Technical Note

Simplified Technique for Superior Capsular Reconstruction Using an Acellular Dermal Allograft

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Abstract: Superior capsular reconstruction is a powerful tool for the treatment of massive irreparable rotator cuff tears. Several authors have described this evolving technique. Issues of graft sizing, graft passage, graft tensioning, and suture management make this a challenging procedure even in the hands of experienced shoulder surgeons. We describe our arthroscopic technique for superior capsular reconstruction using nonirradiated human acellular dermis. We introduce several techniques for graft passage and tensioning that may help to simplify this challenging procedure and make it more reproducible.

Superior capsular reconstruction is a powerful tool for the treatment of massive irreparable rotator cuff tears. Mihata et al.[1-3] first described the biomechanical rationale for this technique and later showed promising clinical results using a fascia lata autograft. Since that time, superior capsular reconstruction has gained popularity. Several authors have modified this technique to use an acellular dermal allograft to improve graft consistency and limit donor-site morbidity.[4-8] Preliminary clinical results of superior capsular reconstruction using an acellular dermal allograft have shown encouraging improvements in pain relief, shoulder function, and radiographic parameters.[9,10] Despite these encouraging results, superior capsular reconstruction remains a challenging operation even in the hands of experienced shoulder surgeons.

This report describes our arthroscopic technique for superior capsular reconstruction using nonirradiated human acellular dermis. We introduce several techniques for graft passage and tensioning that may help to simplify this challenging procedure and make it more reproducible.

Surgical Technique

Patient Setup

We describe a detailed technique for the procedure shown in Video 1. The patient is brought to the operating room and placed under combined regional and general anesthesia. An examination under anesthesia is performed. The patient is then placed in the lateral decubitus position. The arm is padded and placed in traction using a lateral decubitus shoulder traction tower (Arthrex, Naples, FL). The arm is positioned in 30° of abduction and 20° of forward flexion with 10 to 15 lb of traction.

Approach

A standard posterior portal is established, and a 30° arthroscope (Arthrex) is inserted into the glenohumeral joint. Next, an anterosuperior portal is established under direct visualization using an outside-in technique with the aid of a spinal needle. We believe that it is paramount to keep the portal size to a minimum to reduce fluid extravasation. A diagnostic arthroscopy is performed. Any pathology of the biceps or subscapularis is addressed before superior capsular reconstruction. Biceps

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Fig 1. Cadaveric left arm in lateral decubitus position showing portals used for superior capsular reconstruction: anterolateral (AL), anterosuperior (AS), posterior (P), and posterolateral (PL).

tenotomy or tenodesis may be performed according to surgeon preference. If indicated, subacromial decompression and/or distal clavicle excision is performed after superior capsular reconstruction.

The arthroscope is inserted into the subacromial space. An anterolateral portal and a posterolateral portal are then established under direct visualization with the aid of a spinal needle (Fig 1). Excess bursa tissue is debrided with an ablation device (ArthroCare; Smith & Nephew, Andover, MA), and hemostasis is obtained. Care is taken to leave the deltoid fascia intact. The rotator cuff tear is then assessed, and releases are performed to attempt repair. In the setting of a chronic, massive rotator cuff tear with poor mobility, the decision is made to proceed with superior capsular reconstruction.

An ablation device (ArthroCare) is used to remove any residual rotator cuff or soft tissue from the superior glenoid neck and the greater tuberosity footprint. A reciprocating shaver (Ultra Dual Purpose Stealth, 4.2 mm; ConMed Linvatec, Largo, FL) is then used to create a bed of bleeding bone in each area, with care taken not to decorticate.

Medial Anchor Placement and Graft Sizing

The location for the medial-row anchors is chosen while viewing from the anterolateral portal. We plan for 2 double-loaded all-suture anchors (Y-Knot Flex, 1.8 mm; ConMed Linvatec). A spinal needle is used to determine the best trajectory for placing the anterior and posterior anchors. The optimal trajectory may be obtained by using the existing anterosuperior portal, the posterior portal, a Neviaser portal, or percutaneous portals depending on patient anatomy. A straight or curved drill guide may be used as well. Once the ideal trajectory and portal location are determined, the anterior and posterior anchors are drilled and inserted (Fig 2). The suture tails are left in the portal in which they were drilled to aid in suture management.

