Arthroscopic Superior Capsular Reconstruction and Over-the-Top Rotator Cuff Repair Incorporation for Treatment of Massive Rotator Cuff Tears

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Abstract: Massive rotator cuff tears pose significant clinical and surgical challenges for orthopaedic surgeons and increased morbidity to the patient. Left untreated, this pathology can lead to inability to perform daily activities, weakness, pain, and eventual cuff tear arthropathy. Several treatment options exist for irreparable cuff tears, such as reverse shoulder arthroplasty and tendon transfers. However, there exists significant concern for high complication rates and unpredictable clinical outcomes following such treatments. Superior capsular reconstruction (SCR) represents a viable alternative in treating irreparable cuff tears, providing biomechanical stability and improving pain related to this pathology by reducing superior humeral instability and subacromial impingement. Over-the-top repair of the native rotator cuff tendons with incorporation of the SCR allograft may provide surgeons the opportunity to perform a robust repair in situations where arthroplasty or other more invasive procedures were once the only options. The authors present a surgical technique with associated pearls and pitfalls for their preferred procedure of SCR with incorporation of the native rotator cuff in trans-osseous equivalent double-row repair for the treatment of massive, irreparable rotator cuff tears.

Massive rotator cuff tears >5 cm have been reported as frequently as 42% in patients with traumatic rotator cuff injuries, and can lead to debilitating weakness, pain, and shoulder dysfunction. Certain criteria for preoperative determination of an irreparable tear have been suggested, including defect size greater than 5 cm, anterior superior humeral subluxation, acromio-humeral distance of less than 7 mm, and magnetic resonance imaging Goutallier classification grades 3 and 4. However, rotator cuff repair is reliant on tissue quality, as tendons that are excessively retracted or possess overwhelming atrophy are not amenable to repair. Although radiographic parameters are useful in this prediction, the final decision of reparability is often determined intraoperatively.

Although various treatment options for irreparable rotator cuff tears have been described, significant concerns exist regarding high complication rates and variable clinical outcomes. Reverse total shoulder arthroplasty has been advocated in older patients with irreparable rotator cuff dysfunction, but has been associated with an overall complication rate 4 times greater than anatomic shoulder arthroplasty, including an especially high rate of infection (5%). This procedure also poses much greater financial burden on the patient, as well as extended postoperative rehabilitation. Therefore, patients are often only willing to undergo this operation as a last-resort procedure after the irreparable cuff diagnosis is made. Tendon transfers have been used as an alternative in these younger patients for which arthroplasty is not an option.
However, narrow surgical indications limit its use to selected patients, particularly young, active individuals without significant medical comorbidities, previous rotator cuff surgery, deltoid/subscapularis deficiency, or glenohumeral or acromioclavicular joint arthritis. Additionally, outcomes may be influenced by multiple elements such as age, pain, disability, functional demands, patient expectations, and willingness to adhere to lengthy rehabilitation protocols.

More recent literature suggests that superior capsular reconstruction (SCR) may represent a viable alternative in treating an irreparable rotator cuff tear. Mihata et al. described the use of tensor fascia lata graft for SCR with both excellent clinical and biomechanical results. This technique has evolved to use a dermal decellularized allograft in SCR that eliminates the potential donor site morbidity associated with the fascia lata technique. However, limited information exists regarding incorporation of the native rotator cuff in SCR for massive rotator cuff tears. This procedure may provide surgeons the opportunity to incorporate native rotator cuff tissue into a biomechanically robust repair in situations where arthroplasty or other more invasive procedures were once the only options. This Technical Note describes the surgical technique for our preferred procedure of SCR with over-the-top incorporation of the native rotator cuff in transosseous equivalent double-row repair for the treatment of massive irreparable rotator cuff tears in patients with limited glenohumeral arthritis.

