Technical Note

Irreparable Rotator Cuff Tear Treated With Combined Reconstruction of the Superior Capsule and Rotator Cuff: Technique Guidelines

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Abstract: Irreparable rotator cuff tears in young patients can be challenging for the patient and orthopaedic surgeon. Interposition rotator cuff reconstruction has gained popularity in patients with retracted tears and a viable rotator cuff muscle belly. Superior capsular reconstruction is an emerging treatment option that was developed to restore native glenohumeral joint mechanics by creating a superior constraint, which provides a stable glenohumeral fulcrum. Reconstructing both the superior capsule and rotator cuff tendon in the setting of an irreparable tear may improve clinical results in younger patients with viable rotator cuff muscle belly and a maintained acceptable acromiohumeral distance.

Introduction

An irreparable rotator cuff tear in the young and active patient can significantly compromise shoulder function and patient satisfaction. Characteristics that contribute to determining a treatment method include the degree of tendon retraction, the degree of fatty infiltration, acromiohumeral distance, tissue quality, tear chronicity, and failed prior surgery.[1]

Interpositional graft rotator cuff reconstruction (RCR) may solve the problem of tendon deficiency and has shown promising clinical results.[2] Graft reconstruction has demonstrated improved structural integrity on magnetic resonance imaging at 1 year postoperatively when compared to partial primary repair.[3] However, rates of graft healing have been highly variable with low levels of return to preinjury activities.[2,3] The persistence of superior humeral instability may explain graft failures and unsatisfactory function.[1]

Deficiency of the superior capsule significantly increases glenohumeral translation and subacromial contact pressure in abduction, internal rotation, and external rotation.[4] Disruption of the rotator cable or superior capsule can lead to substantial shoulder dysfunction, including pseudoparesis or pseudoparalysis.[5] Mihata et al. described the biomechanical benefits of superior capsular reconstruction (SCR) for irreparable rotator cuff tears.[6] The authors reported improved superior stability and subacromial pressures with SCR alone or when combined with RCR, compared to isolated RCR. Although satisfactory function and superior stability have been reported for SCR, failures approaching 65% and a high rate of persistent pain and poor function have also been described.[7,8] Notably, the mechanical contribution of superior capsule reconstruction may occur despite the lack of radiographic evidence of graft incorporation.[9] Risk factors for failure include female patients, fatty infiltration of the infraspinatus, low surgeon volume, and when performed in the setting of irreparable subscapularis tears.[10]

A subset of patients who pose considerable challenge to an orthopaedic surgeon are active patients under the age of 60 with an irreparable rotator cuff, a viable rotator cuff muscle belly (Goutallier I/II), and mild humeral head superior translation (acromiohumeral

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Table 1. Key Procedural Steps With Corresponding Pitfalls and Pearls

Key Steps	Pitfalls	Pearls
Setup step 1: Lateral decubitus position	With the potential for prolonged surgery time, injury to brachial plexus, and peripheral nerves	Appropriate axillary roll and bony extremity padding of the upper/lower extremity
Setup step 2: Four portals: anterior, lateral, posterior, and posterolateral accessory viewing portal	Deltoid injury, poor visualization, potential for swelling if cannulas are not used	Accessory posterolateral portal for optimal viewing. 10-mm lateral Passport (Arthrex) cannula for optimal graft passage. 5.75 mm cannulas in the anterior/posterior portals.
SCR step 1: Measurement of superior capsule defect	Inaccurate graft size can compromise graft function	Measure with arm abducted 30°. Mark medial and superior side of graft for orientation. Mark the 4 corresponding suture sites on the graft before passing the medial and lateral sutures. The medial marks correspond to the anterior and posterior glenoid anchors. The lateral marks correspond to the distance from the glenoid to the medial row anchors on the tuberosity.
SCR step 2: Glenoid and tuberosity footprint preparation	Insufficient bone preparation may reduce healing potential. Avoid overdecortication, which increases risk of anchor failure	Use a motorized shaver and burr, consider adding vent holes with a drill or anchor punch
SCR step 3: When possible, repair anterior and posterior rotator cuff tissues	When left unrepaired, function may be compromised.	Use anchors for repair
SCR step 4: Two superior glenoid anchors (11 and 1 o'clock)	Anchor malposition, anchor pullout, glenoid penetration, insufficient visualization	Single-loaded anchors to facilitate suture management. Use Nevaiser or accessory anterolateral portals for appropriate drill angle.
SCR step 5: Medial row tuberosity anchors	Articular penetration	Allow 2 cm between anchors.
SCR step 6: Graft preparation	Graft falling to floor, suture entanglement if graft not secured	Secure towel around the arm, clamp graft to the towel with medial/superior orientation mark closest to cannula
SCR step 7: Pass SutureTape glenoid sutures through graft and tie Mulberry knot SCR step 8: Pass FiberTape suture from medial row tuberosity anchor through graft	Suture derangement, Mulberry knot pullout if knot is too small. Scorpion needle may break from multiple passes.	Have multiple Scorpion needles available. Suture is passed 2-3 mm from the medial edge to avoid cutout.
SCR step 9: Introduction of superior capsule graft	Cannula too small to accommodate graft passage, suture	Have an assistant present to hold camera and an assistant to pull graft. Keep anterior and posterior Mulberry knot sutures in corresponding cannula to avoid twisting the graft. The surgeon pushes graft down the tensioned FiberTape sutures using a grasper.
SCR step 10: Secure medial superior capsule graft to glenoid	Suture cutout	Pull first Mulberry knot out of the lateral cannula while maintaining tension on second Mulberry knot tail to avoid graft displacement.
SCR step 11: Secure superior capsule graft to rotator cuff tissue	Suture derangement	Secure graft to adjacent rotator cuff tissue and ensure lateral cannula is free of sutures to allow preparation of RC graft
RCR step 1: Pass two free #2 FiberWire sutures in vertical mattress configuration	Suture derangement	Leave both tails on the superior side of the rotator cuff tendon
RCR step 2: Measure rotator cuff defect from medial to lateral and anterior to posterior and mark the sites on the graft. Cut graft to size.	A graft that is too short will not allow for contact with the lateral tuberosity.	Measure with arm abducted 30°. Add 0.5 cm on all edges. Secure graft similar to SCR step 6
RCR step 3: Pass RC vertical mattress sutures through medial aspect of graft.	Suture derangement, Mulberry knot pullout if knot is too small, Scorpion needle breaking from multiple passes	Place sutures 2-3 mm from graft edge to avoid cutout, tie large Mulberry knots on medial row sutures, leaving a 3-mm tail.

