

# Anterior Capsule Reconstruction Technique With an Acellular Dermal Allograft



Adam Kwapisz, M.D., Ph.D., and John M. Tokish, M.D.

**Abstract:** An irreparable subscapularis may have a debilitating influence on glenohumeral joint biomechanics. Traditional treatment approaches are focused on tendon transfers, among which the most popular are pectoralis major and latissimus dorsi transfers. However, these techniques present significant retear rates, possible nerve injuries, and altered biomechanics. Other techniques like tibialis anterior or iliotibial autograft grafting also have many reported failures. We describe an all-arthroscopic anterior capsule reconstruction technique with an acellular dermal graft.

An irreparable subscapularis (SSC) tear can be a disabling condition and may have a debilitating influence on glenohumeral joint movements and stability.<sup>1,2</sup> Irreparable SSC lesions may also result in significant disability after shoulder arthroplasty.<sup>3,4</sup>

Traditional approaches to the irreparable SSC have centered on tendon transfers, including pectoralis major or latissimus dorsi as the most popular choices. However, these are nonanatomic approaches, altering the native biomechanics, and significant retear rates and complications have been reported, including musculocutaneous and axillary nerve injury.<sup>5-8</sup>

Other approaches to the chronic and retracted SSC lesion with subsequent anterior instability have included an augmented repair, with either tibialis anterior autograft or iliotibial band graft, but other studies have reported high failure with these techniques.<sup>9-11</sup>

More recently, superior rotator cuff deficiency has been addressed with the superior capsule reconstruction

using a human dermal allograft patch.<sup>12</sup> This patch may provide a static stabilizing effect as well as a scaffold for rotator cuff reincorporation.<sup>13</sup> While this technique has produced early promising results in the setting of supra- and infraspinatus muscles, no study has reported its potential in the setting of irreparable SSC tear.

The purpose of this paper is to introduce and describe in detail a technique of arthroscopic anterior capsule reconstruction (ACR) with an acellular dermal allograft (Video 1).

## Surgical Technique

### Preparation Workup

The patient with a suspected irreparable SSC tear is thoroughly evaluated with a history, physical examination, and imaging studies. Patients with this condition often report previous surgery, including arthroplasty, or other open approaches to the shoulder that required takedown of the SSC. Patients with pseudoparalysis with anterior superior escape are also at a high risk for this condition.

During the physical examination, particular attention is paid to passive external rotation, as well as the lift-off, belly-press, and bear-hug tests. If any of these tests are positive, we employ advanced imaging including magnetic resonance imaging or computed tomography in the setting of arthroplasty. These studies are carefully evaluated for the presence of a tear, its chronicity, fatty infiltration, retraction, and associated pathology. The patient is then counseled about the possibility of nonoperative and operative treatment.

In a setting of a physiologically young patient with an irreparable SSC tear, ACR may be advised as one of the options. The patient is also counseled on the risks,

*From the Hawkins Foundation (A.K.); Steadman Hawkins Clinic of the Carolinas, Greenville Health System (J.M.T.), Greenville, South Carolina, U.S.A.; and Clinic of Orthopedics and Pediatric Orthopedics, Medical University of Łódź (A.K.), Łódź, Poland.*

*The authors report the following potential conflicts of interest or sources of funding: A.K. receives support from Arthrex, DePuy, and Mitek. J.M.T. receives support from Arthrex, DePuy, and Mitek. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).*

*Received March 11, 2017; accepted July 12, 2017.*

*Address correspondence to John M. Tokish, M.D., 200 Patewood Drive, Suite C100, Greenville, SC 29615, U.S.A. E-mail: [jtokish@ghs.org](mailto:jtokish@ghs.org)*

