Technical Note

Arthroscopic Superior Capsular Reconstruction Using Hamstring Allograft

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Abstract: Superior capsular reconstruction (SCR) has become an acceptable treatment option for patients with chronic shoulder pain in the setting of an irreparable rotator cuff tear. Several different techniques have been described with varying graft options. In this Technical Note, we introduce a technique for arthroscopic SCR using hamstring allograft tendon. Our described technique allows for a "one-size-fits-all" graft with a "build as you go" construct with no need for intraoperative dimensional defect measurements or specific graft modifications. This technique provides a reliable and reproducible procedure using readily available graft tissue.

Surgical management of massive, irreparable rotator cuff tears presents a challenge to the treating orthopaedic surgeon. In elderly patients, reverse shoulder arthroplasty remains the treatment of choice, especially in the presence of rotator cuff arthropathy.[1] However, in younger patients without secondary glenohumeral arthritis, surgical management is more complex with indications for certain procedures more controversial.[2] Joint-preserving procedures can include debridement, partial rotator cuff repair with or without augmentation, tendon transfers, bridging graft interposition, balloon spacer implantation, and superior capsular reconstruction.[3,4]

Superior capsular reconstruction (SCR) was originally described by Mihata et al.[5] as a treatment option for irreparable rotator cuff tears, whereby the superior capsule is reconstructed to stabilize the humeral head, provide an adequate fulcrum for elevation, and statically prevent superior humeral head migration.[5,6] In their initial outcomes series, Mihata et al.[7,8] published results on SCR using fascia lata autograft and demonstrated significantly improved patient outcomes, range of motion, increased acromiohumeral distance, and return to previous level of function. To decrease the morbidity associated with fascia lata autograft harvest, the use of human acellular dermal allograft has become popularized, with good outcomes reported.[9-12] Others have used dermal xenografts, with outcome studies only documenting moderate improvement in functional outcomes with fairly low graft healing rates approaching 30%.[13] More recently, others have described the use of various different autograft sources for SCR grafts besides fascia lata, including both long head biceps tendon autograft[14,15] and hamstring autograft.[16] While the long head biceps tendon is readily available as local autograft during shoulder surgery without the need for separate incisions to obtain, downsides can include the inability to use as a graft in the presence of a pathologic or partially torn tendon, which commonly can be seen in rotator cuff disease.[17] Downsides to the use of hamstring autograft include the need for separate incisions in addition to the associated morbidity with harvesting about the knee. The use of hamstring allograft provides an easily obtainable and readily available graft source with no associated harvesting morbidity seen with autograft tissue. In this Technical Note, we introduce our technique for arthroscopic superior capsular reconstruction using hamstring allograft (Video 1).

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Surgical Technique

Indications

Our indications for arthroscopic SCR with hamstring allograft are listed in Table 1. These include patients

Table 1. Indications for Arthroscopic Superior Capsular Reconstruction Using Hamstring Allograft

- Irreparable posterosuperior rotator cuff tears
- No glenohumeral arthritis (i.e., Hamada grade I or II)
- Intact and functioning deltoid and trapezius muscles
- Significant shoulder pain with failed nonoperative treatment

with massive irreparable posterosuperior rotator cuff tears with minimal to no glenohumeral arthritis (Hamada grade I or II), an intact and functioning deltoid muscle, significant shoulder pain with daily activities, and failed conservative modalities.

Operating Room Setup

After undergoing a preoperative safety checklist, including surgical marking of the correct extremity, the patient is brought back to the operating room and placed supine on the operating room table. General anesthesia is administered, and the patient is placed in the lateral decubitus position for shoulder arthroscopy with all bony prominences well padded, as described by Jinnah et al.[18] A full preoperative shoulder examination is performed under anesthesia. The operative extremity is prepped and draped in a standard, sterile fashion.

Portal Placement

We use standard anterior and posterior mid-glenoid portals as well as a standard lateral portal. Additionally, we use a Neviaser portal and accessory high posterolateral and anterolateral acromial portals. Figure 1 demonstrates locations of all portals used in our technique.