**Surgical Technique**

**Indications**

The ideal patient candidate for superior capsular reconstruction is a relatively young (≤45 years) patient with limited glenohumeral arthritis and a massive (>5 cm) or irreparable rotator cuff tear. As stated previously, SCR may provide a better surgical alternative to tendon transfers or partial rotator cuff repairs because of the potential for donor site morbidity and risk of failure associated with those procedures in this population. Additionally, reverse shoulder arthroplasty is not preferred because of concerns of implant loosening and failure, high rates of postoperative complications, and potential for destruction of the glenohumeral joint. Other patients who would likely benefit from this procedure are those undergoing revision surgery as a result of failure of a prior rotator cuff repair. In these cases, the remaining tendons are usually more degenerated with a greater degree of fatty infiltration, making complete anatomic repair extremely difficult. SCR may provide an acceptable salvage option for these patients looking to avoid or unable to undergo reverse shoulder arthroplasty.

On physical examination, testing of external and internal rotation strength can provide valuable information for assessing the integrity of the rotator cuff. Commonly used tests designed to evaluate different portions of the rotator cuff, such as the Hornblower sign (teres minor) and bear-hug or belly-press/lift-off (subscapularis), are also useful. Some patients may present with pseudoparalysis of the shoulder, which generally is described as loss of active forward elevation below 90° with anterior superior humeral escape in the setting of a massive, degenerated rotator cuff tear. It is critical to obtain preoperative radiographic and magnetic resonance imaging studies to assess the degree of glenohumeral arthritis, as well as determine the size and location of the rotator cuff tear.

**Patient Positioning**

Modified beach chair is our preferred position for this procedure. Preoperatively, a regional interscalene nerve block is performed with ultrasound guidance. The shoulder is positioned in neutral external rotation and abduction. The patient is then prepared and draped in the standard sterile fashion. An articulated arm holding device (Trimano Arm Holder; Arthrex, Naples, FL) is employed for dynamic arm positioning throughout the operation.

**Portal Placement**

Bony anatomic landmarks are identified and marked on the skin: the spine of the scapula, clavicle, acromion, acromion-clavicular articulation, and coracoid process. The standard posterior portal is placed 2 cm inferior and 1 to 2 cm medial to the posterior lateral aspect of the acromion in the soft spot. The anterior portal is created using an outside-in technique and placed slightly lateral to the coracoid process, directly below the coracoacromial ligament. The lateral portal is placed 3 cm inferior to the lateral aspect of the acromion. An accessory anterolateral portal is placed directly off the anterolateral edge of the acromion. A percutaneous Neviser portal, also established using an outside-in technique, is used to assist with suture passage and is placed medial to the articular convergence of the clavicle, acromioclavicular joint, and scapular spine. Three instrument cannulas (8.25 mm, Twist-In; Arthrex) are used in the anterior, anterolateral, and posterior portals, while a 3 × 12-mm button cannula (PassPort; Arthrex) is used in the lateral portal (Fig 1).

**Preparation and Evaluation of the Glenohumeral Joint**

A systematic evaluation of the entire glenohumeral joint is performed, including dynamic examination of rotator cuff tendons, viewing from the posterior portal. We prefer a 30° arthroscope for optimal visualization (Arthrex). The arthroscope is then placed in the lateral
portal to enter the subacromial space. Removal of bursal tissue and debridement of any synovitis around the capsule or rotator cuff tendons is carried out. The basic rotator cuff repair principles of tendon mobilization, tear pattern recognition, and footprint preparation should be followed. The biceps tendon may be released and later tenotomized or tenodesed if tenosynovitis, fraying, or tearing is present or depending on patient age and activity level. If the supraspinatus and portions of the infraspinatus tendon are found to be irreparable, and the patient has minimal glenohumeral arthritis, a superior capsular reconstruction is performed.

**Anchor Placement**

The sites of glenoid anchor insertion are prepared with a 4.0-mm arthroscopic burr (Arthrex). Using the Neviaser portal, 3.0-mm anchors (SutureTak; Arthrex) loaded with TigerTail (Arthrex) are placed in the 10- and 2-o’clock positions, and the sutures passed through the lateral portal (Fig 2).

After preparing the supraspinatus greater tuberosity footprint with the burr to create a bleeding surface, 2 medial 4.75-mm anchors (Biocomposite Corkscrew FT; Arthrex) are placed, and the sutures are passed out of the lateral portal.