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*2212-6287/17325*

*<http://dx.doi.org/10.1016/j.eats.2017.07.012>*

**Table 1.** Pearls and Pitfalls of the Anterior Capsule Reconstruction Technique

Pearls	Pitfalls
<ol style="list-style-type: none"> <li>1. The surgeon should perform throughout a subscapularis tendon release and be reassured that a tension-free repair is impossible.</li> <li>2. 8.25 mm cannulas (Arthrex) should be used to allow efficient camera and instrument switching, except for the midglenoid portal where flexible 10-mm passport cannula (Arthrex) is suggested.</li> <li>3. A minimum of 15 mm of space between the coracoid and anterior surface of subscapularis is needed; coracoplasty is suggested when needed.</li> <li>4. The axillary nerve can be visualized, with decompressed viewing from the anterior superior portal and working from the midglenoid portal anterior to the subscapularis if necessary.</li> <li>5. The glenoid anterior neck and lesser tuberosity should be biologically prepared to punctate bleeding.</li> <li>6. The lateral and medial anchors should be placed as wide as possible, however, within the dimension of the graft</li> <li>7. The medial edge of the graft should be marked with a marking pen to allow proper identification and suture placing.</li> <li>8. The double-pulley technique described by Koo et al. is suggested for the graft medial fixation.</li> <li>9. Use of an Allis clamp is recommended to introduce the graft into the joint.</li> <li>10. The subscapularis tendon remnants should be attached to the graft if possible.</li> </ol>	<ol style="list-style-type: none"> <li>1. The 10-mm passport cannula (Arthrex Naples, FL) may not allow a free graft passage. We recommend making a longitudinal graft through the cannula.</li> <li>2. The limited space between the coracoid and anterior subscapularis probably has a negative influence on graft survivorship and limits the expected outcomes.</li> <li>3. The axillary nerve may be translocated when the subscapularis muscle is absent and anatomy is compromised. We suggest cautious preparation in the lower part of the glenoid.</li> <li>4. Proper tensioning of the graft may not be possible if the anchors are placed too narrowly.</li> </ol>

possible benefits, and expectations of suggested treatment. Then informed consent is collected for reconstruction versus repair, and the decision is made intraoperatively based on actual lesion size, retraction, and mobility after releases (Table 1).

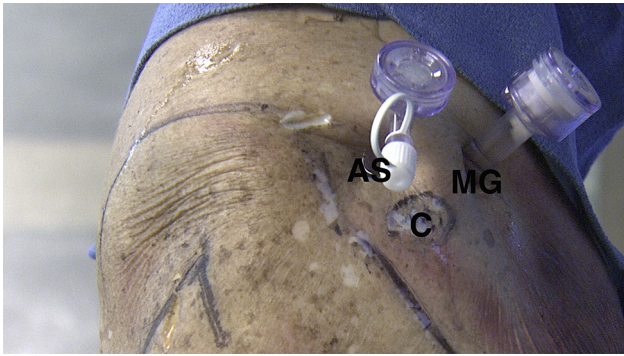
### Surgical Positioning and Diagnostic Arthroscopy

After the induction of general anesthesia, the patient undergoes physical examination, which is a standard of all arthroscopic procedures. This examination again measures the side-to-side difference in passive external rotation, as well as a load and shift for instability. The patient is then positioned in a lateral decubitus position on a beanbag and with the use of padded arm sleeve and balanced suspension (STAR Sleeve, Arthrex, Naples, FL) traction. A posterior portal is established approximately 1 cm medial and 2 cm inferior to the posterolateral edge of acromion. Additional portals are established under direct arthroscopic visualization by an outside-in technique. First, an anterosuperior portal (ASP) is established 1 cm below the clavicle and lateral to the coracoid. Two other portals are helpful. The first is the anterosuperior lateral portal, which is made 1 cm off of the anterior lateral border of the acromion, and a modified midglenoid portal, which is established just lateral to the coracoid and at the top of the SSC remnant. A standard diagnostic arthroscopy is performed within the glenohumeral joint, and any pathology is appropriately addressed. Efficient camera and instrument switching is provided by using 8.25-mm

cannulas (Arthrex), except for the modified midglenoid portal, which incorporates a flexible 10-mm passport cannula (Arthrex). This flexible cannula allows for ease of passage of the graft. In each case, the rotator interval is opened and the anterior surface between the coracoid and SSC is debrided and assessed. We have a low threshold to perform a coracoplasty in the setting of subcoracoid impingement, ensuring there is a minimum of 15 mm of space between the coracoid and anterior surface of the SSC. The SSC is then mobilized by performing additional releases. The tendon remnant release is performed superiorly off the coracoid process, anteriorly off the conjoined tendon, and posteriorly off the capsule and glenoid neck, using caution to protect the axillary nerve passing at its inferior aspect. If necessary, the axillary nerve can be visualized and decompressed, viewing from the ASP and working from the midglenoid portal anterior to the SSC. If after these releases a tension-free repair cannot be accomplished at the native footprint of the SSC, we proceed to ACR (Figs 1-3).