After the glenoid anchors have been placed, measurements are taken for the allograft. The distance between the glenoid anchors is the most critical measurement. This is measured using an arthroscopic ruler (ACL Bullseye Ruler; ConMed Linvatec) introduced from the posterior portal while viewing from the posterolateral portal (Fig 3). Medial-to-lateral measurements are then taken

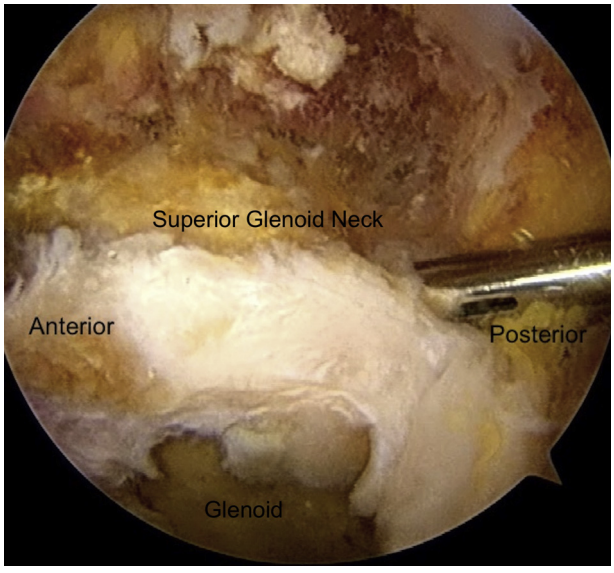

Fig 2. View of left shoulder from anterolateral portal showing posterior anchor placement in superior glenoid neck.

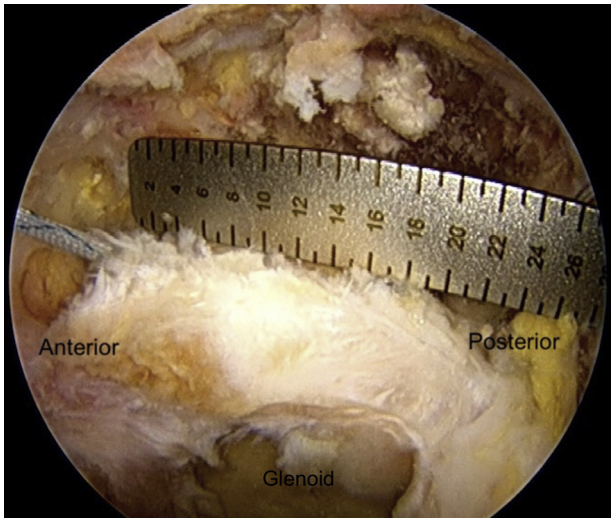

Fig 3. View from anterolateral portal showing measurement for medial side of allograft. The point-to-point distance is measured from the anterior-superior glenoid anchor to the posterior-superior glenoid anchor. The arthroscopic ruler is inserted from the posterior portal.

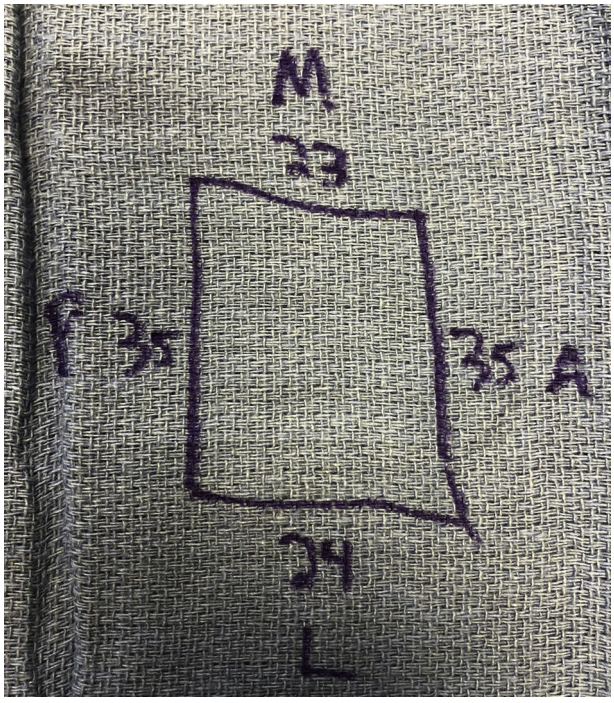

Fig 4. Allograft schematic taken on back table during surgery after all measurements have been recorded. (A, anterior; L, lateral; M, medial; P, posterior.)