Key Steps	Pitfalls	Pearls
RCR step 4: Pass medial row tuberosity anchor FiberTapes into graft.	Suture derangement, Scorpion needle breaking from multiple passes	Measure the distance from the anterior lateral edge of retracted tendon to the anteror medial tuberosity anchor. Mark this distance on the graft measuring laterally from the anteromedial edge of graft. Pass anterior swedged FiberTape at this mark. Repeat for the posterior FiberTape. This step allows bony contact of the RC graft laterally
RCR step 5: Introduction of rotator cuff graft	Same as SCR step 9	Same as SCR step 9
RCR step 6: Secure medial graft to rotator cuff	Same as SCR step 10	Same as SCR step 10
RCR step 7: Insert two lateral row anchors incorporating the two medial anchor FiberTapes	Overtensioning and undertensioning the suture	Remove slack from FiberTape through grafts. Divide the swedged FiberTape tails and incorporate into lateral row anchors.
RCR step 8: Secure anterior and posterior graft to adjacent rotator cuff tissue, and secure lateral graft to lateral row anchor sutures.	Suture passer needle fatigue	Ensure graft is circumferentially secured to rotator cuff and bone.

distance >6 mm). Treatment options include physical therapy, injection, arthroscopic debridement, partial rotator cuff repair, isolated SCR, isolated, combined SCR and RCR or reverse shoulder arthroplasty. The superior capsule has been described as the essential lesion in a RCR, with its repair being integral to restoring native biomechanics.[11] Although clinical data are lacking, biomechanical evidence has been reported for SCR in combination with rotator cuff reconstruction (RCR).[6] This option is intended to provide stability superiorly, which reestablishes the native glenohumeral fulcrum and rotator cuff.

We describe a surgical technique of combined RCR and SCR to address an irreparable rotator cuff in the active adult patient with a viable rotator cuff muscle and maintained acromiohumeral space.

Surgical Technique

The surgery is performed in the lateral decubitus position, under general anesthesia with an interscalene nerve block (Video 1). A standard arthroscopic posterior portal is established, followed by placement of the 30° arthroscope. An anterosuperior portal is established, and a diagnostic arthroscopy is performed of the glenohumeral and subacromial spaces (Table 1). Synovectomy, lysis of adhesions, and rotator cuff mobilization evaluate the reparability of the rotator cuff.