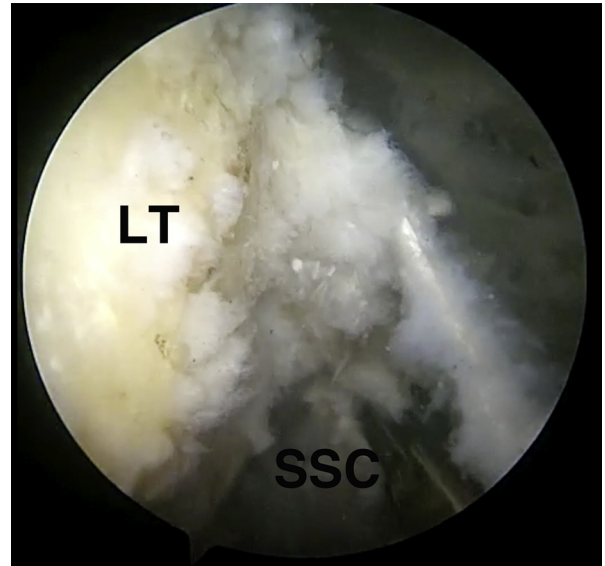
### SSC Bed Preparation

We begin with clearing out the space and preparing the bed for the ACR. The rotator interval is widely open, and the coracoid and conjoined tendon are identified. This is accomplished by viewing from the posterior portal and working from the ASP or midglenoid portal. The SSC remnant is visualized, and the distal extent of the tear is noted, often best viewed from



**Fig 1.** View of the left shoulder with a scheme of standard portals and bony landmarks. (AS, anterosuperior portal; C, coracoid; MG, midglenoid portal.)

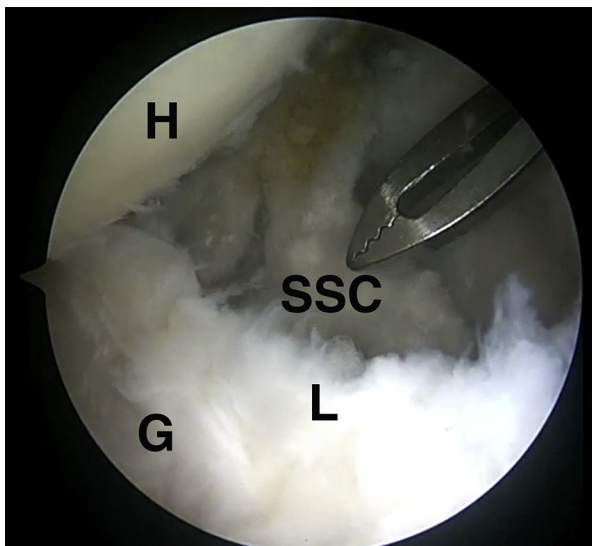
the ASP. There is usually some tissue of the SSC that is still attached distally, and this is noted as it will be stitched to the vertical limb of the ACR later in the case. The lesser tuberosity footprint is then completely exposed. This is best accomplished by viewing from the ASP and working from the anterosuperior lateral portal. This portal allows parallel access to the SSC line of action and is ideal for debridement of the tuberosity. Furthermore, the bicipital groove can be easily visualized and tenodesis can be accomplished through this portal. Once the tuberosity is exposed, the anterior glenoid neck must be prepared to receive the medial graft. Any remnant labrum is generally left in place, and we work to expose the glenoid neck medial to the labral insertion. The neck is biologically prepared to punctate bleeding (Fig 4).