from the anterior anchor to the greater tuberosity and from the posterior anchor to the greater tuberosity with the arthroscopic ruler introduced from the anterolateral and posterolateral portals, respectively. Finally, the anterior-to-posterior dimension of the lateral footprint is measured with the arthroscopic ruler introduced from the anterosuperior portal while viewing from the posterior portal. These measurements are recorded on the back table, and a schematic is made before any graft preparation (Fig 4). The typical graft will be trapezoidal, with the medial glenoid aspect typically smaller than the humeral footprint. All measurements are made point to point, and the graft is cut to the measured size with the understanding that there is inherent elasticity in the graft. This elasticity allows for appropriate tensioning of the graft when sutures are eventually passed and tied 3 to 4 mm inside each corner of the graft. Additional length in the medial-to-lateral dimension is considered if the surgeon prefers a double-row lateral repair.

Allograft Preparation and Delivery and Medial Fixation

We use a nonirradiated acellular human dermal allograft (Allopatch HD; Musculoskeletal Transplant Foundation, Edison, NJ) 3.5 mm in thickness or greater for superior capsular reconstruction. The graft is fashioned into a trapezoid based on the previously recorded measurements. The epidermal side of the graft is marked with a surgical marker indicating proper

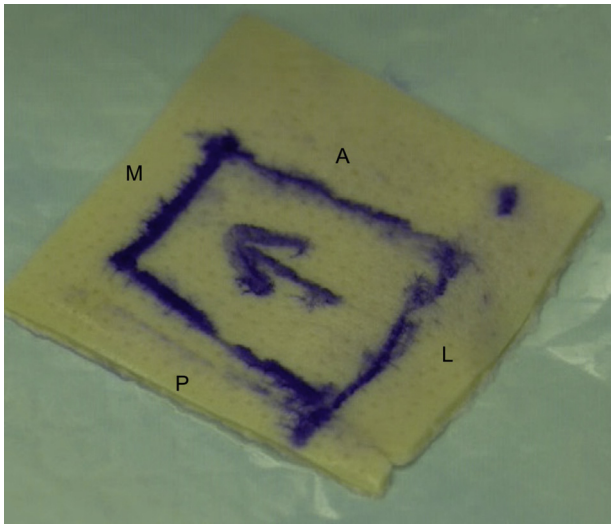

Fig 5. Marked allograft before final sizing. An arrow is drawn on the epidermal surface pointing medially. (A, anterior; L, lateral; M, medial; P, posterior.)

orientation. We draw an arrow pointing in the medial direction so that, when implanted, the epidermal side is oriented toward the bursa and the dermal side is toward the joint and in contact with the glenoid and greater tuberosity bone (Fig 5).

Once the graft has been prepared, an 8.5-mm cannula (Clear-Trac, 8.5 mm × 90 mm; Smith & Nephew) is placed in the anterolateral portal in preparation for graft passage. An additional cannula can be placed in the anterosuperior portal to assist with suture management. One limb of suture from the anterior anchor is retrieved out of the anterolateral cannula using a ring

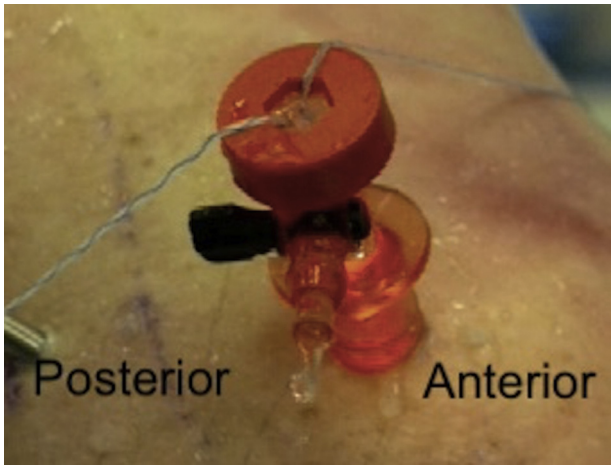

Fig 6. Proper suture management before passing superior glenoid neck sutures through allograft. One suture limb has been retrieved from the anterior anchor in the superior glenoid neck, and one suture has been retrieved from the posterior anchor in the superior glenoid neck. These sutures are kept in their respective positions in the cannula to avoid tangling.