Operative Technique

Intra-articular access is obtained through a standard posterior mid-glenoid portal, approximately 2 cm medial and 2 cm inferior to the posterolateral acromion. A 30° arthroscope is introduced through the posterior mid-glenoid portal, and a full glenohumeral diagnostic examination is performed, specifically evaluating the glenohumeral articular cartilage, the articular side of the posterosuperior rotator cuff remnant, the subscapularis tendon, and the long head biceps tendon anchor. An anterior mid-glenoid portal is established using an outside-in technique allowing instrumentation access for joint debridement. The long head biceps tendon is either left in place or tenotimized based on visualized pathology with patient-specific factors used to determine whether a tenotomy or tenodesis is performed.

The arthroscope is moved into the subacromial space using the posterior mid-glenoid portal to view the bursal side of the posterosuperior rotator cuff remnant. A lateral portal is established using an outside-in technique with spinal needle localization approximately 3 to 4 cm lateral to the acromion in line with the posterior aspect of the acromioclavicular joint. Adhesions are released and a thorough subacromial bursal decompression is performed in all directions in addition to an acromioplasty to ensure adequate visualization for the entirety of the procedure.

Viewing from the lateral portal, an accessory high posterolateral portal is established via an outside-in technique just off the posterolateral acromial edge, ensuring that access to the glenoid rim is possible. Additional portals may be used to access the glenoid rim located just anterior to the clavicle in line with the rotator interval portal and just posterior to the acromion in line with the mid-posterior portal. The greater tuberosity rotator cuff footprint is debrided to a bleeding cancellous bone bed using a combination of shaver/burr instrumentation from the posterior portal. The remnant

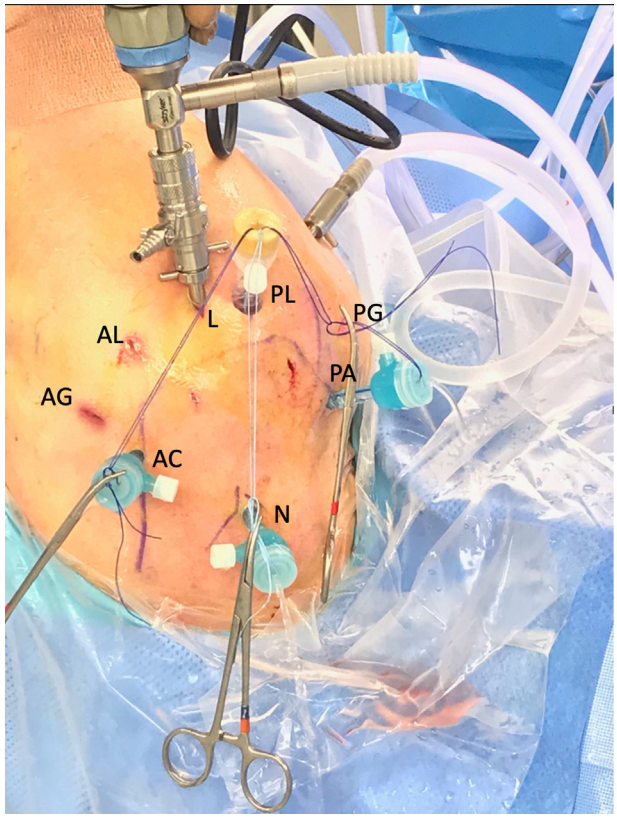

Fig 1. Intraoperative picture of a right shoulder in the lateral decubitus position demonstrating the portals used for arthroscopic superior capsular reconstruction. We use standard posterior mid-glenoid (PG), anterior mid-glenoid (AG), and lateral (L) portals. Access to the glenoid neck is obtained through accessory anterior clavicular (AC) and posterior acromial (PA) portals as well as a standard Neviaser (N) portal, which is also used for graft passage. Additionally, anterolateral (AL) and posterolateral (PL) portals are used for a combination of viewing, graft passage, and greater tuberosity anchor placement.