**Graft Preparation, Passage, and Fixation**

Using an arthroscopic measurement probe (220 mm, 60°; Arthrex), medial-lateral and anterior-posterior distances between anchors are measured and recorded for graft preparation. The graft (ArthroFlex; Arthrex) is sized to the appropriate dimensions on the back table, leaving 5 mm extra on the outer anterior, posterior, and medial edges, while leaving an extra 10 mm on the lateral edge. Through a percutaneous Neviaser approach, a stitch is placed and fixated to the center of the medial edge of the graft to aid in shuttling. The 2 sutures from each of the other 2 glenoid anchors are passed through each of the 2 corners on the same medial edge of the graft (Fig 3).

One suture limb from each glenoid anchor is taken and tied together. The other suture limbs are used as pulleys to slide the graft through the lateral PassPort cannula (Video 1). The lateral sutures (FiberTape;
Arthrex) are not passed at this time to prevent graft twisting. An arthroscopic grasper (KingFisher; Arthrex) can be used to assist in delicately pushing the graft forward into place over the top of the glenoid and under the native rotator cuff (Fig 4A). Care should be taken to properly manage sutures and not pull the graft overzealously to avoid suture or anchor pull-out (Table 1). The glenoid anchor sutures are taken with an arthroscopic retriever (FiberTape Retriever; Arthrex) through the anterior portal and tied down to fixate the graft (Fig 4B and C).

Incorporation of Native Rotator Cuff Repair

Now that the medial aspect of the graft has been fixated, a suture-passing device (FastPass Scorpion; Arthrex) is used to pass the sutures from the anterior and posterior greater tuberosity anchors through anterior and posterior corners, respectively, on the lateral edge of the graft (Video 1; Fig 5A). Care is taken to avoid twisting the graft by passing the anterior sutures through the anterior portal for suture management (Table 1; Fig 5B). An angled suture-passing device (ReelPass SutureLasso, 90°; Arthrex) is then used to pass the sutures from the posterior tuberosity anchor through the native rotator cuff to begin incorporation into the double-row repair (Fig 6).

The KingFisher grasper (Arthrex) is simultaneously used to achieve maximum tendon approximation. Once passed through the rotator cuff, the posterior sutures are drawn out of the posterior portal. The anterior tuberosity anchor sutures are passed through the rotator cuff in a similar fashion and drawn out of the anterior portal. The tension placed on the sutures as they are passed out of the shoulder reduces the graft to the correct position (Video 1). The arm is then placed in 30° of abduction to help achieve adequate graft tension. After passage through the native rotator cuff, the greater tuberosity sutures can be used to begin the transosseous equivalent double-row repair and tied down to incorporate the native tendon “over the top” (Fig 7).

Final Testing and Concomitant Procedures

On completion, the shoulder is put through range of motion testing under arthroscopic visualization to assess the integrity of the repair (Fig 8). Any remaining pathology is addressed. We normally perform a biceps tenodesis, with our preferred technique being open subpectoral tenodesis.

Rehabilitation

Adequate rehabilitation is critical to the postoperative success of this procedure. Our preferred protocol consists of 4 separate phases (weeks 0-6, weeks 6-8, weeks 8-12, and months 3-12), similar to other published rehabilitation protocols available in the literature.13 During the first 6 postoperative weeks, patients are to remain in a sling with an abduction pillow to allow for adequate healing of the rotator cuff and dermal allograft. Only range of motion at the elbow, wrist, and hand is allowed. Formal physical therapy is withheld until after 6 weeks. Between 6 and 8 weeks, patients are permitted passive range of motion and grip-strengthening exercises. Range of motion goals are 140° of forward elevation, 40° of external rotation at the side, and maximum 60° to 80° of abduction. During weeks 8 to 12, active-assisted range of motion exercises are begun, with active range of motion done as tolerated. Range of motion goals are the same as in weeks 6 to 8, but with the incorporation of light passive stretches at end ranges. Scapular exercises are initiated, with progressive resistive exercises done for major muscle groups (pectoralis muscles, latissimus dorsi, etc.). Isometric strengthening is permitted with the arm at the side. Finally, from months 3 to 12, patients are advanced to full range of motion with passive stretching at end ranges. Advanced strengthening exercises are commenced 3 times per week, including isometrics, resistance bands, and light weights (1-5 lb). Eccentrically resisted exercises, plyometrics, and proprioception routines are started after week 16. Patients are expected to reach maximum medical improvement at 12 months postoperatively.