Fig 7. After graft sizing and preparation, the allograft is ready to be advanced into the cannula using 2 independent single pulleys.

grasper. One limb of suture from the posterior anchor is then retrieved out of the anterolateral cannula using a ring grasper. The anterior suture is kept anteriorly in the cannula, and the posterior anchor is kept posteriorly (Fig 6). A ring grasper is used to run the posterior suture 1 final time before passing through the graft to prevent tangles. The anterior suture is then shuttled through the graft using an antegrade suture passer (Expressew 3; DePuy Mitek, Raynham, MA). A large mulberry knot is tied to secure this suture and allow shuttling. This process is repeated for the posterior suture (Fig 7). The graft is then placed in the aperture of the anterolateral cannula and folded in half along its longitudinal axis (Fig 8). The opposite limbs of the suture anchors are pulled simultaneously as an arthroscopic grasper is used to help guide the allograft through the cannula. The free lateral edge of the allograft is then tucked downward into the glenohumeral joint space to allow for increased visualization (Fig 9). The sutures are retrieved and tied individually to secure

Fig 8. As the assistant pulls simultaneously on each independent single pulley, the graft is folded longitudinally and advanced into the anterolateral cannula. An arthroscopic grasper is used to assist in advancing the graft through the cannula.

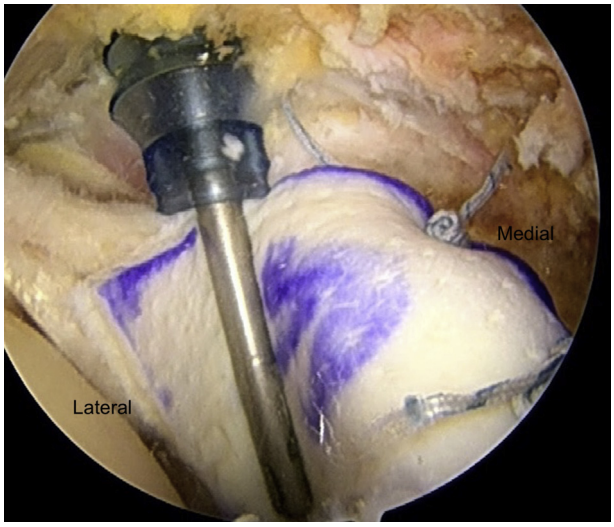

Fig 9. As viewed from the posterolateral portal, the graft has been advanced to the superior glenoid neck by the use of 2 independent single pulleys. The graft is tucked into the glenohumeral joint to increase visualization.

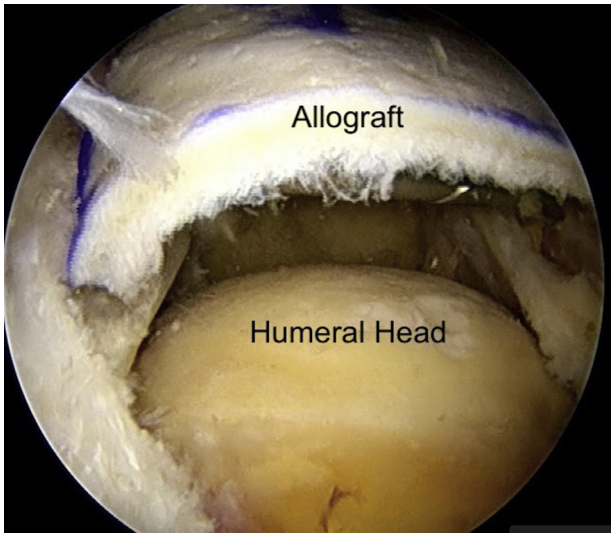

Fig 10. As viewed from the anterolateral portal, the graft has been secured to the superior glenoid neck. The graft may now be secured to the greater tuberosity as if it were a rotator cuff tear.

