when possible, are important to achieve successful revision RCR.

Complications

The overall complication rate of arthroscopic RCR is approximately 10%. Complications associated with open and arthroscopic RCR include disruption of the deltoid origin, infection, foreign body reaction, stiffness, and neurologic injury. These complications lead to a poor result after RCR and may also contribute to failure of the repaired rotator cuff tissue.

Failure of the deltoid after RCR may occur gradually or acutely. Deltoid disruption can occur in open repair as a result of rupture of the repaired deltoid muscle and fascia. Excessive deltoid release from the lateral acromion can also result in deltoid failure in mini-open RCR. In addition,
overly aggressive anterior acromioplasty with inappropriate anterior deltoid release in arthroscopic RCR may lead to deltoid disruption and even acromial fracture. Patients with deltoid failure may present with a defect in the deltoid or significant weakness with forward elevation or abduction, or both.

Infection is an uncommon complication of RCR. Herrera et al.\(^2^6\) reported an infection rate of 1.9% in 360 patients who underwent arthroscopic subacromial decompression, followed by mini-open RCR. Of 7 patients with postoperative infection, 4 had disruption of the repair, and 3 remained intact. After surgical debridement, antibiotics, and revision RCR when needed, all patients had satisfactory results at a minimum 12-month follow-up.\(^2^6\) Iannotti et al.\(^2^8\) reported 15 patients who underwent open RCR with augmentation using porcine small intestine mucosa. Two patients developed postoperative swelling, with negative gram stains, that was complicated by complete disruption of the RCR.\(^2^8\)

The most common organism complicating rotator cuff repair is Propionobacterium acnes, affecting 50% to 86% of postoperative infections.\(^1^,^2^6\) Surgical irrigation and debridement and intravenous antibiotics are necessary to eradicate the infection. Even when properly treated, postoperative infection often results in stiffness, adhesions, failure of the repaired tissue, and continued pain. Athwal et al.\(^1\) monitored 29 patients with postoperative infection after RCR for a mean of 8.2 years. At final follow-up, the results were excellent in 7 shoulders, satisfactory in 9, and unsatisfactory in 11.\(^1\)

Foreign body reactions have been reported in RCR, particularly with bioabsorbable materials.\(^1^5,^4^1\) Loose suture anchors and debris can cause foreign body reactions that may be difficult to distinguish from infection. Sterile abscess may occur as a result of foreign body reaction. Sometimes foreign body reaction is only discovered at the time of revision surgery, as evidenced by inflammatory tissue or excessive scar tissue surrounding loose or protruberant implant materials. These reactions are uncommon, but should be treated when symptomatic with removal of the foreign body and surgical revision, if necessary (Fig. 1).

Postoperative shoulder stiffness is the most common complication after RCR and is seen in 5% to 10% of patients.\(^7,^2^7\) Many factors can contribute to postoperative stiffness, including diabetes, hypothyroidism, adhesive capsulitis, calcific tendonitis, partial articular supraspinatus tendon avulsion repair, labral repair, and workers’ compensation claim.\(^2^7\) Inadequate rehabilitation with underaggressive physical therapy or patient noncompliance can also contribute to stiffness. Postoperative stiffness may occur even in the absence of any known risk factors. Preoperative shoulder stiffness is a risk factor for postoperative stiffness after RCR. A retrospective review by Tauro et al.\(^4^8\) found that RCR range of motion did not improve postoperatively in patients with a preoperative total range of motion deficit of 70° or greater.

