Management of the Irreparable Rotator Cuff Tear

Abstract

When evaluating patients with irreparable rotator cuff tears, orthopaedic surgeons have an increasingly wide array of surgical options, including both established techniques and emerging technologies. However, significant variability exists in the clinical evaluation and surgical indications in this subset, and definitions for pseudoparalysis and tear irreparability are inconsistent. In older patients with symptomatic rotator cuff arthropathy and relatively sedentary demands, the reverse total shoulder arthroplasty has been established as the preferred treatment option, producing reliable improvements in both pain and function. In younger patients without glenohumeral arthritis or pseudoparalysis, joint-preserving options are preferred, with recent literature highlighting alternative options including partial repair, bridging or interpositional graft placement, tendon transfers (ie, latissimus, trapezius, and pectoralis major), superior capsular reconstruction, and subacromial spacer placement. In this review article, we address the topic of irreparable rotator cuff tears, emphasizing the workup, indications for various treatment options, and clinical outcomes.

Rotator cuff pathology is the most common source of shoulder disability and among the most prevalent conditions treated by practicing orthopaedic surgeons. Rotator cuff tears may reflect acute or acute-on-chronic onset of symptoms or most commonly may develop as a result of a chronic degeneration process, with both intrinsic and extrinsic risk factors noted. An estimated 50% of patients will have radiographic evidence of bilateral rotator cuff tear after age 66 years, although symptoms may vary. Massive rotator cuff tears—defined as defects measuring >5 cm or involving two or more torn tendons—are not necessarily synonymous with irreparable tears because many massive tears can be repaired with adequate mobilization and advanced arthroscopic techniques. Although repair can be performed, structural failure after primary repair of large- to massive-size tears may occur in up to 25% to 94% of cases by 2 years, most commonly at the bone-tendon interface. Ongoing research is evaluating the effects of newer, advanced rotator cuff repair techniques including graft augmentation, superior capsular reconstruction (SCR), and subacromial balloon spacer to improve functional outcomes in treatment of massive rotator cuff tears.

The identification and management of true irreparable rotator cuff tears present unique challenges for the orthopaedic surgeon, both in terms of cost containment and immediate versus delayed long-term patient benefit. In older patients with...
symptomatic rotator cuff arthropathy and relatively sedentary demands, nonsurgical management and reverse total shoulder arthroplasty (RSA) have been established as the preferred treatment options, producing reliable improvements in both pain and function.6-8 For younger patients without secondary arthritis, advanced acromiohumeral remodeling, and/or pseudoparalysis, joint-preserving options are preferred whenever possible because of concerns about patient-specific demands and long-term implant survivorship. In this review article, we address the topic of irreparable rotator cuff tears, emphasizing the workup, indications for various treatment options, and clinical outcomes.

Identification of the Irreparable Rotator Cuff Tear

Preoperatively, irreparable tears can frequently be difficult to distinguish from large or massive repairable tears based on examination and imaging studies alone, although certain criteria have been proposed.9,10 Irreparable rotator cuff tears are generally large (in both AP and medial-lateral dimensions) and retracted with poor or attenuated tissue quality, muscular atrophy, and fatty infiltration.10,11 The ultimate assessment of reparability is determined intraoperatively after tendon mobilization and interval releases. Burkhart found that 85% of massive rotator cuff tears were completely repairable, although only 57% of tears with Goutallier 3 to 4 fatty infiltration of the supraspinatus were repairable.12,13 Nevertheless, a thorough preoperative assessment is critical in surgical planning to identify tear patterns that are potentially irreparable to prepare for alternative treatment strategies.

Patient Evaluation

Patients undergo a detailed history to assess for pain and disability of the affected shoulder. Occupational demands, involvement in leisure or sporting activities, hand dominance, tobacco use, and medical comorbidities are assessed. The degree of pain and disability may not correlate with the size and reparability of the associated rotator cuff tear.14 Traumatic versus atraumatic onset and symptom chronicity are important variables to assess because traumatic tear or those with more acute presentation may be more likely to be repairable, particularly when associated with pseudoparalysis. Finally, previous surgical history, including advanced radiographic imaging, arthroscopic images, and surgical reports, should be obtained and scrutinized to determine initial tear pattern, tissue quality, concomitant procedures, untreated pathology, and potential technical errors (eg, violation of the myotendinous junction and implant prominence).

Physical examination starts with inspection of the affected shoulder and periscapular musculature, with care to assess for atrophy of the supraspinatus and infraspinatus in their respective fossae. Visible atrophy on examination is suggestive of chronicity and advanced rotator cuff fatty infiltration that contribute to poor tissue mobility and difficulty with primary repair. Neurovascular examination is performed to assess axillary nerve function with sensation and deltoid motor function.