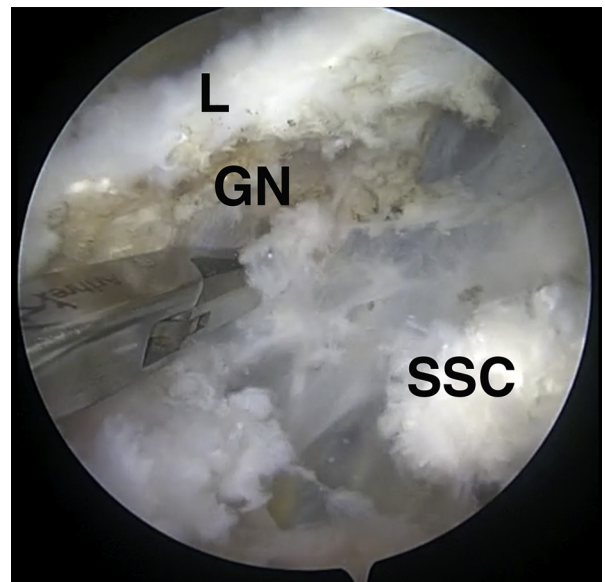
**Fig 3.** View from the anterosuperior portal of the left shoulder (lateral decubitus position) of lesser tuberosity (LT) and subscapularis tendon remnant (SSC).

**Glenoid Anchor Placement.** A glenoid anchor (3-0 suture tack, Arthrex) is placed at the inferior portion of the remnant SSC. This is generally placed adjacent to the 5 o'clock position, down the face approximately 1 cm, and introduced from the modified midglenoid portal. A second anchor is placed at the top of the SSC remnant usually just above the 3 o'clock position and similarly medialized.

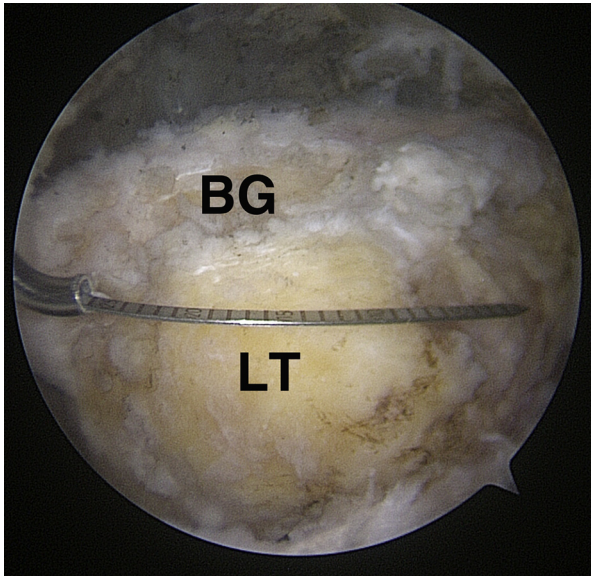
**Humeral Anchor Placement.** A single 4.75 Bio-composite SwiveLock anchor (Arthrex) is placed at the



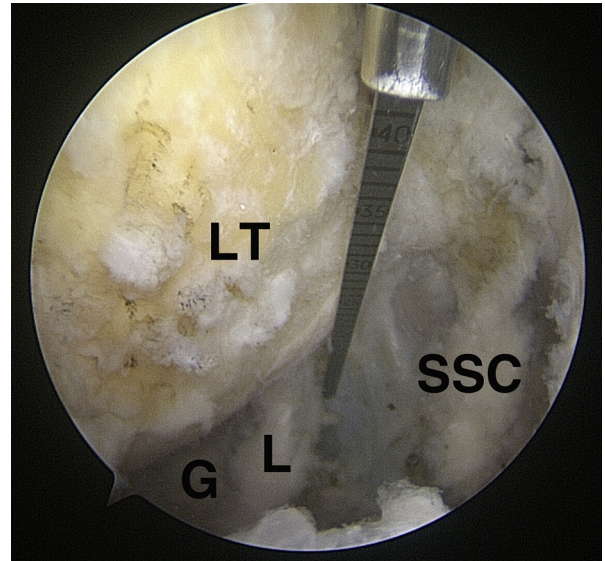
**Fig 2.** Intra-articular view of the left shoulder from the posterior portal, lateral decubitus position. Glenohumeral joint view of irreparable subscapularis muscle tears. Throughout, tendon release was previously performed. (G, glenoid; H, humeral head; L, labrum; SSC, subscapularis tendon remnant.)



**Fig 4.** Intra-articular view of the left shoulder from the anterosuperior portal; lateral decubitus position. Glenoid neck (GN) preparation for medial graft fixation. (L, labrum; SSC, subscapularis tendon remnant.)