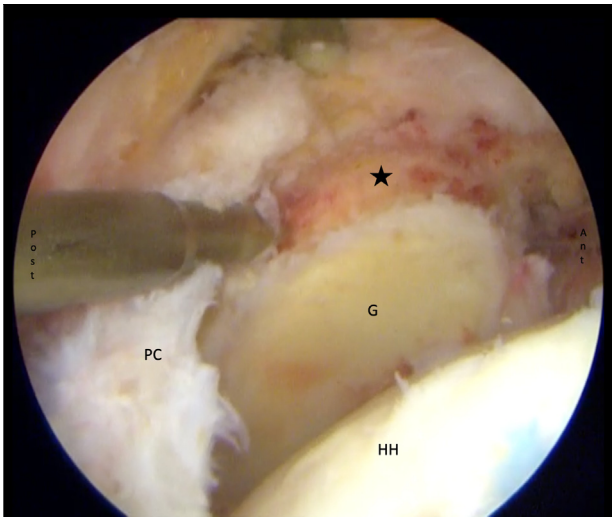

Fig 2. Arthroscopic picture of a right shoulder in the lateral decubitus position viewing from the lateral portal with the humeral head (HH) and glenoid (G) visualized. Anterior (Ant) and posterior (Post) directions are labeled for reference. The remnant posterior cuff (PC) is visualized, which is split longitudinally to gain full access to the glenoid (G) from the subacromial space. The glenoid neck (*star*) is decorticated to a bleeding cancellous surface for subsequent anchor placement.

cuff is split sharply, parallel to its fibers, all the way to the level of the glenoid neck to allow access to the superior glenoid for anchor placement. Using a combination of shaver/burr instrumentation, the superior glenoid neck is debrided and decorticated to bleeding cancellous bone to the level of the coracoid neck anteriorly and the border of the remaining posterior cuff posteriorly (Fig 2). Next, a Neviaser portal is established via an outside-in technique in the superior

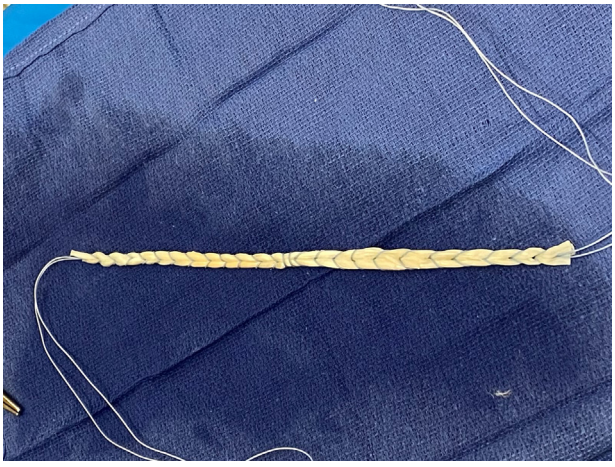

Fig 3. Semitendinosus allograft prepared with 2 No. 2 FiberLoop (Arthrex) sutures starting from the middle of the tendon and whipstitched in a locking fashion toward each end of the graft such that the graft is fully whipstitched with free suture at both graft ends.

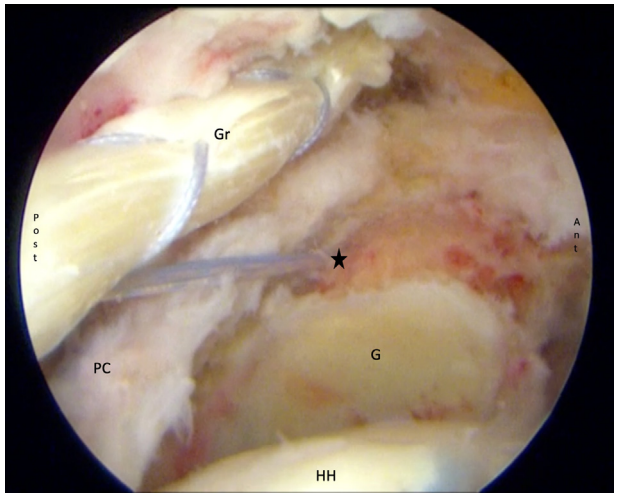

Fig 4. Arthroscopic picture of a right shoulder in the lateral decubitus position viewing from the lateral portal with the humeral head (HH), glenoid (G), and posterior remnant cuff (PC) visualized. Anterior (Ant) and posterior (Post) directions are labeled for reference. A 1.9-mm SutureFix anchor (Smith & Nephew) is placed in the posteromedial glenoid neck (*star*). The semitendinosus graft (Gr) is shuttled into the shoulder through the posterolateral portal and out the Neviaser portal, where it is docked to allow adequate visualization during graft passage and fixation.