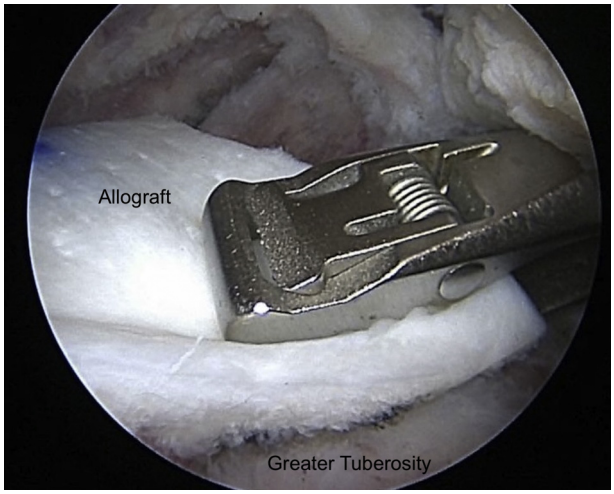

Fig 11. As viewed from the posterolateral portal, an anterograde suture-passing device is used as a grasper to determine the proper location for the anterior anchor in the greater tuberosity to ensure appropriate tension. A spinal needle is inserted percutaneously to determine the vector for anchor insertion.

the medial aspect of the graft to the superior glenoid. It is important to retrieve the stick knot end of the suture first to prevent inadvertent knot unraveling. At this point, the graft is well contoured and secured medially and can be fixed to the greater tuberosity as if it were a standard rotator cuff tear (Fig 10).

Allograft Tensioning and Lateral Fixation

The anchor position in the greater tuberosity is determined by grasping the allograft with a ring grasper inserted from the anterolateral portal and stretching the graft to its desired location (Fig 11). During this step, it may be helpful to view from the posterior portal and/or posterolateral portal. Once the anchor position is determined, a spinal needle is used to create a percutaneous portal for anchor insertion. A self-punching triple-loaded all-suture anchor (Y-Knot RC, 2.8 mm; ConMed Linvatec) is inserted through this percutaneous portal. One limb of each suture is passed through the allograft 3 to 4 mm from the lateral edge using an antegrade suture passer (Expressew 3). These sutures are tied sequentially to secure the graft anteriorly to the greater tuberosity. Passing the sutures 3 mm from the lateral edge takes all residual slack out of the allograft and ensures proper tensioning (Fig 12). This process is repeated for the posterior fixation on the greater tuberosity footprint to complete the lateral fixation of the allograft (Fig 13). If the surgeon elects for double-row fixation of the lateral margin, sutures can be placed in a mattress fashion and secured laterally with a knotless anchor. The allograft is then fixed to the remaining posterior rotator cuff and to the rotator interval with 2 to 3 free sutures in the manner described by Tokish and Beicker.[5] If there is redundant infraspinatus tissue, it can be advanced over the graft to create additional tension. The final construct is then inspected while the arm is gently rotated.

Postoperative Rehabilitation

The patient is placed in a sling with an abduction pillow for 6 weeks. Passive range of motion is allowed at 6 weeks. Active range of motion is allowed at

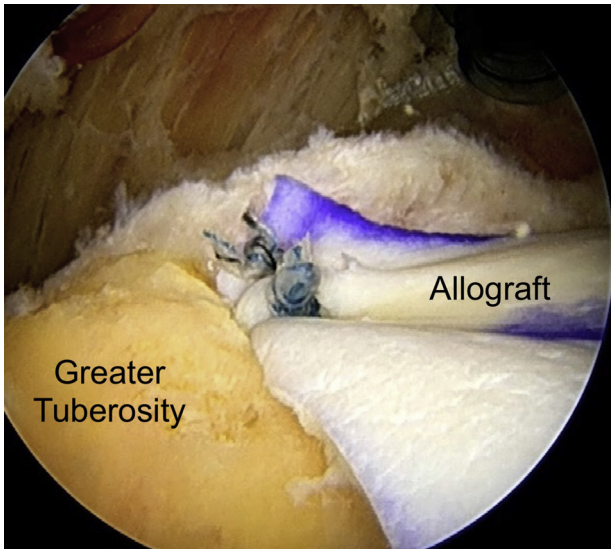

Fig 12. As viewed from the posterior portal, the allograft has been secured to the anterior anchor in the greater tuberosity using 2 simple sutures tied with SMC knots. Final graft tensioning will be completed with posterior anchor fixation.