Neurologic injuries from surgical RCR may be direct nerve injury, stretch neuropraxia, or complex regional pain disorder (reflex sympathetic dystrophy). Stretch neuropraxia is more commonly seen in shoulder arthroscopy using the lateral decubitus position than the beach chair position.\(^4^6\) Care should be taken to avoid excessive traction on the arm and to appropriately position the neck to reduce tension during shoulder arthroscopy. When positioning the patient for shoulder arthroscopy in the lateral decubitus position, the head and neck should be parallel to the body when the arm is in balanced suspension. Direct nerve injury is very uncommon if standard arthroscopic portals are correctly placed. The 5 o’clock portal is the most dangerous of the commonly used portals, with a distance of approximately 15 mm from the axillary nerve and artery.\(^3^8\)

### Diagnostic errors

Incorrect or incomplete diagnosis can lead to poor results after RCR. Supraspinatus tears may be associated with “hidden” lesions of the rotator interval, long head of the biceps tendon, or subscapularis tear.\(^4^9\) Unrecognized suprascascal neuropathy can cause continued pain, particularly in patients with massive rotator cuff tears. Electrodiagnostic studies can be useful to detect suprascascal neuropathy.\(^6\) Undetected symptomatic os acromiale can cause continued pain after RCR that may be worsened by acromioplasty. Failure to recognize and treat concomitant pathology can result in persistent pain and dysfunction.

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<td>• Failure to heal</td>
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<td>• Traumatic failure</td>
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Figure 1  Foreign body reaction to bioabsorbable suture anchor. This reaction was associated with failed rotator cuff repair and required revision repair.
Concomitant diagnoses may make the diagnosis of rotator cuff pathology more difficult. Shoulder pain may be caused by cervical radiculopathy, adhesive capsulitis, neuromuscular disorders, and referred pain from non-musculoskeletal pathology such as cholecystitis or cardiac and pulmonary disease. Repair of partial or full-thickness rotator cuff tear without treating the true origin of the patient’s symptoms may result in continued or worsened symptoms.

Technical errors

Successful RCR is dependent on determining tear patterns and properly mobilizing and repairing the rotator cuff tissue. Recent evidence shows that degenerative rotator cuff tears most commonly originate in the center of the “rotator crescent,” approximately 15 mm posterior to the biceps tendon. Kim et al determined that the most frequent location of degenerative rotator cuff tears is at the junction of the insertions of the supraspinatus and infraspinatus.

Rotator cuff tears may be classified as (1) crescent-shaped, (2) U-shaped, (3) L-shaped, and (4) massive, contracted, immobile tears. The posterior rotator cuff tissue tends to be more mobile than anterior tissue. It is critical to thoroughly evaluate the mobility of the rotator cuff tissue to devise a repair construct. Proper tissue mobilization must be performed with scar tissue release and rotator interval slides when needed. When necessary, a margin-convergence repair should be performed to reduce tension on the repaired tendon edges. The quality of the tissue should be taken into account when placing sutures. Thin and weak rotator cuff tissue is likely to tear further and result in suture cutout. When placing sutures in weak rotator cuff tissue, it is beneficial to place additional sutures at multiple fixation points. Excessive tissue tension results in early failure. Incomplete tissue mobilization may lead to early suture–tendon interface failure or iatrogenic tissue damage.

Improper suture anchor placement can result in anchor pullout or ineffective soft tissue fixation to the greater tuberosity. In a study comparing different angles of suture anchor placement, Strauss et al determined that suture anchors placed at 90° to the junction of the greater tuberosity and the humeral head articular surface provided better soft tissue fixation than the classic deadman’s angle of 45°. Protruding metal or bioabsorbable suture anchors can also cause damage by abrading the acromion, glenohumeral joint surfaces, or rotator cuff tissue. Suture anchors that pull out of bone can result in loose bodies that can damage the articular surface and other structures in the shoulder. Kirchhoff et al showed that the greater tuberosity bone quality is greatest in its posteromedial aspect and that bone quality significantly decreased with age. These factors should be considered when placing suture anchors in the greater tuberosity.

Failure to heal

Rotator cuff failure most commonly occurs from a failure of the repaired tissue to heal. Even in well-performed RCR, healing may not occur (Fig. 2). The rate of failed RCR in the literature is extremely variable, ranging from 19% to 94%. A poor healing environment may be caused by poor rotator cuff and greater tuberosity vascularity, poor rotator cuff tissue, and poor bone quality. Advanced patient age and 2 or more torn rotator cuff tendons correlate with RCR failure. Failed RCR is associated with advanced muscle atrophy and fatty degeneration. Double-row RCR is increasingly used to maximize rotator cuff footprint coverage, although the current literature does not support the clinical benefit of double-row RCR.