shoulder soft spot, ensuring adequate access to the superior glenoid neck for anchor placement and graft shuttling. A 5.0-mm cannula is then placed through this portal. Prior to the SCR procedure, any remaining infraspinatus tendon that can be mobilized and repaired to the greater tuberosity is important, especially to recreate the posterior cuff cable as well as a posterior border for the SCR reconstruction.

A semitendinosus allograft is prepared with 2 No. 2 FiberLoop (Arthrex) sutures starting from the middle of the tendon and whipstitched in a locking fashion toward each end of the graft such that the graft is fully whipstitched with free suture at both graft ends (Fig 3). Viewing from the lateral portal, a 1.9-mm SutureFix anchor (Smith & Nephew) is placed in the posteromedial glenoid neck through the working Neviaser portal in preparation to eventually anchor the graft to the glenoid posteriorly. Next, a looped No. 1 PDS (Ethicon) suture through the Neviaser portal is used to shuttle the hamstring graft into the subacromial space through the posterolateral portal from lateral to medial (Fig 4). The lateral free end of the graft is anchored to the posterolateral humeral cuff footprint adjacent to the remaining posterior cuff with a 5.5-mm Healicoil knotless anchor (Smith & Nephew) through the posterolateral portal using the free end of the previously placed whipstitched No. 2 FiberLoop suture (Arthrex) through the graft (Fig 5A). An extra stitch through this anchor is docked and saved for final