**Fig 5.** Intra-articular view of the left shoulder; anterosuperior portal is the viewing portal, lateral decubitus position. Superior-inferior graft dimension measurement on the humeral head. (BG, bicipital groove; LT, lesser trochanter.)



**Fig 7.** Intra-articular view of the left shoulder from the anterosuperior portal. Lateral-medial dimension graft dimension measurement. (G, glenoid; L, labrum; LT, lesser trochanter; SSC, subscapularis tendon remnant.)

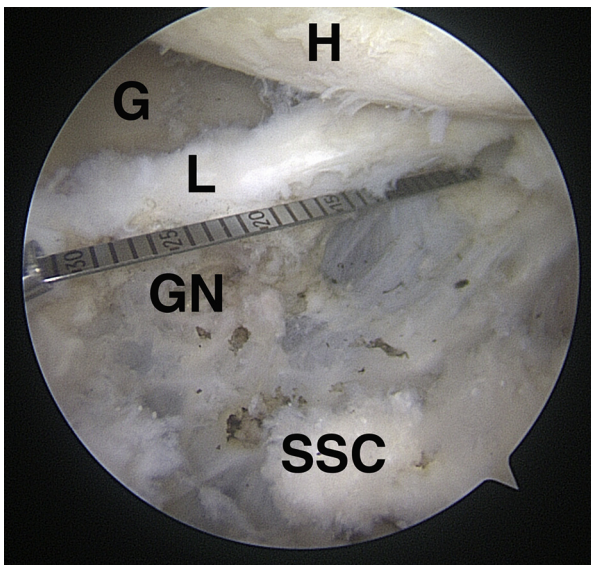
junction of the inferior remnant SSC attachment on the humerus and the articular margin. This represents the articular native insertion of the SSC and will allow reattachment between the graft and the remnant SSC later in the case. A second anchor is placed at the junction of the articular surface and parallel to the top of the bicipital groove. This represents the articular insertion of the leading edge of the SSC and should be relatively parallel to the 3 o'clock glenoid anchor

representing the leading edge of the SSC. The anchors are best placed through the midglenoid portal, and then the sutures from the anchors are retrieved through the anterosuperolateral portal for later use.

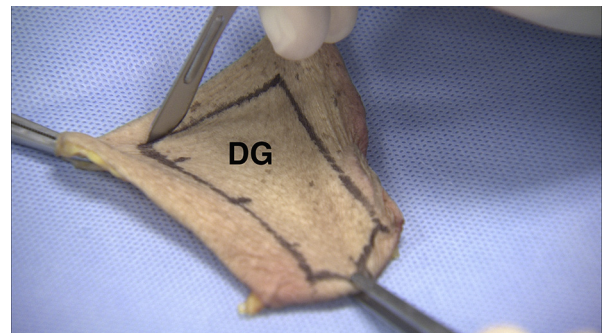
### Graft Sizing and Preparation

The dimensions of the future graft size are measured with a calibrated arthroscopic probe. The medial-lateral distance is measured between the previously prepared anterior glenoid neck anchors and the humeral anchors. In addition, the surgeon measures the superior-inferior distance between the anchors of the humeral footprint as well as the distance between previously placed glenoid anchors (Figs 5-7).

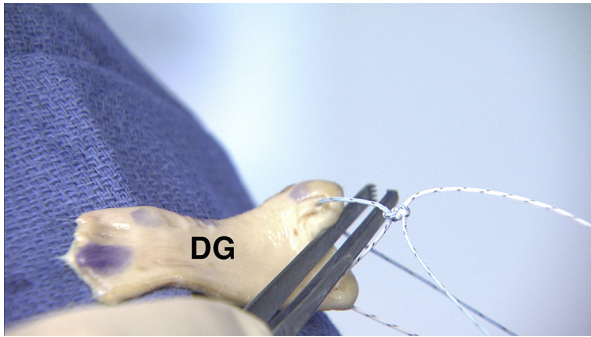
The graft (2 mm ArthroFlex Patch; Arthrex) is prepared on a back table, sized, and trimmed according to the previous measurements. Each dimension has 5 mm added to the measure between anchors, and the medial to lateral dimension has 10 mm added to allow for a



**Fig 6.** Intra-articular view of the left shoulder from the anterosuperior portal. Superior-inferior graft dimension measurement on the glenoid neck (GN). (G, glenoid; H, humeral head; L, labrum; SSC, subscapularis tendon remnant.)