Discussion

The superior glenohumeral capsule and rotator cuff tendons have been established as critical components to the stability of the glenohumeral joint, and authors have argued that rotator cuff repair must also involve the
restoration of capsular anatomy to maximize clinical outcomes.\(^1\) Although more groups have generated interest in performing SCR with utilization of allografts for massive, complicated rotator cuff tears, the current state of literature regarding the clinical efficacy of SCR for rotator cuff tears is lacking. The majority of established evidence comes from biomechanical studies that have analyzed the impact of the glenohumeral capsule on the

![Image](image.png)

**Fig 4.** (A) An arthroscopic grasper (KingFisher; Arthrex) can be used to assist in delicately pushing the graft forward into place over the top of the glenoid and under the native rotator cuff. Note the relative locations of the dermal allograft (G) and the native rotator cuff (R). Care should be taken to properly manage sutures, which are also labeled, and not pull the graft overzealously to avoid suture or anchor pull-out. The view is from the posterior portal on the right shoulder with the patient in modified beach chair position. (B) Proper suture management is critical to the success of this procedure. An arthroscopic retriever (FiberTape Retriever; Arthrex) is used to pull the sutures outside of the anterior portal to allow for tying. The location of the dermal allograft (G) relative to the native rotator cuff (R) is noted. The view is from the posterior portal on the right shoulder with the patient in modified beach chair position. (C) The 2 suture limbs from the glenoid anchors are tied down with an arthroscopic knot pusher via the anterior portal to achieve medial fixation of the dermal allograft (G) to the glenoid under the native rotator cuff (R). These sutures are then cut with a knot cutter. Adequate medial fixation is critical to the integrity of the repaired glenohumeral capsule, as well as the overall postoperative outcome. The view is from the posterior portal on the right shoulder with the patient in modified beach chair position.

**Table 1. Surgeon Pearls and Pitfalls**

| Pearls | Pitfalls |
|--------|----------|
| Only attaching sutures to the medial graft side reduces the chance of tangling and facilitates passage | Improper placement of glenoid anchors may result in damage to articular cartilage or suprascapular nerve |
| Manipulate the graft with arthroscopic grasper/retriever to achieve proper orientation | Excessive pulling on sutures when passing the graft may cause pull-out from graft or anchor site |
| Complete tendon approximation is unnecessary as long as native cuff is incorporated into the repair | Improper suture management when passing them through the graft may result in graft twisting |
| Abduct the arm approximately 30° when passing greater tuberosity sutures through the cuff to achieve adequate graft tension | Inadequate graft tension may result in failure to limit superior translation of the humeral head |
kinematics of the shoulder. In one of the first studies on this topic, Mihata et al. showed that reconstruction of the capsule with fascia lata grafts was found to significantly reduce superior translation of the humerus (5.4 ± 0.7 mm vs 3.0 ± 1.9 mm, \( P < .05 \)), as well as subacromial contact pressures (0.07 ± 0.04 MPa vs 0.01 ± 0.01 MPa, \( P < .05 \)). Further studies with similar methods have confirmed the role of glenohumeral capsule reconstruction in reducing peak subacromial contact pressures (83% of intact at 30° abduction, \( P < .05 \)) and superior glenohumeral translation (110% of intact at 30° abduction, \( P < .05 \)) to pre-supraspinatus tear levels. A more recent biomechanical study compared the original fascia lata graft to the dermal allograft for SCR

![Fig 5](image1.jpg)

Fig 5. (A) The sutures from the anterior tuberosity anchor are passed through the dermal allograft (G) using a FastPass Scorpion (Arthrex). Note the location of the native rotator cuff (R). The sizing markings put on the graft during the sizing and preparation stages assist with orientation and ensure passage of the sutures through the correct location on the graft. The view is from the posterior portal on the right shoulder with the patient in modified beach chair position. (B) Once the anterior tuberosity anchor sutures have been passed through the dermal allograft (G), the arthroscopic retriever (FiberTape Retriever; Arthrex) is used to pass them through the anterior portal. The purpose of this is to establish a clear field of view and reduce the risk of graft tangling, which can significantly delay the case. Suture management is heavily emphasized as a key factor in achieving success with this procedure. The view is from the posterior portal on the right shoulder with the patient in modified beach chair position.