Inherent patient factors such as medical comorbidities may impede rotator cuff healing. A laboratory study that compared RCR in rats with and without medically induced diabetes found the diabetic rats exhibited significantly less fibrocartilage and organized collagen at the tendon–bone interface and a reduced ultimate load-to-failure. Clinically, diabetic patients have worse results and higher rates of infection and failure than nondiabetic patients. Smoking has also been shown to increase the RCR failure rate and worsen clinical results.

Traumatic failure

Traumatic RCR failure can occur in the early postoperative period (first 3 months) or in the late period (after rotator cuff healing; Fig. 3). Early trauma can occur as a single traumatic event, such as a fall on the outstretched hand, or from overly aggressive postoperative rehabilitation. Premature active range of motion or patient noncompliance to proper physical therapy limitations may result in early failure. Early failure most commonly occurs at the suture–tissue interface as the suture cuts out through the tissue.

Late traumatic failure occurs after complete healing of the rotator cuff. Similar to primary rotator cuff tears, late traumatic failure can result from acute injuries or repetitive trauma.

Diagnosis

Evaluation of the painful or weak shoulder after primary RCR consists of a detailed history, physical examination, and imaging. Signs of a possible failed RCR include persistent pain, weakness, and stiffness that do not respond to appropriate postoperative physical therapy. Early recurrent rotator cuff tear should be suspected in patients with unexpected pain or weakness that does not improve along the typical course of postoperative recovery. Patient history should include preoperative symptoms, extent of preoperative and postoperative physical therapy, use of preoperative or postoperative injections, medical comorbidities, and
nicotine use. New symptoms such as night pain, weakness, pain at rest, stiffness, fevers, chills, and wound problems should be evaluated.

The operative notes and arthroscopic images should be reviewed carefully. RCR technique (ie, open or arthroscopic, single-row, double-row, or transosseous equivalent), tear size and configuration, and additional procedures performed at the index repair should be reviewed. Determining a timeline of symptoms after surgery is important; for example, did the patient do well initially and have an acute event resulting in recurrence of pain, or did the patient’s symptoms never improve after the index procedure.

Physical examination includes active and passive range of motion of the affected and unaffected shoulders as well as manual muscle strength testing. The periscapular musculature should be inspected for any signs of muscle atrophy or scapular winging. Signs of scapular dyskinesis during forward elevation may provide clues about the etiology of pain and weakness. Provocative maneuvers should be performed to detect biceps tendon pathology, labral tears, subscapularis tear, and acromioclavicular joint pathology. Examination of the cervical spine and a detailed neurologic examination may reveal cervical radiculopathy or neurologic disorders as a contributing factor to persistent shoulder pain. Nerve conduction studies should be performed when suprascapular neuropathy, cervical radiculopathy, or other peripheral neuropathies are considered.

Standard shoulder radiographs, including anteroposterior, axillary lateral, and scapular Y (outlet) views, may show humeral head migration, glenohumeral arthritis, subacromial spurs, and implant or anchor migration. Additional diagnostic imaging, such as ultrasound, magnetic resonance imaging (MRI), or computed tomography arthrogram, should be used to aid in the identification of recurrent rotator cuff tears. MRI may not provide the same sensitivity to recurrent rotator cuff tear as with primary rotator cuff tear because of artifact and altered signals from postsurgical changes as well as retained suture and metal or bioabsorbable suture anchors (Fig. 4). MRI in this setting has a reported accuracy of 70% to 90%. MRI with intra-articular contrast may be used to increase the sensitivity of detection of recurrent rotator cuff tears.

Ultrasound is a useful imaging modality that avoids the issues related to suture anchors and postsurgical changes that complicate MRI after RCR. The utility of ultrasound depends on the technical expertise of the ultrasound technician. Prickett et al compared ultrasound imaging with arthroscopic findings in a diagnostic study (level of evidence: II) and determined that ultrasound was 91% sensitive, 86% specific, and 89% accurate for identifying recurrent rotator cuff tears after previous repair.