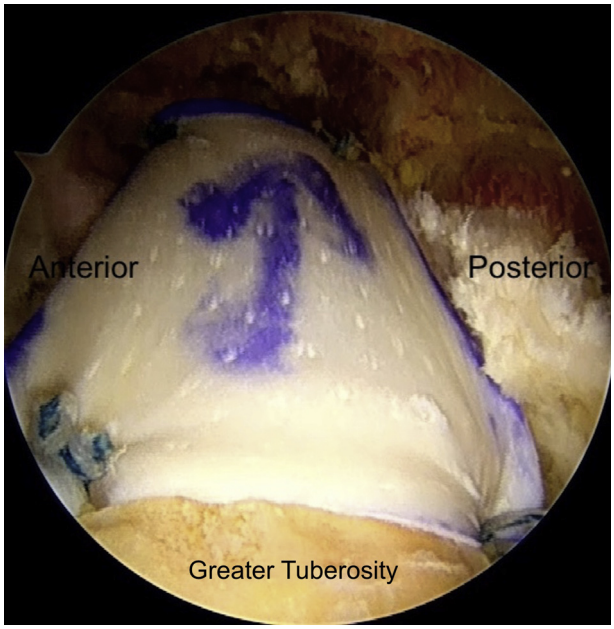

Fig 13. As viewed from the anterolateral portal, lateral fixation of the allograft in the greater tuberosity has been completed. Proper graft tension is verified.

Table 1. Pearls and Pitfalls of Superior Capsular Reconstruction With Allograft

Pearls	Pitfalls
Perform adequate debridement of bursa and remaining rotator cuff tissue to obtain necessary visualization	Failure to establish portals with proper orientation and trajectory
Maintain adequate visualization and hemostasis throughout case	Failure to obtain adequate visualization of bony glenoid and greater tuberosity footprints
Establish glenoid and greater tuberosity footprints for sizing of allograft	Failure to appropriately orient allograft for delivery through cannula
Use mulberry knots and longitudinal fold of allograft for ease of graft delivery	Failure to maintain proper suture management during shuttling and fixation of allograft
Ensure good knot and loop security to secure allograft to repair site	
Ensure patient compliance with postoperative instructions to optimize graft healing	

12 weeks. A team-based approach is used to ensure slow, safe progression through rehabilitation to allow for graft healing and incorporation. Pearls and pitfalls of our superior capsular reconstruction technique are shown in Table 1, and advantages and disadvantages are shown in Table 2.

Discussion

Superior capsular reconstruction is a promising operation to treat one of the most challenging conditions in shoulder surgery. We commend the work of previous authors who initially described this technically demanding operation.[1-7] We believe that our technique helps to simplify issues with suture management especially during graft passage. Our method of graft measurement after insertion of the medial anchors leads to more accurate sizing. In addition, placing the lateral anchors after achieving medial fixation affords the ability to fine-tune graft tensioning and avoids suture entanglement in the graft-shuttling process.

As the performing surgeons' comfort level increases with the simplified technique, they may choose to add an additional glenoid anchor and humeral anchors, still using the simplified shuttling technique. For medial fixation, we consider adding a central anchor if the spread between the anchors is greater than 2 cm. Laterally, the graft can measure longer to cover the entire supraspinatus footprint, and a second row of knotless anchors can be added to create a double-row construct.

Risks associated with this procedure include those associated with use of allograft tissue, namely the risk of infectious disease transmission, failure of graft incorporation, and foreign-body reaction to the graft tissue. It is also important to ensure the graft is tensioned appropriately because an undertensioned graft may not adequately restore superior stability to the shoulder and an over-tensioned graft may be at increased risk of tearing. Superior capsular reconstruction is generally not recommended in the setting of a nonfunctional deltoid or a large, irreparable subscapularis tear. Deltoid function is necessary for functional improvement after surgery, and the desired anterior-posterior force coupling of the rotator cuff muscles cannot be restored without an intact or repairable subscapularis tendon.

We hope that our technique will reduce the complexity of this procedure and allow surgeons to perform the operation more efficiently and more reproducibly. The senior authors (J.R.L., J.S.A.) believe that this technique is an excellent way to introduce the arthroscopic shoulder surgeon to superior capsular reconstruction and allow for evolution of the technique as the individual skill set of the surgeon evolves.

Table 2. Advantages and Disadvantages of Superior Capsular Reconstruction With Allograft

Advantages	Disadvantages
Restores acromiohumeral distance to improve shoulder biomechanics in setting of irreparable rotator cuff tear	Technically demanding procedure for inexperienced arthroscopists
Reproducible technique for complex and technically demanding procedure	Expense of acellular dermal allograft
Simplified suture management and graft tensioning via placement of lateral anchors after medial fixation is achieved	Strict patient compliance required during postoperative healing phase
Human acellular dermis allograft provides structural matrix for healing	
Avoids donor-site morbidity of autograft harvest	

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