Active and passive range of motion are then evaluated and compared with the unaffected, contralateral shoulder, while bearing in mind that patients may present with bilateral rotator cuff pathology. Patients with disrupted rotator cuff force couples or cable involvement due to a massive or irreparable tear may exhibit significant losses of active range forward elevation with relatively preserved passive range of motion.15 When the patient is unable to elevate the arm beyond 90° actively despite intact passive motion, the patient is commonly said to have pseudoparalysis, although we prefer the more nuanced terminology of pseudoparesis for active elevation that falls short of 90° with pseudoparalysis reserved for patients essentially without active elevation and anterior translation on attempted elevation consistent with anterior-superior escape or migration.15 It is important to attempt to distinguish true weakness-mediated pseudoparalysis from pain-mediated and effort-mediated false positives. Subacromial injection or lidocaine challenge can reduce the contribution of pain in equivocal cases and help to discern between effort- and pain-mediated etiologies and structural deficits. Ultimately, the identification of pseudoparalysis is based on a combination of clinical examination and imaging studies confirming massive cuff pathology with superior humeral migration.

Rotator cuff strength is evaluated and compared with the contralateral side, with significant weakness present in patients with poorly compensated massive or irreparable tears. The supraspinatus is assessed with resisted forward elevation in the scapular plane and maximal internal rotation. The infraspinatus is assessed with resisted external rotation with the arm adducted. The subscapularis is assessed with belly press, lift-off, and bear hug testing, which may differentially assess the upper and lower aspects of the subscapularis.16 Resisted external rotation or a Hornblower test is performed in 90° of abduction and 90° of external rotation to assess the teres minor.17 Furthermore, increased passive motion and lag signs may be identified, including increased passive internal rotation and external rotation lag for
infraspinatus, increased passive external rotation and internal rotation lag for subscapularis, and drop arm sign for supraspinatus.

**Imaging**

Patients are initially evaluated with standard, three-view radiographic series of the shoulder, including a true AP (Grashey), outlet (scapular Y), and axillary lateral images. Radiographs are used to identify associated glenohumeral arthritis or rotator cuff arthropathy according to the Hamada classification, reciprocal remodeling changes in the greater tuberosity and corresponding undersurface of the acromion, acromiohumeral distance, presence of subluxation or anterosuperior escape, and acromial morphology (Figure 1). Narrowing of the acromiohumeral distance below 5 to 6 mm has been associated with massive tears with advanced fatty infiltration that may render tissue irreparable.

MRI is the predominant advanced imaging modality used for evaluation of the potentially irreparable rotator cuff tear, used to define tear size, shape, involved tendons, and fatty infiltration. However, CT or CT arthrography is generally reserved for patients with contraindications to MRI, metal artifact, or severe rotator cuff arthropathy where glenoid version, bone stock in the glenoid vault, and/or digital templating is to be performed for RSA. Although initially described by Goutallier et al on the basis of CT, the Fuchs modification assessing rotator cuff fatty infiltration on the T1 sagittal oblique image immediately lateral to the scapular spine’s attachment to the body of the scapula given the predominant role of MRI in evaluating rotator cuff pathology. Grade 3 and 4 represent severe fatty infiltration with equal or greater amounts of fat compared with muscle, respectively, and are generally found in irreparable tears.

Several authors have correlated preoperative MRI findings with reparability of rotator cuff tears. Sugihara et al found that irreparable tears correlated with tear length or width over 4 cm, severe fatty infiltration of the supraspinatus and infraspinatus. Similarly, Yoo et al found that irreparable tears correlated with grade 4 supraspinatus fatty infiltration, grade 3 or 4 infraspinatus fatty infiltration, and tear length and width over 3.1 to 3.2 cm. Dwyer et al ascertained that retraction of the tear to or beyond the glenoid, severe fatty infiltration of the supraspinatus and infraspinatus, a positive tangent sign, and superior humeral migration were associated with irreparable tears. A recent study by Kim et al analyzed multiple MRI factors finding that the best predictors of reparable tears were infraspinatus fatty infiltration grade <3 and tear retraction to the humeral head or less. Therefore, surgeons should be aware that irreparable rotator cuff tear is likely in patients with narrowing of the acromiohumeral distance below 5 to 6 mm, severe (grade 3 and 4) fatty infiltration of the supraspinatus and infraspinatus, and tears retracted to the glenoid (Figure 2).