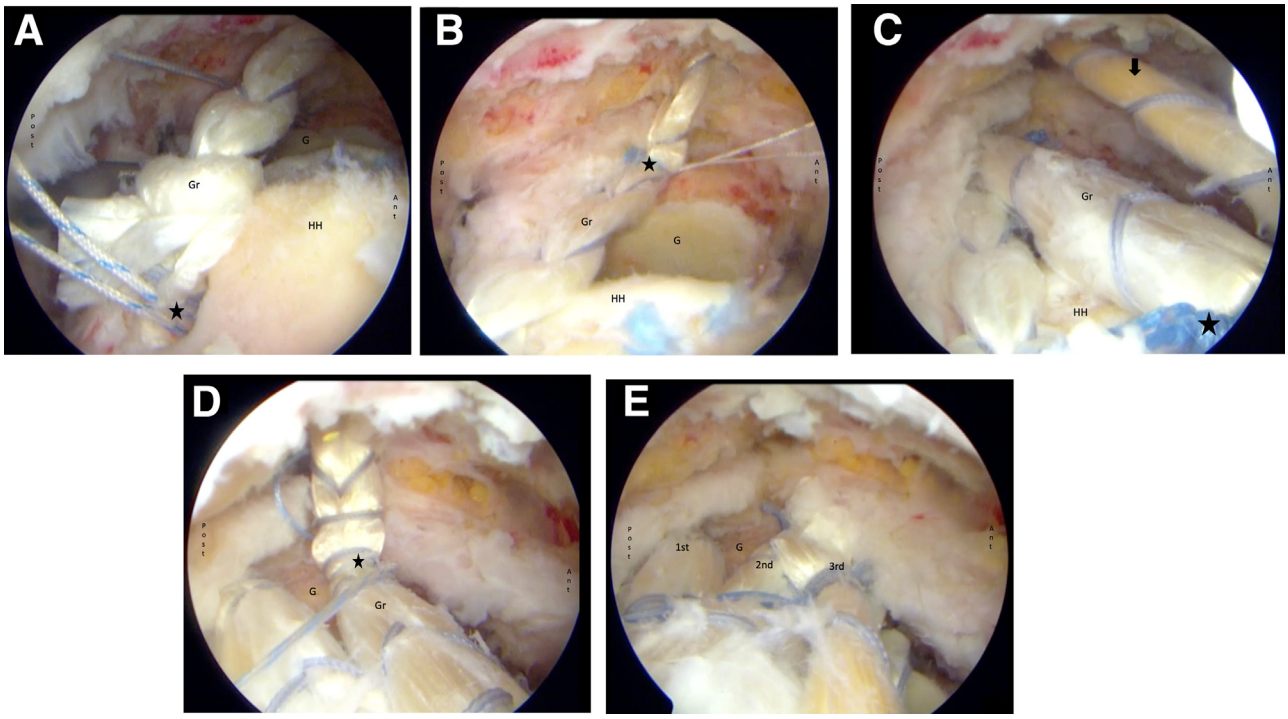

Fig 5. Arthroscopic picture of a right shoulder in the lateral decubitus position viewing from the lateral portal with the humeral head (HH) and glenoid (G) visualized. Anterior (Ant) and posterior (Post) directions are labeled for reference. (A) The lateral free end of the whipstitched semitendinosus graft (Gr) is anchored to the posterolateral humeral cuff footprint adjacent to the remaining posterior cuff with a 5.5-mm Healicoil knotless anchor (Smith & Nephew) (*star*) placed through the posterolateral portal using the free end of the whipstitched suture through the graft. (B) The graft (Gr) is then secured medially on the posterolateral glenoid neck (*star*) using arthroscopic knot fixation from the previously placed 1.9-mm SutureFix anchor (Smith & Nephew). (C) The graft (Gr) is then brought back laterally to the humeral head (HH) and secured with arthroscopic knot fixation (*star*) just anterior to the previously placed initial humeral head anchor using a 4.75-mm Healicoil anchor (Smith & Nephew) placed through the posterolateral portal. The remaining graft (*arrow*) continues to be docked out of the Neviaser portal, which aids in visualization and graft passage. (D) The graft (Gr) is again brought back medially and secured to the glenoid (G) neck (*star*) with another 1.9-mm SutureFix anchor (Smith & Nephew) just anterior to the previous anchor using arthroscopic knot fixation. (E) Final glenoid (G) fixation with the free end of the graft (Gr) using another 1.9-mm SutureFix anchor (Smith & Nephew) placed at the base of the coracoid such that there are 3 graft limbs (first, second, third) fixed from posterior to anterior.

construct fixation later. The graft is then brought across the humeral head interval medially to the glenoid and secured to the glenoid using the previously placed 1.9-mm SutureFix anchor (Smith & Nephew) at the posteromedial glenoid with arthroscopic knot fixation (Fig 5B). The tendon is then snaked back laterally to the tuberosity footprint, tensioned, and secured with arthroscopic knots to the tuberosity footprint using a 4.75-mm Healicoil anchor (Smith & Nephew) placed through the posterolateral portal (Fig 5C). The second free stitch through this anchor is brought back posteriorly to the initial graft dock site at the 5.5-mm Healicoil anchor (Smith & Nephew) and secured to the graft with knot fixation for added security. Another 1.9-mm SutureFix anchor (Smith & Nephew) is placed on the glenoid, just anterior to the previous glenoid anchor through the Neviaser portal, and the tendon is brought back medially and anchored to the glenoid with arthroscopic knot fixation (Fig 5D). The tendon is snaked back laterally across the humeral head interval, tensioned, and fixed to the tuberosity footprint using another 4.75-mm Healicoil anchor (Smith & Nephew) placed through the anterolateral portal, slightly more anterior to the previous tuberosity anchor. A second free stitch through this anchor is docked and saved for later final construct fixation. Lastly, a final 1.9-mm SutureFix anchor (Smith & Nephew) is placed at the base of the coracoid on the anteromedial glenoid through a separate percutaneous portal just anterior to the clavicle, and the end of the hamstring tendon graft is subsequently brought medially and secured to the glenoid with knot fixation (Fig 5E). An additional stitch is used through the 1.9-mm anchor (Smith & Nephew) and tied to the free end of the graft's whipstitched No. 2 FiberLoop sutures (Arthrex) for added security.