**Fig 8.** Graft preparation and trimming. (DG, dermal graft.)

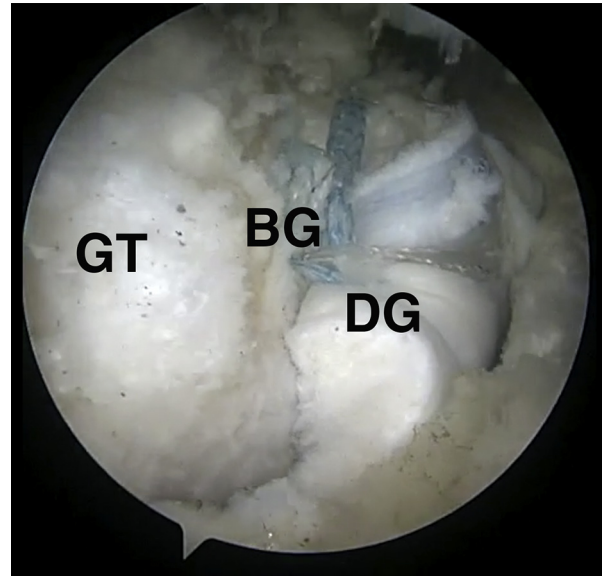


**Fig 9.** Graft placed outside to the shoulder and prepared to be introduced into the joint by using the double-pulley technique. (DG, dermal graft.)

double-row tissue extension. The medial edge of the graft is marked with a marking pen, allowing proper medial sutures placing and future arthroscopic identification. As graft thickness and durability make sutures difficult to pass with a free needle, an arthroscopic suture passer (Labral Scorpion, Arthrex) can be used to penetrate the graft (Fig 8).

**Graft Insertion and Medial Fixation**

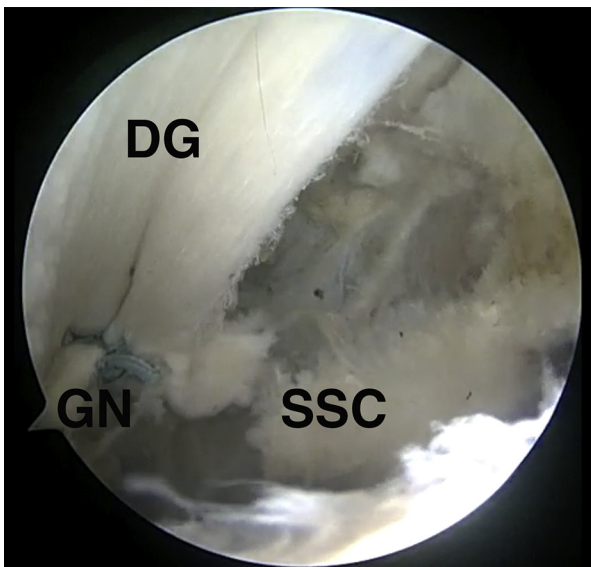
The graft is brought just outside the shoulder near the midglenoid portal through which the glenoid anchors tails were brought. The medial fixation is accomplished through a “double pulley” technique, as described by Koo et al.<sup>14</sup> This technique is accomplished by passing one limb from each suture anchor through the medial aspect of the graft outside the shoulder using a suture-passing device. These limbs are then tied together over a switching stick with a surgeon’s knot and backed up