Superior Capsule Reconstruction

If the rotator cuff tear is determined to be irreparable (Fig 1), the superior glenoid rim and greater tuberosity are debrided of remaining soft tissues. An accessory

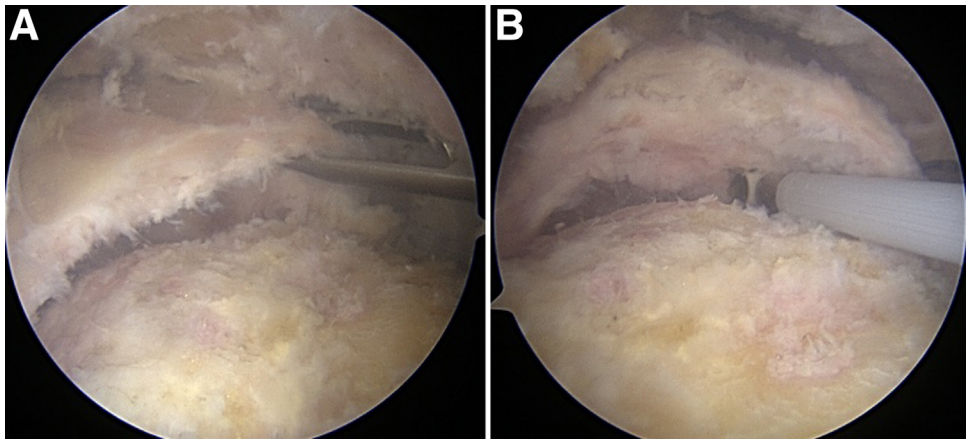

Fig 1. (A) Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal demonstrating retracted irreparable tear following preparation of tuberosity for anchor placement. (B) Preparation of the superior glenoid with debridement of residual labrum for glenoid anchor placement.

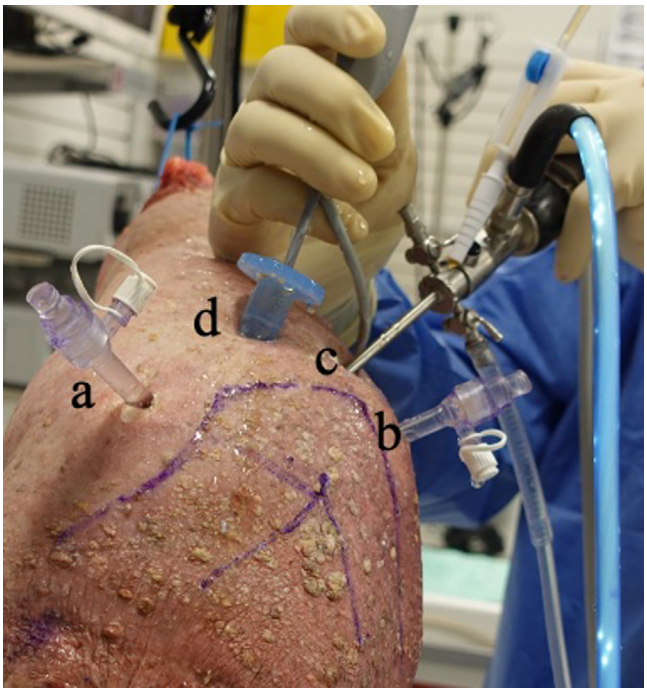

Fig 2. Ex vivo image of a right shoulder in a lateral decubitus position viewed from superior with the arthroscope in the posterolateral accessory portal. Setup includes Arthrex 5.75-mm Crystal Cannula anteriorly (a) and posteriorly (b), the arthroscope in the accessory posterolateral portal (c), and the CoolCut device performing debridement through Arthrex PassPort Button cannula in the lateral portal (d).

posterolateral camera portal is established for improved visualization (Fig 2). Anterior and posterior cannulas are placed. Anterior and posterior rotator cuff tendon tears should be repaired with anchor fixation when possible, to improve postoperative function. The superior capsule size is measured from the superior glenoid rim to the humeral articular margin in the sagittal and coronal planes with the arm adducted. If present, the long head of the biceps tendon may be tenodesed or retained to secure the anterior graft. Two 2.6-mm FiberTak suture anchors loaded with #2 SutureTape (Arthrex, Naples, FL) are placed at the 11 o'clock and 1 o'clock positions of the glenoid using a Nevasier portal or accessory incisions (Fig 3). These sutures are stored in corresponding anterior and posterior cannulas. Next, two medial row 4.75-mm SwiveLock anchors, loaded with a no. 2 FiberWire and a swedged FiberTape (Arthrex) are placed at the anteromedial and posteromedial articular tuberosity margin through a small incision off the lateral acromion (Fig 4).

A 3-mm human acellular dermal graft (ArthroFlex; Arthrex) is prepared, according to the measured dimension of the superior capsule (Fig 5). The graft, which is oversized by 2-3 mm on both the medial and lateral aspects of the graft, is used to accommodate for suture placement. A mark is placed on the medial and superior aspects of the graft to facilitate graft orientation during implantation. One tail of the SutureTape from the anterior glenoid anchor is retrieved through the lateral 10-mm diameter cannula and passed using a Scorpion suture passer (Arthrex) through the anteromedial aspect of the graft 2-3 mm in from the edge to avoid suture cutout. A large Mulberry knot is tied on the superior surface of the graft leaving a 1-cm tail (Fig 6). The same process is repeated for the posterior glenoid anchor, with the suture placed on the posteromedial aspect of the graft. Being careful to avoid suture entanglement, the swedged FiberTape is retrieved from the anterior medial row tuberosity anchor and is passed through the anterolateral aspect of the graft, 2-3 mm in from the edge. This step is repeated for the posterior medial row tuberosity anchor, placing the suture at the posterolateral aspect of the graft. No Mulberry knots are tied on the FiberTapes, and the swedged ends are maintained.