This produces a graft construct that essentially fills the superior rotator cuff void with 3 glenoid-based anchors and 3 humeral-based anchors with the hamstring graft

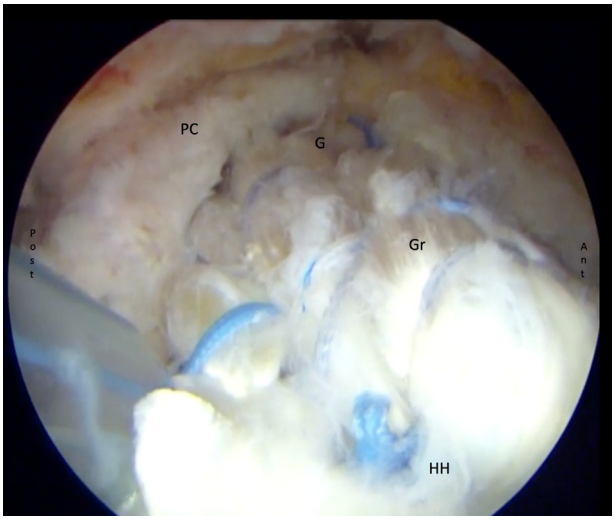

Fig 6. Arthroscopic picture of a right shoulder in the lateral decubitus position viewing from the lateral portal with the humeral head (HH), glenoid (G), and posterior remnant cuff (PC) visualized. Anterior (Ant) and posterior (Post) directions are labeled for reference. The graft construct (Gr) fills the previous superior rotator cuff void. There are a total of 3 main glenoid-based anchors and 3 main humeral-based anchors with the hamstring graft "snaked" between the anchors in an alternating fashion from posterior to anterior.

"snaked" between the anchors in an alternating fashion from posterior to anterior (Fig 6). The extra sutures placed through the initial posterior tuberosity 5.5-mm Healicoil anchor (Smith & Nephew) and the final most anterior tuberosity 4.75-mm Healicoil anchor (Smith & Nephew) are weaved through the lateral aspect of the graft in an opposing fashion to create intermingling of all the bundles and subsequently anchored to the greater tuberosity using two 5.0-mm Healicoil knotless anchors (Smith & Nephew) placed anteromedially and posteromedially. Finally, a No. 2 UltraBraid suture (Smith & Nephew) is placed medially in a large convergence-style stitch through the remnant superior cuff that was initially split for extra fixation and added security. Figure 7 and Figure 8 demonstrate the final construct from the subacromial space and intra-articular space, respectively.

Postoperative Care

Postoperatively, the patient is placed into a sling with abduction pillow to be worn at all times. Beginning postoperative day 1, the patient is instructed to come out of the sling for pendulum exercises and elbow, wrist, and hand range of motion. Passive shoulder range of motion is begun around 2 weeks postoperatively with restrictions to 90 degrees forward elevation, 45 degrees abduction, and external rotation. The sling is discontinued around 6 weeks postoperatively, and active and active-assisted range of motion is begun at that time. Strengthening typically begins around 8 to 12 weeks postoperatively. If a biceps tenodesis is performed concomitantly, active elbow flexion and eccentric loads on the biceps are avoided for 6 weeks postoperatively.

Discussion

Management of massive, irreparable rotator cuff tears presents a challenge to orthopaedic surgeons, especially those involving younger, symptomatic patients with preserved glenohumeral articular cartilage. SCR has become an operative option in the surgeon's armamentarium with good outcomes reported at midterm follow-up.[8,19] Since Mihata et al.'s initial description of SCR using fascia lata autograft,[5] others have described techniques using various different autograft sources,[14-16] with the use of dermal allograft tissue popularized in the United States.[9,11,12,19] In this Technical Note, we report a technique using hamstring allograft. Our indications as well as the advantages and disadvantages to our described technique are listed in Table 1 and Table 2, respectively. Pearls and pitfalls of our technique are listed in Table 3.