**Nonsurgical Treatment**

Nonsurgical treatment is used as the first-line treatment for patients with irreparable rotator cuff tear and can be successful in many patients, although there may be significant progression of tear size, fatty infiltration, and rotator cuff arthropathy. Nonsurgical treatment involves physical therapy to strengthen and re-educate the deltoid, remaining rotator cuff tissue, and the periscapular musculature. Typically, we recommend a supine deltoid reactivation program to

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Figure 2

MRI sagittal and coronal images showing findings suggestive of irreparable rotator cuff tear including grade 4 atrophy of the supraspinatus and infraspinatus with massive tear retracted to the glenoid.

determine whether elevation can be restored. NSAIDs and subacromial corticosteroid injections can also reduce pain and improve function, while also allowing more accurate assessment of active and passive range of motion in the absence of pain. Nonsurgical management is favored in patients with lower functional demands, those who are poor medical candidates for surgery, and those with relatively mild pain and mild shoulder dysfunction. Some patients with poorly compensated force couples resulting in clinical pseudoparalysis may improve with nonsurgical treatment as well, although many will go on to elect surgical treatment in our experience. Although anterior deltoid re-education has been explored as a potential treatment, recent results indicate only 40% success.

Surgical Treatment Options

Reverse Total Shoulder Arthroplasty

If nonsurgical treatment fails, various surgical treatment options are considered. In patients with Hamada grade 3 or greater reflecting more intermediate- to advanced-stage rotator cuff arthropathy, those with anterosuperior escape or severe pseudoparalysis, or those older than age 65 years, the RSA is our preferred treatment option. Age is generally a relative contraindication and is adjusted based on individual patient assessment. Long-term outcomes of RSA for rotator cuff arthropathy in a generally older patient population have resulted in reliable pain relief and improved function. Outcomes of RSA for irreparable rotator cuff tear without arthritis are promising in short- to mid-term follow-up, with most studies addressing patients older than 65 years with pseudoparalysis. Hartzler et al analyzed patients who underwent RSA for irreparable rotator cuff tear without arthritis at a minimum 2-year follow-up, finding that age <60 years, high preoperative function, and neurologic dysfunction were associated with poor outcomes. Boileau et al found that the subgroup of patients with preoperative active elevation over 90° had loss of active elevation with 27% dissatisfaction rate. Ernstrbrunner et al recently reported a series of RSA for patients younger than age 60 years with a mean follow-up period of 11.7 years, finding subjective and functional improvement but with 39% complication rate and 9% failure rate. Therefore, we urge caution in applying RSA to younger patient populations with irreparable tears, minimal arthritis, and good preoperative function because they may not obtain their desired functional improvement and implant longevity remains a potential concern with higher activity levels and occupational demands.

Partial Repair

Traditionally, irreparable rotator cuff tears were treated with a combination of débridement, subacromial decompression, partial repair, and/or biceps tenotomy or tenodesis. Partial repair is thought to work by restoring the force couple and the resultant cable system for force transmission. Tension free repair is important to achieve, and medialized by up to 10 mm for the supraspinatus may enhance the ability to achieve partial repair, although it changes shoulder biomechanics. Shon et al found that partial repair resulted in initial improvement of symptoms, but functional outcome was variable and results deteriorated over time with 50% dissatisfaction at 2-year follow-up. Cuff et al found that at 5 years after partial repair for patients who had intact preoperative active elevation averaging 168°, patients had improved American Shoulder and Elbow Surgeons (ASES) and simple shoulder test scores and reduction in pain, but that Hamada grade progressed in 36% and there was a 29% failure rate based on a composite end point of ASES, revision, or development of pseudoparalysis. Tuberoplasty has also been proposed as an option for irreparable rotator cuff tear without pseudoparalysis, with one study reporting mean 8-year outcomes in a series of 16 patients showing pain relief from visual analog scale (VAS) 6.9 to 2.3 and Constant score improvement from 27.2 to 59.2. Although partial
repair can improve pain and function by restoring the force couple, the authors generally opt for other options for an irreparable tear because the results of partial repair have tended to be less reliable in our experience.

**Tendon Transfers**

Tendon transfers have been described for restoring force couples in the shoulder with irreparable rotator cuff tear. Latissimus dorsi transfer is generally used to replace the irreparable posterosuperior rotator cuff and has been shown to improve pain for patients with irreparable posterosuperior rotator cuff tears, although functional outcomes are more variable. Inferior outcomes can be expected for patients with subscapularis dysfunction, severe teres minor fatty infiltration, revision procedures, and those with arthritic changes. Furthermore, there may be glenohumeral arthritis progression in a third of patients. Iannotti et al performed an electromyography study showing that the latissimus tendon contracted in phase during active external rotation for 6/9 patients with a good clinical result and 0/5 patients with a poor clinical result.