Surgical indications

The indications for surgery in the setting of failed RCR are similar to the indications for primary repair. A thorough discussion with the patient includes an analysis of the possible causes of failure and a frank dialogue about the patient’s postoperative expectations. The surgeon and patient should be aware of the factors that can and cannot be changed when deciding on revision RCR surgery.

In the setting of an acute traumatic retear in a physiologically young, healthy, active patient, revision surgery is generally recommended. Patients in other settings should undergo a trial of nonoperative management focusing on restoring range of motion, strengthening the remaining portions of the rotator cuff, deltoid, and, especially, the periscapular musculature (low trapezius and rhomboids). Patient age, medical comorbidities, functional impairment, size of the previous rotator cuff tear (number of tendons...
involved), presence of muscle atrophy, fatty infiltration, chronicity of the tear, and activity level are all factors to consider when deciding if revision RCR is appropriate.

Patients with nonrepairable tears with severe rotator cuff atrophy and fatty degeneration may not be candidates for revision RCR. Tendon transfers may be used in patients without advanced glenohumeral arthritis who have significant loss of external rotation strength.2 Satisfactory short-term outcomes with arthroscopic debridement have been reported in patients with a massive rotator cuff tear.9,25 Arthroscopic debridement has had short-term success and may be useful, particularly for elderly, low-demand patients with pain but good preservation of active motion.9,25 Reverse shoulder arthroplasty is indicated for severe cuff tear arthropathy.

Technical aspects of revision RCR

Successful revision RCR begins with a thorough evaluation of the causes of failure and an attempt to correct these factors (Fig. 5). Diagnostic errors must be corrected to achieve a successful result. Patient factors that can be changed to improve the outcome, such as smoking, should be addressed.

Revision RCR can be performed using all-arthroscopic, mini-open, or open techniques, depending on surgeon preference and familiarity. Deltoid avulsion from prior open surgery or overly aggressive anterior acromioplasty requires open deltoid repair.22

The lateral decubitus or beach chair position may be used. Arthroscopic portals should be placed in the anatomically necessary locations. The surgeon should not be bound to using previously healed arthroscopic portals because reusing inappropriately placed arthroscopic portals can make the surgery technically awkward and more difficult.

A thorough arthroscopic evaluation includes careful assessment of the long head of the biceps tendon, glenoid labrum, and subscapularis tendon. Acromioplasty may be necessary, but care should be taken to avoid overaggressive acromial resection, which might lead to acromial fracture.

Retorn rotator cuff tissue is often of poor quality, with increased muscle atrophy and fatty infiltration.29 Careful handling of the rotator cuff is extremely important to prevent further iatrogenic tissue damage. Adhesions between the anterior supraspinatus and the anterior deltoid may significantly limit anterior rotator cuff mobility (Fig. 6). Scar tissue should be freed to adequately mobilize the rotator cuff. Adhesions should be circumferentially debrided on the bursal and articular sides of the rotator cuff. Retained sutures should be removed, when possible, to avoid conflict with suture-passing instruments and interference with tissue approximation to bone.

Careful preparation of the greater tuberosity should maximize rotator cuff footprint coverage. Double-row and transosseous equivalent repair may be considered to optimize tissue fixation (Fig. 7). Even when no hardware is visible arthroscopically or radiographically, a tap should be used with suture anchor placement to avoid suture anchor damage from embedded retained hardware. Metal hardware should be left intact and avoided because hardware removal may create bone defects that may weaken the greater tuberosity and limit fixation. Loose or protuberant suture anchors should be removed as needed. When inserting new suture anchors in or around previous suture anchor tracks, oversized anchors should be considered to improve anchor security. If bone defects prevent the use of suture anchors, sutures should be placed using transosseous techniques, being careful to avoid greater tuberosity fracture.