Despite the type of graft used, SCR remains a technically demanding procedure with a steep learning curve. Compared to techniques using dermal allograft tissue, our technique provides several advantages. First, hamstring allograft tissue is typically more readily

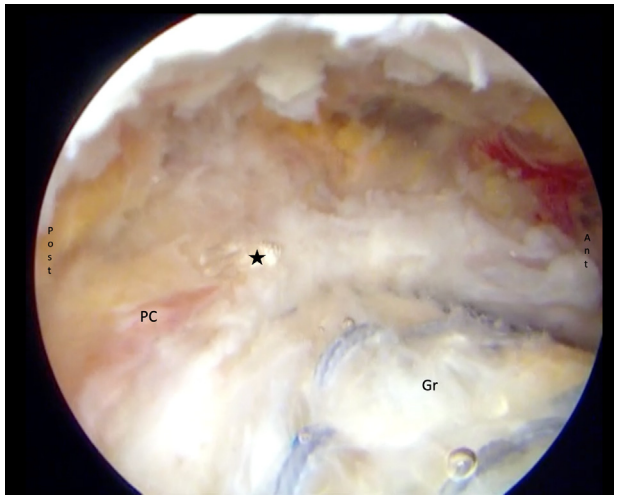

Fig 7. Arthroscopic picture of a right shoulder in the lateral decubitus position viewing from the lateral portal in the subacromial space. Anterior (Ant) and posterior (Post) directions are labeled for reference. Following final graft (Gr) fixation on both the humeral and glenoid sides in a snaking posterior to anterior direction to fill the previous superior rotator cuff void, a No. 2 UltraBraid suture is placed medially in a large convergence-style stitch (*star*) through the remnant superior cuff (PC) that was initially split longitudinally for extra fixation and added security.

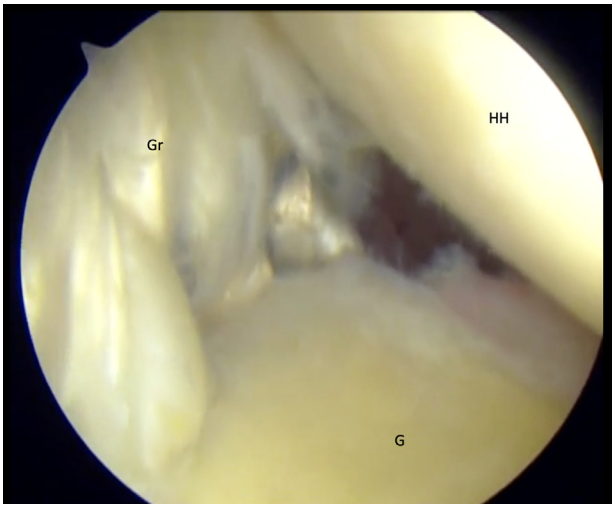

Fig 8. Intra-articular picture of a right shoulder in the lateral decubitus position viewing from the posterior mid-glenoid portal with the glenoid (G) and humeral head (HH) visualized. The undersurface of the graft construct (Gr) is seen replacing the previous rotator cuff void prior to superior capsular reconstruction.

available and cheaper than dermal allograft tissue. Second, our technique allows for a "one-size-fits-all" graft with a "build as you go" construct with no need for intraoperative dimensional defect measurements or specific graft modifications that often increase operative time. Additionally, one can quickly modify the construct to include as many graft bundles or anchors as desired both on the glenoid and the humeral side. Lastly, graft passage, arguably one of the more difficult steps to the SCR procedure, is technically easier with improved visualization during both passage and fixation with the benefit of avoiding suture entanglement, which is more commonly encountered when using single large-size allograft tissue.

Poorer clinical outcomes following SCR have been shown to be multifactorial,[9,20] with technical aspects relating to surgeon experience, graft thickness, and anchor number and location.[19] In particular, previous studies have shown that a thicker graft (≥6 mm) more adequately restores superior glenohumeral stability when compared to thinner grafts and thus contributes to decreased failure rates and improved outcomes.[21,22] However, with increasing single-graft dermal allograft thickness, visualization during graft passage and fixation becomes increasingly more difficult. Hamstring allograft tissue is typically ≥6 mm in thickness and when fixated in an alternating glenoid/humeral head fashion as described in our technique, graft passage and visualization are both optimized. Additionally, with the ability to modify the graft construct intraoperatively, one can easily double the graft bundles to further increase graft thickness.