![Fig 6](image2.jpg)

Fig 6. (A) Once the sutures are passed through the dermal allograft (G), an angled suture-passing device (ReelPass SutureLasso, 90°; Arthrex) is used to pass the sutures from the posterior tuberosity anchor through the native rotator cuff (R) to begin incorporation into the double-row repair. The arthroscopic grasper (KingFisher; Arthrex) is used to manipulate the native rotator cuff and achieve adequate tendon approximation. The view is from the lateral portal on the right shoulder with the patient in modified beach chair position. (B) In a similar fashion, an angled suture-passing device (ReelPass SutureLasso, 90°; Arthrex) is used to pass the sutures from the anterior tuberosity anchor through the native rotator cuff (R) to begin incorporation into the double-row repair. Note the position of the dermal allograft (G) relative to the native rotator cuff (R). The arthroscopic grasper (KingFisher; Arthrex) is used to manipulate the native rotator cuff and achieve adequate tendon approximation. The view is from the lateral portal on the right shoulder with the patient in modified beach chair position.
and found that the fascia lata graft completely restored humeral translation ($P < .05$), superior glenohumeral joint force ($P < .05$), and subacromial contact pressure ($P < .05$) without changing length. The dermal allograft also completely restored subacromial contact pressure ($P < .05$) and glenohumeral joint force ($P < .05$), though significantly elongating (15%) during testing. This was one of the first studies to directly compare the original fascia lata technique to dermal allografts, and the findings reveal the need for further investigation to determine efficacy and optimal indications for each technique.

Although scarce, the clinical evidence that does currently exist regarding SCR for treatment of rotator cuff tears is promising. Significant improvements in American Shoulder and Elbow Surgeons scores (23.5 to 92.9, $P < .001$), active elevation (84° to 148°, $P < .001$), external rotation (26° to 40°, $P < .01$), and acromiohumeral distance (4.6 ± 2.2 mm to 8.7 ± 2.6 mm, $P < .001$) after SCR with fascia lata were reported in a small cohort of 23 patients with 34.1-month follow-up. A more recent series of 9 patients who underwent SCR with Arthrex dermal allograft for massive rotator cuff tears (the same graft as shown in this Technical Note), reported significant improvements in American Shoulder and Elbow Surgeons scores (43.54 to 84.56, $P < .001$), visual analog scale pain scores (6.25 to 0.38, $P < .001$), and acromiohumeral distance (4.50 to 8.48 mm, $P < .001$) at minimum 2 years' follow-up. It is worthy to note there was no significant difference in outcomes between these patients and a historical control group that underwent standard rotator cuff repair, which is impressive in its own right. Additionally, ultrasonography revealed the presence of blood vessels within the tissue of the graft between 4 and 8 months postoperatively, which indicates a positive biological healing response to the dermal allograft. A larger case series of 88 patients reported significantly improved visual analog scale pain scores (4.0 to 1.5, $P = .005$) and American Shoulder and Elbow Surgeons scores (52 to 82, $P = .005$), as well as both strength ($P = .004$) and range of motion ($P = .007$) in forward flexion and abduction at 1 year follow-up after SCR with dermal allograft for patients with massive, irreparable rotator cuff tears. The authors also found increased acromiohumeral intervals (mean 7.1 to

![Fig 7](image1.png)

**Fig 7.** Repair of the native rotator cuff (R) over the top of the dermal allograft (G) is begun and depicted here. Some side-to-side stitching may be necessary to achieve adequate tendon approximation. An angled suture-passing device (ReelPass SutureLasso, 90°; Arthrex) greatly facilitates this portion of the case, and can be used in conjunction with an arthroscopic grasper (KingFisher; Arthrex). The view is from the Lateral Portal on the right shoulder with the patient in modified beach chair position.