The anatomy of failed previous RCR is in many ways similar to the setting of a massive retracted rotator cuff tear (ie, significant tendon retraction and scarring), often
requiring extensive tendon mobilization to achieve anatomic repair. In addition, once soft tissue mobilization is achieved, the tissue quality can be somewhat poor and may benefit from additional structural support at the repair site.

Several authors have described biologic augmentation in the setting of a massive rotator cuff tear with the use of a variety of graft types. These techniques have included the use of xenografts (porcine dermal collagen and porcine small intestine submucosa) or synthetics (collagen rich extracellular matrices). These materials have been used to augment repairs when tissue quality is poor and to bridge gaps when tears are unable to be mobilized to obtain reduction to the tuberosity. Wong et al reported 45 patients who underwent arthroscopic RCR with xenografts. At a minimum 2-year follow-up, the mean University of California-Los Angeles (UCLA) score improved from 18.4 to 27.5. To our knowledge, no studies have reported the results of these materials in the revision setting.

Suprascapular neuropathy occurs when there is traction on the nerve at the spinoglenoid or suprascapular notch or compression from a tight or ossified spinoglenoid or transverse scapular ligament. In the setting of a retracted rotator cuff tear, tension can be placed on the suprascapular nerve as the tendon retract and the nerve gets caught at the base of the scapular spine at the suprascapular notch. Injury to the suprascapular nerve can result in muscle atrophy specifically involving the supraspinatus and infraspinatus. Suprascapular nerve involvement can contribute to patients’ symptoms of pain and weakness in external rotation as well as fatty infiltration and atrophy of the supraspinatus and infraspinatus resulting poor tissue quality for repair.

Tendon mobilization during repair can release the tension placed on the suprascapular nerve, with reversal of suprascapular neuropathy as seen on electrodiagnostic studies. In addition, some surgeons advocate decompression of the nerve at the suprascapular notch at the time of massive RCR. To our knowledge, no studies have reported the outcome of suprascapular nerve decompression in the setting of revision RCR.

Postoperative rehabilitation is similar to primary RCR. A slower progression to active motion may be considered. Care should be taken to avoid excessively slow progression of passive range of motion, which may lead to postoperative stiffness and limited results, although Deutsch et al showed that a decelerated rehabilitation program can be successfully used to improve healing without increasing postoperative stiffness.

Results of revision RCR

A limited number of studies have reported the outcomes after revision RCR using open or arthroscopic techniques. All of these studies are retrospective reviews or case series (level of evidence: IV; Table II).

Results of open revision RCR

DeOrio et al reported the results after open revision RCR in 24 patients and did not demonstrate a high incidence of successful results, with only 4 (17%) good results, 6 (25%) fair results, and 13 (58%) poor results. Shoulder abduction after revision surgery resulted in only minimal improvements in range of motion, from an abduction average of 78° (range, 0°-180°) preoperatively to 85° (range, 0°-180°) postoperatively. Postoperative external rotation was not improved (average, 43°; range, 30°-75°). In addition, at an average 46-month follow-up, 63% continued to have moderate to severe pain and 26% required a second revision surgery.

Bigliani et al reported somewhat better results after open revision RCR in 31 patients. At an average follow-up of 73 months, 16 (52%) had good to excellent results, 7 (23%) had fair results, and 8 (26%) had poor results. Pain relief was good to excellent in 25 patients (81%) at the final
follow-up. Forward flexion (average: 76° preoperatively vs 112° postoperatively) and external rotation (average: 15° preoperatively vs 35° postoperatively) improved after revision surgery. Poor results were associated with detachment of the deltoid origin, lateral acromionectomy, and poor tissue quality.