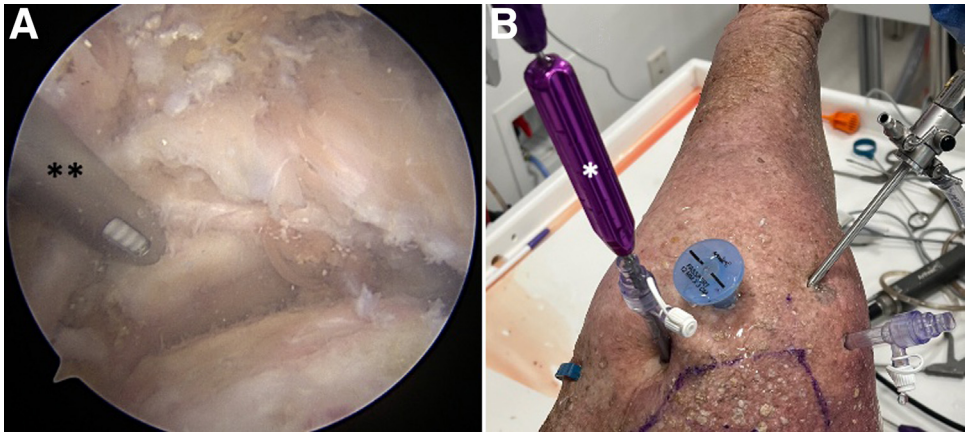

Fig 3. Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal showing insertion of posterior superior glenoid SutureTak anchor (**) through the posterior cannula (A). Ex vivo image showing insertion of anterior superior glenoid anchor (*) through the anterior cannula (B).

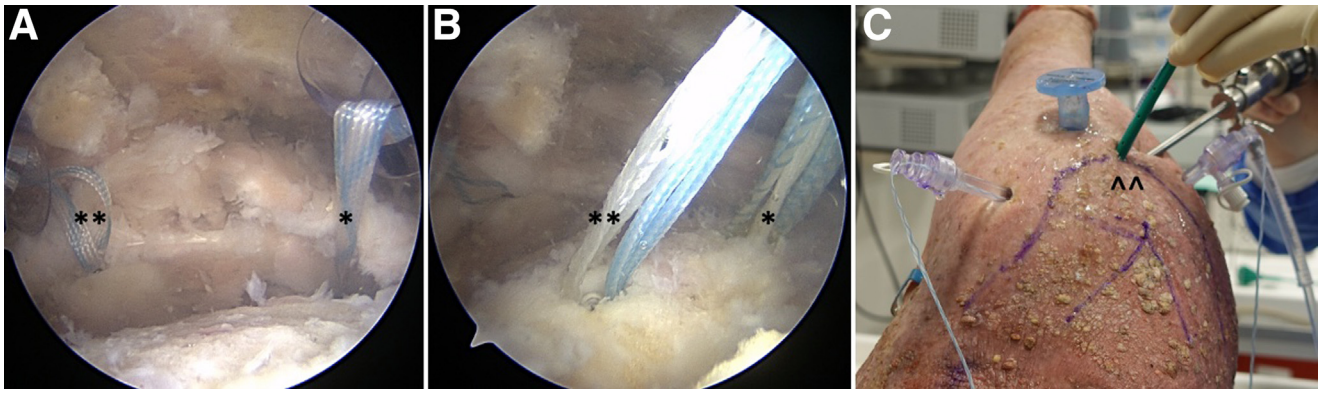

Fig 4. Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal showing glenoid SutureTak anchors loaded with no. 2 SutureTape (A) and medial tuberosity SwiveLock anchors loaded with swedged no. 2 FiberTape and no. 2 FiberWire suture (B). (* denotes the anterior anchors, and ** denotes the posterior anchors.) Ex vivo image of a right shoulder viewed from superior with the arthroscope in the posterolateral accessory portal showing the insertion of the medial tuberosity SwiveLock anchors through a small stab incision (-) off the lateral border of the acromion (C).