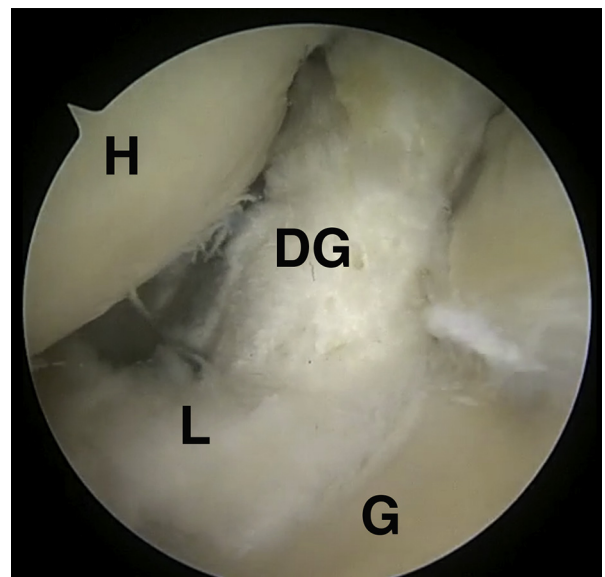
**Fig 11.** Intra-articular view of the left shoulder (lateral decubitus position); view from the anterosuperior portal of the lateral fixation of the graft. (BG, bicipital groove; DG, dermal graft; GT, greater trochanter.)

with 6 half hitches on alternating posts. The excess length is cut to the knot with short tails (Fig 9).

The graft is then rolled, and an Allis clamp is placed around the graft and fastened at its humeral edge. The graft is then inserted through the flexible cannula at the midglenoid position by pushing the Allis clamp into the shoulder. Simultaneously, the remaining limbs of the glenoid suture anchors are pulled to remove suture redundancy. Once the graft is completely inside the shoulder, the clamp



**Fig 10.** Intra-articular view of the left shoulder (lateral decubitus position); view from the anterosuperior portal of medial fixation of the graft. (DG, dermal graft; GN, glenoid neck; SSC, suprascapularis tendon graft.)



**Fig 12.** Glenohumeral left joint view from the posterior portal of accomplished anterior capsule reconstruction. (DG, dermal graft; G, glenoid; H, humeral head; L, labrum.)

**Table 2.** Advantages and Disadvantages of the Anterior Capsule Reconstruction Technique

Advantages	Disadvantages
No donor side morbidity.	Technically demanding.
No time loss for harvesting.	May not be suitable for severe osteoarthritis cases.
No remnant tissue needed.	No clinical data for anterior capsule reconstruction (available for superior capsule reconstruction).
Option to rebalance force couples.	Graft reimbursement may vary between countries.
May delay/prevent shoulder arthroplasty in a setting of irreparable subscapularis lesion.	
May delay/prevent total shoulder arthroplasty revision in a setting of irreparable subscapularis lesion.	

is removed. A tissue grasper from the anterosuperior lateral portal can be used to grasp the humeral edge of the graft to assist in holding the graft in the proper position while it is secured to the glenoid. The glenoid anchor limbs are then pulled from the midglenoid portal. The tension on the respective sutures pulls through the suture anchors on the other limb, which is in turn tied to the other anchor's corresponding limb. The result is tension through this double pulley, which reduces the graft down to the glenoid bone. Once the graft is in place, the remaining glenoid anchor limbs are tied together with a nonsliding knot and advanced down, securing the glenoid fixation. Excess suture is cut (Fig 10).

### Lateral Graft Fixation to Humerus

The lateral graft is secured using a double-row suture speed bridge using the previously placed humeral anchors. The suture-passing device (Scorpion, Arthrex) is loaded with the welded edge of the inferior humeral anchor, and the suture is passed through the anterosuperior lateral portal, through the inferior lateral edge of the patch, approximately 1 cm in from the edge, to allow a tissue bridge for double-row repair. The suture is retrieved through the midglenoid portal to aid in suture management as well as to allow tension on the suture to remove any slack. In a similar fashion, the superior anchor's welded edge of the suture is passed in the superior lateral aspect of the graft and retrieved from the midglenoid portal. The welded portion of each suture is trimmed, leaving 4 total limbs. One limb from each suture anchor is then retrieved through the anterosuperior lateral portal. A lateral row of anchors is placed in the bicipital groove, parallel and lateral to the previously placed humeral anchors, assuming that the biceps tenodesis is performed below the groove. This is accomplished by using an awl to place the pilot hole in the desired location, first inferior and then superior. The sutures (one limb from each of the medial row of humeral anchors) are now loaded into the knotless anchor (4.75 SwiveLock, Arthrex) and inserted into the inferior hole. Likewise, the other suture pair is retrieved from the midglenoid portal to the anterosuperior lateral portal, loaded into another anchor, and secured into the lateral row superior position, completing the double-row humeral repair (Fig 11).