Neviaser et al.\textsuperscript{39} reported 50 patients who underwent open revision RCR with a mean 30-month follow-up. At final follow-up, 92% of patients had improved pain postoperatively, 26 had improved range of motion, with a mean 50° improvement in forward flexion, and 90% of patients were satisfied with their final result.\textsuperscript{39}
Djurasevic et al\textsuperscript{22} reported the outcome of 80 patients after open revision RCR at an average final follow-up of 49 months. Results were categorized by tear size at the time of revision surgery as massive/large in 51 patients or medium/small in 29. The massive/large group had 15 (29%) excellent, 12 (24%) good, 7 (14%) fair, and 17 (33%) poor results. The medium/small group had 11 (38%) excellent, 8 (28%) good, 2 (7%) fair, and 8 (28%) poor results at final follow-up. The overall result, including all tear types, was satisfactory in 55 patients (69%). The average pain rating improved from 7.4 preoperatively to 3.0 postoperatively, with 86% reporting pain relief after revision surgery. The authors concluded that results of revision rotator cuff surgery are inferior to primary repair and factors that can predict success are an intact deltoid, good-quality tissue, only one prior procedure, and preoperative forward elevation above the horizontal plane.

### Results of arthroscopic revision RCR

Lo et al\textsuperscript{34} reported the results after arthroscopic revision RCR in 14 patients at an average final follow-up of 23 months. Of these, 13 were satisfied with the outcome of their shoulder, with 4 (28.5%) excellent, 5 (36%) good, 5 (28.5%) fair, and 1 (7%) poor result. Patients had a statistically significant improvement in UCLA scores, from 13.1 ± 2.3 preoperatively to 28.6 ± 7.1 postoperatively. The authors reported statistically and clinically significant improvements, preoperatively to postoperatively, in forward flexion (120.7° ± 48.9° to 153.6° ± 33.1°) and external rotation (26.1° ± 19.3° to 44.3° ± 15.9°) as well as a statistically and clinically significant improvement in average pain scores, from 8.5 ± 2.6 to 3.8 ± 2.0. Although the authors performed a retrospective review of this small series, their power analysis demonstrated more than 90% power for these data.

Keener et al\textsuperscript{29} retrospectively reviewed 21 patients after arthroscopic revision RCR, with an average final follow-up of 33 months. The authors reported clinically and statistically significant improvements, from preoperatively to postoperatively, in the visual analog pain (VAS) score (6.1 ± 1.8 to 2.8 ± 2.6), Simple Shoulder Test (SST; 5.3 ± 3.2 to 8.8 ± 3.3), American Shoulder and Elbow Surgeons (ASES; 40.1 ± 16.0 to 73.0 ± 25.2), forward flexion (130.3° ± 37.3° to 146.7° ± 30.5), and external rotation (44.7° ± 14.9° to 55.2° ± 21.7°). In only 10 patients (48%) was a healed revision repair seen on postoperative ultrasound imaging. The authors found that patient age and number of tendons torn correlated with repair integrity at follow-up. They did not find a difference in outcomes (SST, VAS, or ASES) in patients with or without tendon healing, but their post hoc power analysis found the study was underpowered to be able to detect a significant difference between groups. The study did find a statistical difference in the Constant score between the intact repair (76.2) and recurrent tear (60.7) group.

In a similar study, Piasecki et al\textsuperscript{44} reviewed the results of 54 patients who underwent arthroscopic revision RCR at an average follow-up of 31 months. The authors found an improvement, from preoperatively to postoperatively, in the ASES (43.8 ± 5.7 to 68.1 ± 7.2) and SST (3.56 ± 0.8 to 7.5 ± 1.1), which were both clinically and statistically significant. The revision RCR failed in 6 patients (11%), and additional surgery was required. This study did not demonstrate significant postoperative improvements in VAS scores or shoulder range of motion (forward flexion or external rotation). Additional analysis demonstrated that a history of more than one prior shoulder surgery was associated with a higher failure rate (odds ratio, 8.33; 95% confidence interval, 0.9-77.1) and that tear size was not predictive of postoperative failure.

### Conclusion

Failed RCR may be caused by surgical complications, diagnostic errors, technical errors, failure to heal, and traumatic failure. The results of revision RCR are inferior to primary RCR; however, more recent studies show improvement in surgical results. Open or arthroscopic techniques may be successful in revision RCR. Care should be taken to protect and mobilize torn tissue and achieve maximal footprint coverage in revision RCR.

### Disclaimer

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Revision rotator cuff repair