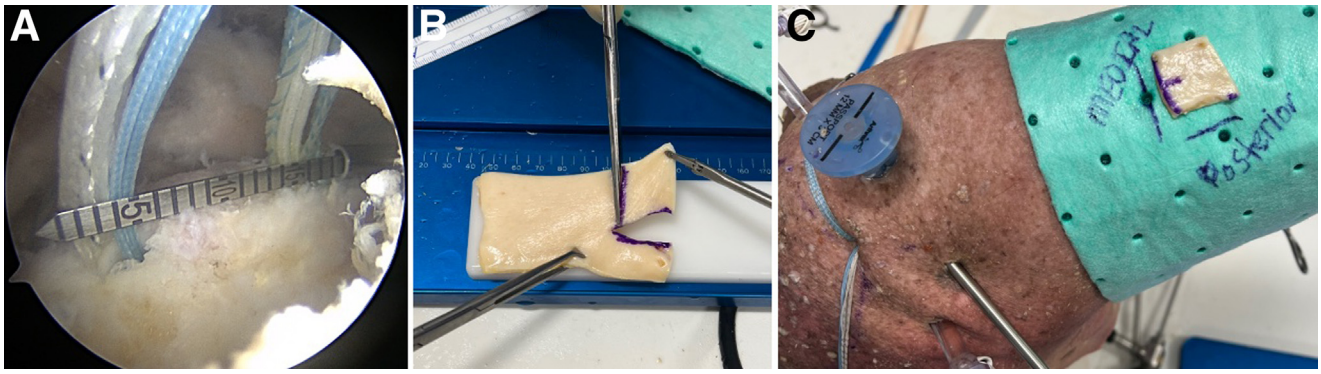

Fig 5. Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal demonstrating the measurement guide used to determine the appropriate size of the graft, adding 0.5 cm in the sagittal and coronal planes (A). The 3-mm ArthroFLEX graft is trimmed to the measured dimensions (B) and a mark is placed on the superior and medial aspect of the graft for orientation (C).

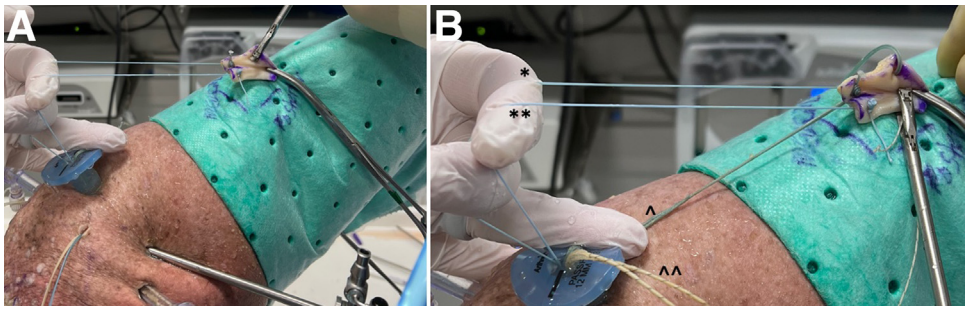

Fig 6. Ex vivo images viewed from posterior of a right shoulder showing graft preparation. The graft is clamped to a towel, and the glenoid SutureTapes are secured to the medial aspect of the graft with Mulberry knots after passing with a Scorpion suture passer (A). Note the assistant's hand separating the four sutures into separate quadrants to avoid graft entanglement, as the Scorpion is used to pass the swedged FiberTape through the posterolateral aspect of the graft (B). (* denotes the SutureTape from the anterior glenoid anchor, ** denotes the SutureTape from the posterior glenoid anchor, ^ denotes the swedged FiberTape from the anterior medial row tuberosity anchor, and ^^ denotes the swedged FiberTape from the posterior medial row tuberosity anchor.)

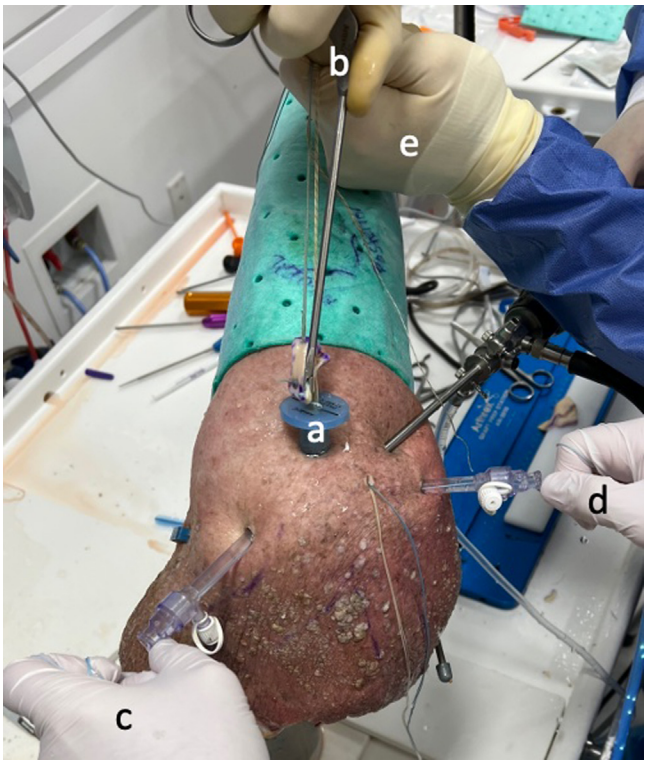

Fig 7. Ex vivo image of a right shoulder viewed from superior with the arthroscope in the posterolateral accessory portal showing the graft being shuttled into a lateral 10-mm PassPort Button cannula (a) using a large grasper (b). The assistant pulls the anterior (c) and posterior (d) glenoid anchor SutureTapes through their corresponding cannulas, while the surgeon pushes the graft into the cannula and simultaneously tensions the FiberTape sutures (e).