There have been several published SCR techniques using the long head biceps tendon (LHBT) autograft.[17,23] Brandão et al.[23] recently described a "biceps loop technique" whereby the LHBT is rerouted through a humeral bone tunnel and back to the glenoid, with a lower cost construct being a proposed benefit. Kim et al.[17] described an alternating humeral head to glenoid graft fixation technique, termed the "snake technique," using LHBT autograft. While our technique shares the similarity of "snaking" fixation between the humeral head and glenoid, the use of biceps tendon autograft has several disadvantages when compared to hamstring allograft tissue. First, any significant LHBT pathology (i.e., fraying or partial tearing), which is commonly seen with massive, irreparable rotator cuff tears, precludes its use for SCR. Second, leaving the LHBT attached to the glenoid tubercle can be a continued shoulder pain generator as there is literature to support improved outcomes with isolated biceps tenodesis for massive irreparable rotator cuff tears. Lastly, the length of available graft is limited by anatomic constraints and may be difficult to adequately fill the superior capsular void in massive, retracted posterosuperior rotator cuff tears. This concept of "side-to-side" graft suturing has been highlighted in several biomechanical reviews of SCR, which help increase graft stability and prevent elongation and thus decrease graft failure.[24,25] Our described technique avoids these pitfalls and allows for a more consistent preoperative plan and operative execution.

Table 2. Advantages and Disadvantages of Arthroscopic Superior Capsular Reconstruction (SCR) Using Hamstring Allograft

Advantages	Disadvantages
• Technically easier from a graft passage perspective compared to single large-size allograft SCR techniques • Avoid suture entanglements during fixation • No donor site morbidity compared to autograft tissue use • Hamstring allograft cheaper than dermal allograft • "One size fits all" with a "build as you go" construct. No need to make intraoperative measurements or modify graft. One can modify technique to include as many anchors as desired • Redundant fixation on the glenoid side and humeral side for better reinforcement of the graft	• Costs related to suture anchor use • Allograft tissue use • Still a technically demanding procedure • Lateral decubitus position may potentially make it more difficult to open if required as compared with the beach-chair position

Table 3. Pearls and Pitfalls of Arthroscopic Superior Capsular Reconstruction Using Hamstring Allograft

- This technique is indicated in patients with massive irreparable rotator cuff tears with minimal to no glenohumeral arthritis and persistent shoulder pain that have failed all conservative measures.
- Evaluate the glenohumeral joint arthroscopically at the time of surgery to determine if any significant arthrosis exists, which would be a contraindication to this procedure.
- Ensure an adequate subacromial bursectomy and scar removal is performed along with removal of any prior suture. An acromioplasty (if needed) is performed in order to obtain and maintain adequate visualization for the entirety of the case.
- Repair any posterior rotator cuff tears back to the tuberosity (if reparable) to establish a posterior template/cable for graft passage during the procedure. This can also provide functional benefits to the patient.
- Reinforcing the reconstruction with a large convergence-style stitch medially using any remaining cuff tissue and intertwining stitches through graft tissue laterally can help improve construct fixation and security.

Disadvantages to our technique are listed in Table 2. These include expenses related to the relatively high number of anchors used for fixation in addition to the use of allograft tissue, which may have lower healing rates and a higher risk for infection when compared to autograft tissue. Despite this, if desired, one could harvest a patient's semitendinosus at the time of surgery and use autograft tissue instead with our described technique. One limitation to our technique is that intraoperative conversion to a partial tendon repair with augmentation or even a "bridging" graft repair technique, both of which can be a common scenario, is not possible using hamstring allograft and would require separate dermal allograft tissue.

In summary, we describe a straightforward technique for superior capsular reconstruction using readily available hamstring allograft tissue in a "build as you go" fashion with the ability to easily modify your construct intraoperatively and advantages that include improved ease of graft passage, visualization, and graft fixation.

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