Lower trapezius transfer has been more recently popularized for management of irreparable posterosuperior rotator cuff tear. At average 47-month follow-up, Elhassan et al found improved pain, functional scores, and range of motion, especially for patients with preoperative active elevation of >60°. Biomechanical evidence suggests that the lower trapezius transfer can be superior to latissimus transfer to restore joint reactive force and shoulder kinematics. Further study will be necessary to define the role of lower trapezius transfer and relative merits of this transfer compared with latissimus dorsi transfer or other options for irreparable posterosuperior rotator cuff tears. Pectoralis major transfer has been described to replace an irreparable anterosuperior tear involving the subscapularis, with multiple described techniques and literature mostly limited to retrospective case series with short-term follow-up. Moroder et al reported that 27 patients with average 10-year follow-up had improved pain and internal rotation, with 77% satisfaction. Rotator cuff arthropathy progressed in 67% of patients, but only one patient underwent revision to RSA. Latissimus dorsi transfer has also been described for the treatment of subscapularis insufficiency, although clinical outcomes data are lacking to date.

**Bridging Interpositional Graft**

Bridging interpositional grafts have been described for irreparable rotator cuff tears, with results predominantly from small case series with short-term follow-up. The graft is secured to the irreparable rotator cuff tendon and bridges the remaining cuff and the footprint on the humerus. Grafts used include autograft biceps tendon and fascia lata, allografts, xenografts, and synthetic materials. Structural healing has varied from 58% to 100%, and patients have had improved outcomes compared with preoperative. Mori et al reported a comparative study in which patients underwent either partial repair or partial repair with fascia lata autograft bridging interposition. They found that at 36-month follow-up, both groups had significant improvement compared with preoperative. The graft group achieved superior Constant and ASES scores, with no difference in UCLA scores compared with the partial repair group. The percentage of intact repairs was 79% for the graft group versus 58% for the partial repair group on postoperative imaging.

**Subacromial Spacer**

An emerging strategy for management of irreparable rotator cuff tear has been the implantation of a degradable subacromial spacer that seeks to prevent humeral head elevation, thereby centering the humeral head in the glenoid and improving the ability of the deltoid to actively elevate the arm. This device (InSpace; OrthoSpace, Israel) can be inserted arthroscopically into the subacromial space and inflated with saline before being sealed (Figure 3). The balloon is designed to degrade between 2 and 12 months postoperatively. It is currently the subject of an ongoing clinical trial in the United States. Senekovic et al reported 5-year follow-up of a series of 20 patients with a mean age of 69 years who underwent this procedure without rotator cuff repair. The rate of follow-up for this study was poor with only 63%, with one patient undergoing RSA at 4 years, two patients dying of unrelated causes, and six patients otherwise lost to follow-up. They found that over 50% of subjects exceeded the minimal clinically significant improvement of >10 points on the Constant Score, with over 40% showing >25-point improvement. Deranlot et al reported mean 32.8-month outcomes after spacer implantation in 37 patients with Hamada grade 1 or 2 rotator cuff tears and an average age of 69.8 years. They found improved forward elevation from 130° to 160°, external rotation from 30° to 45°, and Constant Score from 44.8° to 76.0°. One patient underwent revision for spacer migration, and Hamada progression was observed in 19% of patients.
SCR has recently been proposed as a strategy for management of irreparable rotator cuff tears by reconstructing the superior capsule as a static restraint to prevent superior migration of the humeral head and maintain native glenohumeral station.43 This technique involves anchors into the superior glenoid and greater tuberosity with an autograft fascia lata or acellular dermal allograft to recreate the superior capsule (Figure 4). Biomechanical data have shown promising results of SCR,43 and the limited clinical outcomes available reveal potential to relieve

**Superior Capsular Reconstruction**

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*Figure 3*

Arthroscopic insertion of the subacromial balloon spacer (OrthoSpace) for massive irreparable rotator cuff tear. **A**, Diagnostic arthroscopy viewing from the mid-lateral portal showing massive irreparable rotator cuff tear. **B**, The deflated balloon spacer is inserted from the mid-lateral portal, and **C** saline is inserted to expand the balloon in subacromial space.