Fig 8. Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal showing retrieval of Mulberry knot from the posterior glenoid anchor and its corresponding limb is stored in the posterior cannula. These sutures are tied to secure the medial aspect of the graft to the glenoid. This step is repeated for the anterior Mulberry knot from the anterior glenoid anchor.

While maintaining tension on the two FiberTape sutures, the superior capsule graft is simultaneously pushed down the FiberTapes by the surgeon using a grasper and pulled into the shoulder with the SutureTape tails by the assistant (Fig 7). Once the graft is seated, the anterior Mulberry knot is retrieved along with its tail from the anterior cannula (Fig 8). An arthroscopic knot is tied, and the suture is cut leaving a 3-mm tail. This step is repeated for the posterior Mulberry knot. The graft is secured to the subscapularis anteriorly and infraspinatus or teres minor posteriorly using the remaining no. 2 FiberWire from the tuberosity anchors. This secures the medial, anterior, and posterior aspects of the superior capsule graft.

Rotator Cuff Reconstruction

The rotator cuff defect is measured in the sagittal and coronal planes. One cm is added in the sagittal and coronal planes to accommodate a 0.5 cm overlap of the rotator cuff anteriorly, posteriorly and medially, and of the tuberosity laterally (Fig 3). A 3-mm ArthroFlex graft is trimmed to size, and orientation markings are made similar to the superior capsule graft.

Using a Scorpion, a no. 2 FiberWire suture is passed through the anterior aspect of the retracted rotator cuff tissue in a vertical mattress configuration, leaving both suture ends on the superior aspect of the rotator cuff (Fig 9). This step is repeated for the posterior aspect of the retracted tendon. For large tears, this step should be repeated at each 1-cm interval. These sutures are saved in the anterior and posterior corresponding cannulas.

The rotator cuff graft is then prepared in a similar fashion to the superior capsule graft. The lateral-most tail of the anterior vertical mattress suture is passed through the anteromedial aspect of the graft, and a Mulberry knot is tied (Fig 10). The process is repeated for the posterior vertical mattress suture. Next, the swedged FiberTapes exiting the lateral aspect of the superior capsule graft are retrieved. These are passed through the graft at a distance measured from the medial edge of the graft corresponding to the distance from the stump of the rotator cuff to the medial row anchor.

Using the same technique as with the superior capsule graft, the rotator cuff graft is then delivered through the lateral cannula. Again, the Mulberry knots and their corresponding tails are retrieved and tied arthroscopically to secure the graft to the retracted end of the rotator cuff. The FiberTape sutures previously placed through both grafts are placed in a lateral row anchor construct, securing both grafts laterally (Fig 11). The swedged ends are now released creating two tails for each FiberTape suture. One tail of each FiberTape is loaded into a lateral row 4.75-mm

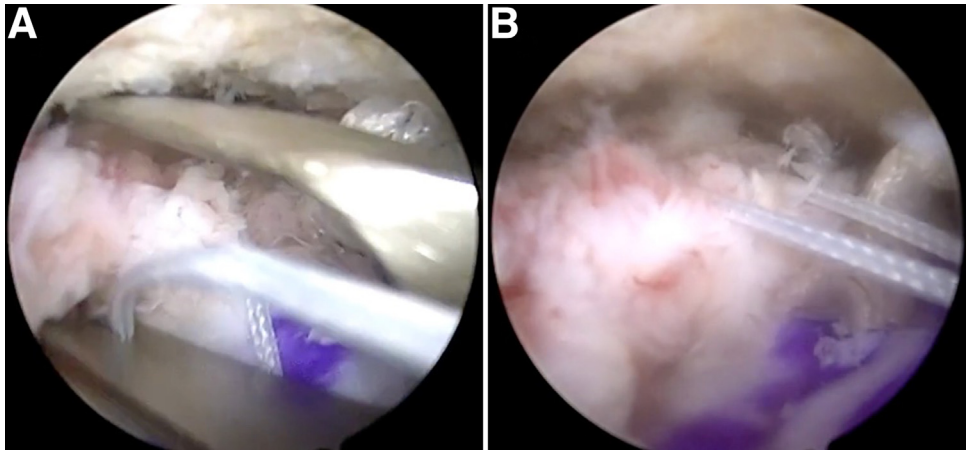

Fig 9. Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal showing Scorpion passing a vertical mattress no. 2 FiberWire suture into the anterior aspect of the retracted rotator cuff (A) with the suture ends exiting the superior aspect of the graft. This allows the rotator cuff graft to be fixed to the rotator cuff with graft-tendon overlap (B). These steps are repeated for the posterior aspect of the retracted rotator cuff.