![Fig 8](image2.png)

**Fig 8.** (A) The transosseous equivalent double-row repair is performed and a final arthroscopic evaluation of the repair with range of motion testing is done to assess repair integrity. The view is from the Lateral Portal on the right shoulder with the patient in modified beach chair position. (B) The transosseous equivalent double-row repair is performed and a final arthroscopic evaluation of the repair with range of motion testing is done to assess repair integrity. Portions of the dermal allograft may still remain visible on completion of the repair, which is acceptable and should not compromise outcome. The view is from the lateral portal on the right shoulder with the patient in modified beach chair position.
Table 2. SCR Procedure Advantages and Disadvantages

| Advantages | Disadvantages |
|------------|--------------|
| Dermal allograft eliminates potential for donor site morbidity | Technically challenging procedure for surgeon to perform |
| Position of glenoid anchors on the superior glenoid will not preclude potential reverse total shoulder arthroplasty in the future | Dermal allografts may not be readily available in all settings and can be costly |
| Arthroscopic approach poses less risk for bleeding and infection compared with open procedures | Lengthy rehabilitation often necessary |
| Allows for intervention in patients for whom arthroplasty or tendon transfers are contraindicated | No clear guidelines established for several of technical aspects (ie, graft passage/sizing, arm position, biologic augmentation) |

SCR, superior capsular reconstruction.

9.7 mm, $P = .049$) and described a new radiographic parameter, called superior capsular distance, that may prove clinically useful to quantify restoration and maintenance of superior capsular stability in the future. The preliminary results from these studies suggest that SCR possesses legitimate clinical potential for treatment of massive rotator cuff tears, with utilization of dermal allografts offering additional advantages such as lack of donor site morbidity risks compared with fascia lata (Table 2).

Although available evidence indicates that SCR with dermal allograft may eventually play a significant role in the treatment of massive rotator cuff tears, further studies are warranted before this technique can be considered part of standard care. Controlled clinical trials with larger sample sizes and long-term follow-up are necessary to better evaluate clinical efficacy and draw generalizable conclusions in the face of increasing commercial demand and utilization of dermal allograft. SCR also poses certain risks and limitations that are important to keep in mind. Overall, the procedure is extremely technically challenging, even for expert surgeons with years of experience in arthroscopy. Accurate placement of the glenoid anchors is critical to avoid iatrogenic damage to the articular cartilage of the glenoid fossa or suprascapular nerve, which can severely diminish patient function and quality of life postoperatively. Difficulty can also arise when passing the graft through the arthroscopic portals because of the thickness of the robust dermal allograft. Placing too much tension on the sutures may result in glenoid anchor pull-out, which increases operative time, cost, and potential risk for other intraoperative complications. Suture management is vital to the success of the procedure. Because the sutures are attached to the glenoid anchors and passed through the dermal allograft, improper or careless suture management can result in graft twisting and suture tangling. Arthroscopically untangling the allograft with FiberTape sutures (Arthrex) on it in a limited working space would pose an enormous technical obstacle to even the most experienced surgeon.

Additionally, a consensus has yet to be established regarding several technical aspects of the procedure, such as optimum graft sizing and suture orientation, degrees of arm abduction for ideal graft tension, and the potential role of biologic augmentation (bone marrow aspirate concentrate or platelet-rich plasma) (Table 2). There is also limited evidence describing the potential impact of concomitant procedures frequently performed with rotator cuff repair, such as acromioplasty, on outcomes of SCR with a dermal allograft. Initial biomechanical analysis has shown that acromioplasty may reduce subacromial contact area, but effects on humeral head position, superior translation, and peak contact pressures are unclear. Investigations focusing on these points in the future would help us address these particular uncertainties. Nonetheless, our preferred technique for arthroscopic SCR with dermal allograft and incorporation of rotator cuff repair has proven an extremely valuable option in our practice for the management of massive, degenerated rotator cuff tears in patients unwilling or unable to undergo other treatments such as tendon transfers or shoulder arthroplasty.

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