*Figure 4*

SCR with acellular dermal allograft for massive irreparable rotator cuff tear. **A**, Diagnostic arthroscopy revealing massive rotator cuff tear retracted to the glenoid that was found to be irreparable. **B**, Anchors are inserted on the superior glenoid and greater tuberosity adjacent to the articular margin. **C**, Measurements are taken from the anchors, and the graft is cut to the appropriate size. **D**, The graft is secured with lateral row fixation and side-to-side repair of the graft to the residual posterior rotator cuff. **E**, Completed SCR is shown. SCR = superior capsular reconstruction.
pain and restore function for patients with irreparable rotator cuff tear and intermittently, pseudoparalysis. Mihata et al reported the initial series of SCR with fascia lata autograft in 24 shoulders predominantly Hamada grade 1 and 2 (92.2%) at mean 34.1-month follow-up (range, 24 to 51). Four cases were revisions, and 20/24 cases (83.3%) were primary procedures. After SCR, patients had markedly improved forward elevation from 84° to 148°, external rotation from 26° to 40°, and American Shoulder and Elbow Surgeons score from 23.5 to 92.9, whereas the acromiohumeral distance reversed from 4.6 ± 2.2 mm preoperatively to 8.7 ± 2.6 mm postoperatively. Postoperative MRI showed that the SCR graft and rotator cuff tendon were intact in 20/24 shoulders (83.3%), with three cases of retear of the infraspinatus (12.5%) and one case of graft tear (4.2%). In a further larger series of 102 SCRs with fascia lata autograft, Mihata et al found similar improvements of motion and functional scores, 95/102 (93%) with intact graft and tendon, return to previous work in 32/34 (94%), and return to recreational sports for 26/26 (100%).

Denard et al recently published preliminary results of SCR with dermal allograft in 59 patients with minimum 1-year follow-up, finding improved forward flexion (130° to 158°), external rotation (36° to 45°), VAS pain (5.8 to 1.7), and ASES (43.6 to 77.5). They found that 45% (9/20) of grafts were completely healed on postoperative MRI, with graft failure occurring most commonly on the humeral side (7 cases), followed by intrasubstance (3 cases) and glenoid side (1 case). The success rate was 74.6% (46/59), but 11 patients (18.6%) went on to a revision procedure including seven RSAs. Future studies are needed to confirm the long-term viability and survivorship of this and determine whether the results of Mihata et al using a 4-ply thickness fascia lata autograft differ from results using a thinner 3- to 4-mm dermal allograft as is currently done in the United States.

**Authors’ Preferred Treatment Algorithm**

Treatment is individualized to each patient, taking into account factors including age, preoperative function, shoulder pathology, and patient goals and demands. Initial treatment is nonsurgical, involving physical therapy, activity modification, oral medications, and cortisone injections. If nonsurgical treatment fails, surgical options are discussed according to our preferred treatment algorithm (Figure 5).

The RSA is our preferred treatment option for patients with intermediate-to advanced-stage rotator cuff arthropathy (Hamada grade 3 or greater). We also favor RSA for those with anterosuperior escape, pseudoparalysis, and/or lower demand individuals older than 65 years. The RSA provides the most reliable pain relief and restoration of function in these situations, although we will consider nonarthroplasty options such as SCR in younger patients with pseudoparalysis or older patients with high functional demands.

For patients with Hamada grades 1 and 2 younger than 65 years without pseudoparalysis, our preferred treatment is arthroscopic SCR, assuming that the rotator cuff is truly irreparable intraoperatively. The authors’ experience has been that SCR with an acellular dermal allograft offers reliable pain relief and more consistent functional improvements than alternative techniques such as tendon transfers or partial rotator cuff repair. In the uncommon situation of an irreparable subscapularis tear
combined with irreparable posterosuperior rotator cuff tear, we would generally perform RSA, although SCR with combined split pectoralis major transfer to address the subscapularis deficiency could be an option for a patient who wished to avoid arthroplasty. We have limited experience with balloon arthroplasty and interpositional grafts, although these are also promising non-arthroplasty treatment options.

Summary

Patients with irreparable rotator cuff tears present diagnostic and treatment challenges for orthopaedic surgeons. Careful physical examination and imaging evaluation with radiographs and MRI can help to delineate patients with pseudoparalysis and predict those with repairable versus irreparable tears. In older patients with rotator cuff arthropathy and relatively sedentary demands, the RSA has been established as the preferred treatment option, producing reliable improvements in pain and function. In younger patients without significant arthritis, joint-preserving options are preferred, with an increasing array of treatment options including partial repair, bridging interpositional graft placement, tendon transfers (ie, latissimus, trapezius, subscapularis deficiency could be an option for a patient who wished to avoid arthroplasty. We have limited experience with balloon arthroplasty and interpositional grafts, although these are also promising non-arthroplasty treatment options.

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