SwiveLock anchor anteriorly. This step is repeated for the posterior anchor. The anchors are placed with the arm in 20° of abduction. The anterior and posterior sides of the graft can then be secured to the native rotator cuff using the remaining sutures from the lateral anchors or with additional sutures (Figs 12 and 13).

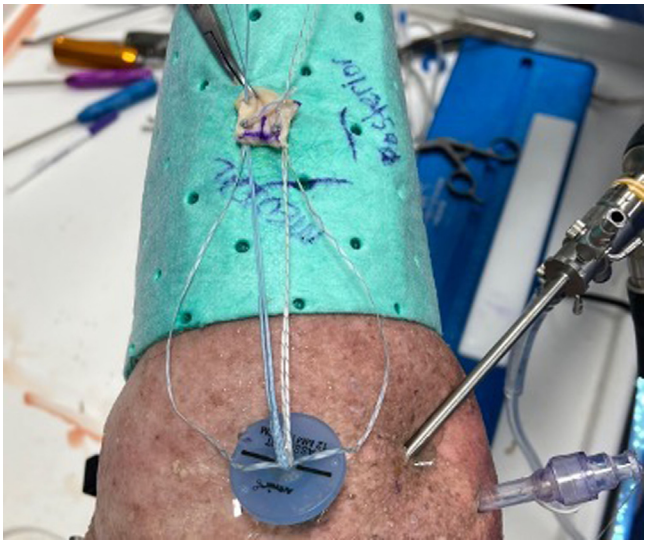

Fig 10. Ex vivo image of a right shoulder viewed from superior with the arthroscope in the posterolateral accessory portal. The prepared rotator cuff graft is shown with the sutures from the medial aspect of the retracted rotator cuff secured to the medial aspect of the graft with Mulberry knots. The FiberTape sutures from the lateral row tuberosity anchor are passed through the lateral aspect of the graft. In a similar fashion to the superior capsule graft, the rotator cuff graft is shuttled into the shoulder. The Mulberry knots are retrieved and tied to secure the rotator cuff graft to the rotator cuff.

Postoperative Care

Rehabilitation begins with protected passive range of motion for the first 9 weeks, limiting forward flexion (<100°), extension (neutral), and abduction (<40°). The sling is discontinued at 9 weeks, followed by initiation of isometric strengthening and progression of active and active-assisted range of motion. Concentric and eccentric strengthening begins at 12 weeks.

Discussion

The active adult patient with irreparable RCT presents a dilemma with few surgical options. We describe a technique of combined SCR and RCR in these patients with a viable rotator cuff muscle and maintained acromiohumeral space. Clinical characteristics for inclusion are a Goutallier Stage I/II rotator cuff, acromiohumeral distance of 5 mm or more without evidence of bony remodeling of the humeral head or acromion.

There is mechanical and kinematic advantages with the described dual graft construct which may not be provided by a single graft reconstruction. The superior capsule graft recreates the static superior stabilizer of the shoulder, and the rotator cuff graft restores dynamic capacity to an otherwise irreparable tissue. The restored rotator cuff contributes to the superior stability of the humerus and a stable fulcrum for elevation of the arm. This treatment may be indicated for the high-demand younger adult with a primary irreparable rotator cuff tear or a failed prior repair. This treatment option increases the likelihood of activity restoration and may delay arthroplasty.

The recent literature describes satisfactory short-term results for graft reconstruction in massive irreparable RCTs. Across multiple graft types, interpositional graft

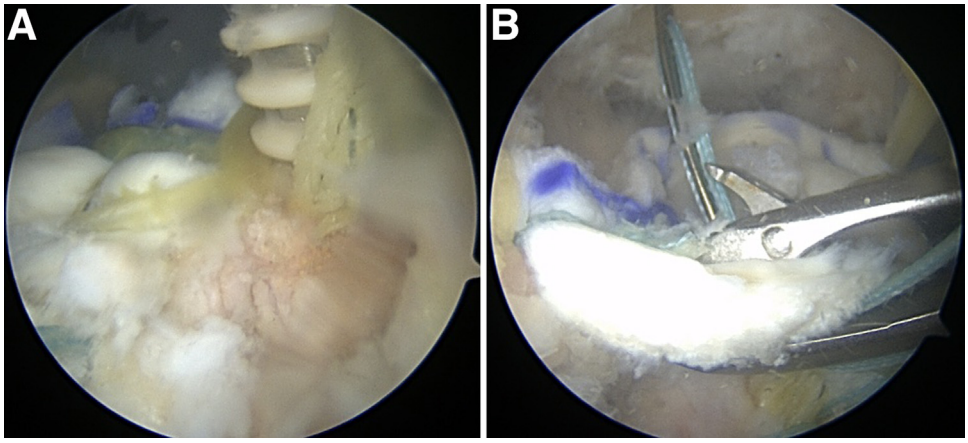

Fig 11. Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal demonstrating the dual graft construct. The rotator cuff graft (RC) was sized to accommodate lateral overlap with respect to the superior capsule graft (SC). This allowed both grafts to have bony contact with the tuberosity.