### Final Inspection, Closure, and Postoperative Rehabilitation

Once the graft is secured in its place, the remnant SSC is stitched to the graft. Inferiorly this is generally parallel, but the torn retracted edge is also attached using mattress sutures so that future firing of the SSC remnant can tension the graft. The humerus can be gently moved to arthroscopically inspect its tension and response to motion. If no other procedure is planned, all portals can be closed in a standard manner. Postoperatively, the patient is treated with a typical SSC tendon repair protocol, which is shoulder immobilization in a sling with external rotation limited to 30°. The patient is allowed to perform elbow, wrist, and hand exercises. Gentle passive glenohumeral joint motions are also allowed. Six weeks after the surgery, motion progression is begun and strengthening is allowed no sooner than 12 weeks postoperatively. The patient is advised to return to previous activity when range of motion, strength, and confidence return, which is generally 6 months after the surgery (Fig 12).

### Discussion

Irreparable SSC tendon lesions may have a significant negative effect on glenohumeral joint kinematics.<sup>1,2,7,9,15,16</sup>

The SSC tendon plays an essential role as an anterior stabilizer of the shoulder, and thus its loss can compromise stability. This is true in both the native shoulder, and perhaps more commonly, after shoulder arthroplasty.<sup>3,4,16-18</sup>

Jackson et al. reported rerupture rate of 47% in patients after total shoulder arthroplasty.<sup>19</sup> While not all of these reruptures are symptomatic, some studies have documented the necessity of revision surgery for SSC retear.<sup>3,4,20</sup> The most popular treatment to address the irreparable SSC is muscle transfer.<sup>7,16,18,21-23</sup>

The pectoralis major tendon transfer is often suggested as a reasonable option for irreparable SSC tear, and transfers of trapezius muscle, latissimus dorsi, and pectoralis minor are also described. Although those techniques provide a fair amount of functional improvement, they only partially restore proper joint

kinematics, thus they are much less effective in patients with rotator cuff dysfunction.

Shin et al., in the most recent systematic study, included 5 studies reporting changes in range of motion after pectoralis muscle transfer.<sup>7</sup> They noted significant changes in forward elevation (from 102.3° to 130.3°) and in abduction (from 108.1° to 135.4°). However, significant reduction in external rotation (from 55.6° to 44.7°) is also reported. Only one study reports change in internal reduction, which showed no significant difference from 77° to 78°. Additionally, each of these procedures alters native anatomy and biomechanics of transferred muscles, and the overall failure rate may reach 12.8%.<sup>5-7,16,18,22-25</sup>

Each of these procedures may also be at risk for surrounding nerve structures, Ruiz-Ibán et al. reported that in 21% of specimens there was not enough space between the coracoid process and musculocutaneous nerve branches for the pectoralis major transfer. Undesired contact between transferred tendon and nerve structures was observed in more than 50% of specimens.<sup>8</sup> The axillary nerve may be also endangered with muscle transfers; Elhassan et al. reported impingement between nerve and tendons when combined latissimus dorsi and teres major transfer was performed on cadavers.<sup>5</sup>

Furthermore, Lee and Mun reported that harvesting of latissimus dorsi tendon results in patient reported discomfort in 41% cases and objectively evaluated shoulder disability is described in 20% cases.<sup>26</sup> Moreover, incidence of iatrogenic permanent axillary and musculocutaneous nerves dysfunction are also reported in the literature.<sup>7</sup>

Application of multiple types of tendon augments have also been described.<sup>27,28</sup> Whereas some investigators recommended not using allograft for treatment of massive rotator cuff lesions, others report significant outcome improvement when implanted.<sup>29,30</sup> Snyder et al. have previously shown good integration and minimal immunologic risk with this kind of graft. This graft also has no donor side morbidity and, is accessible, durable, and easy to prepare.<sup>12,31</sup>

Early promising results of superior capsule reconstruction for irreparable rotator cuff tears have prompted us to adapt this technique for ACR, which is discussed here. We have employed this technique for irreparable SSC in the setting of chronic lesions and revision instability cases, as well as in patients with symptomatic SSC insufficiency after total shoulder replacement. Although short-term results are promising, longer follow-up studies are necessary to fully evaluate this technique (Table 2).

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