repair of irreparable RCT have demonstrated clinical and biomechanical efficacy.[12] Further, aggregate results demonstrate improved clinical outcomes at short to mid-term follow up for graft reconstruction of the superior capsule and for interpositional grafting of the rotator cuff.[13] Although these reports are compelling, the long-term durability of these constructs is unknown.

We acknowledge the limitations inherent to this technique, including the additional time requirement and the fiscal burden of a dual graft reconstruction. The complexities of performing a graft interposition, and the potential for graft or suture entanglement contributes to a more time-intensive procedure. Additionally, with lengthened surgical time there is potential for soft tissue swelling and other perioperative complications. Knowledgeable assistance and a well-orchestrated operative setup are critical for an efficient case.

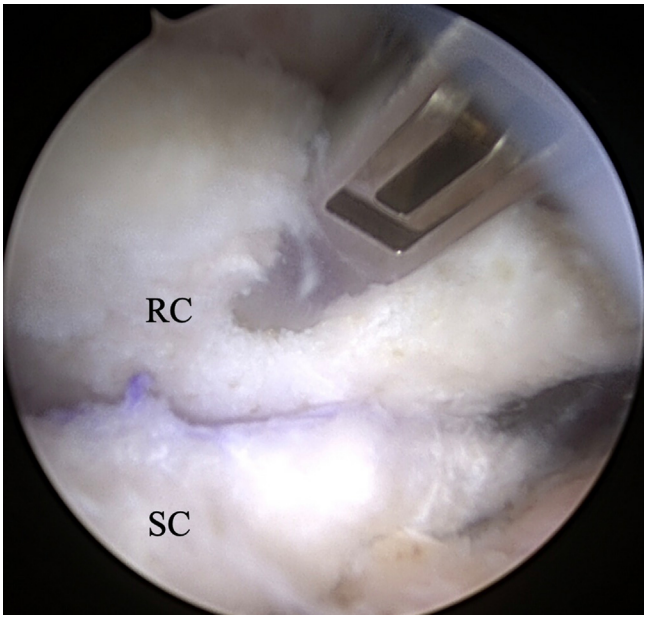

Fig 12. Arthroscopic image of a right shoulder viewed from the posterolateral accessory portal showing the anterior lateral row anchor being placed on the tuberosity in a similar fashion to the previously placed posterior anchor. The anchors are each loaded with one FiberTape suture tail from each medial row tuberosity anchor. This secures the lateral aspect of both grafts to the tuberosity (A). The graft is secured circumferentially to the adjacent rotator cuff using FiberWire sutures, either from existing anchors or with free suture (B).

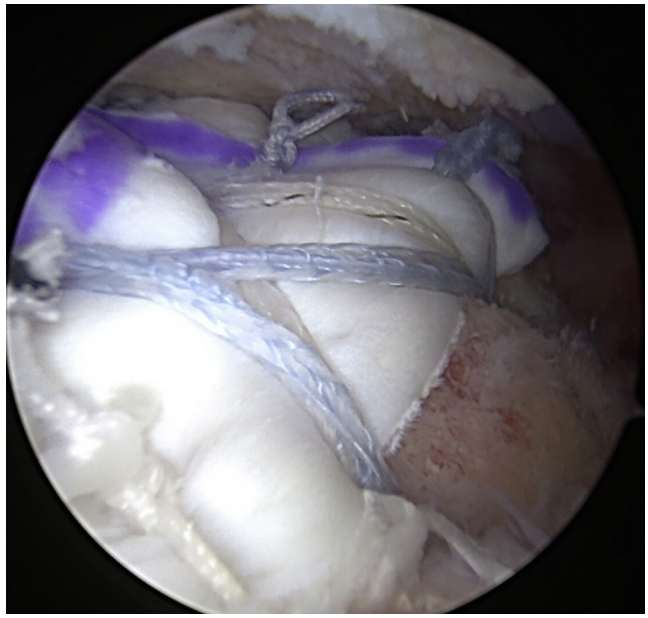

Fig 13. Example of a final construct of combined reconstruction of the superior capsule and rotator cuff viewed through the posterolateral accessory portal of a right shoulder.

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