Technical Note

Semitendinosus Allograft Cable Reconstruction Technique for Massive Irreparable Rotator Cuff Tears

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Abstract: Massive irreparable rotator cuff tears are difficult to treat. Disruption of the rotator cable and joint capsule leads to altered glenohumeral joint mechanics, superior migration of the humeral head, and limited overhead function. A few graft options exist for reconstruction, with limited outcomes data. A newer technique using a hamstring allograft provides benefits compared with other graft reconstruction options. This Technical Note describes a rotator cable reconstruction using a V-shaped hamstring allograft for treatment of a massive, irreparable rotator cuff tear.

Massive, irreparable rotator cuff tears lead to a disruption in glenohumeral joint mechanics and superior migration of the humerus. The rotator cuff muscles function to provide a dynamic stabilizer to the glenohumeral joint and prevent superior migration of the humeral head when the deltoid muscle contracts.[1] When the force couples of the rotator cuff are disrupted, passive restraints, such as the superior capsule, remain to prevent humeral head migration. Ultimately, with failure, superior humeral migration and dysfunction result.

Massive rotator cuff tears are a difficult problem to treat. Of the limited treatment options, superior capsular reconstruction (SCR) has become immensely popular in the last few years. The technique has shown improvement in biomechanically restoring superior stability, but long-term outcomes data are limited. The procedure can also be technically demanding. Using tensor fascia lata autograft, as originally described by Mihata et al.,[2] leads to increased surgical time and morbidity. Dermal allograft has been suggested as an alternative but is costly and has variable healing rates to bone.[3] The long head of the biceps tendon is another graft option[4-6]; however, it is not always present in the setting of a massive rotator cuff tear, and there is controversy as to whether this structure is able to adequately correct superior migration.[7]

Another option available for reconstruction is tendon allograft. Various techniques using tendon allograft and patches have been described with mixed findings. A study by Denard et al.[8] suggested that a V-shaped hamstring allograft is biomechanically strong enough to restore the disrupted cable attachments and correct superior migration of the humeral head. As the anterior and posterior attachments of the rotator cable are the most important sites for maintenance of overhead function, this procedure aims to restore the disrupted rotator cable. Hamstring allograft has demonstrated successful outcomes in the knee literature for reconstruction as well as acromioclavicular joint reconstruction in the shoulder. In this article, we discuss a novel technique of rotator cable reconstruction with a semitendinosus allograft for treatment of a massive, irreparable rotator cuff tear.

Technique

The patient is placed in the lateral decubitus position. A posterior portal is first created in standard fashion, and a diagnostic exam is performed. The subscapularis tendon is assessed and repaired in the standard fashion if torn. In the setting of an intact subscapularis tendon,

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the biceps tendon is preserved if intact. Attention is then turned to the subacromial space, and the rotator cuff tear pattern is assessed. Anterosuperolateral (ASL) and lateral working portals are established. A 7- to 8-mm threaded cannula is placed in the ASL portal, and a 10-mm flexible cannula (PassPort; Arthrex, Naples FL) is placed in the lateral portal.

After the rotator cuff tear is determined to be irreparable, the glenoid is prepared. Care is taken to preserve the superior labrum. Next, a superior portal is established, and a tensionable knotless anchor (2.6-mm Knotless FiberTak; Arthrex) is placed at the superior aspect of the glenoid, ∼5 mm medial to the biceps tendon origin. This anchor has a fixed #5 repair suture and a sliding shuttling suture, the latter of which is used to shuttle the repair suture into a knotless mechanism that is within the body of the anchor. The repair suture from the glenoid anchor is retrieved out the lateral working portal and used to measure the distances between the glenoid and the lateral edge of the greater tuberosity both anteromedially and posteromedially (Fig. 1).

Next, attention is turned toward the allograft. The graft is thawed, and the center of the allograft is marked for future placement over the midportion of the superior glenoid. To account for graft folding that occurs at the glenoid anchor site, 5 mm is added to the overall length. The previously recorded tuberosity distances are then measured from this center point, and the ends are whipstitched for 10 to 15 mm, with the suture tails exiting the ends. Once the graft is prepared, it is tensioned on the graft preparation stand.

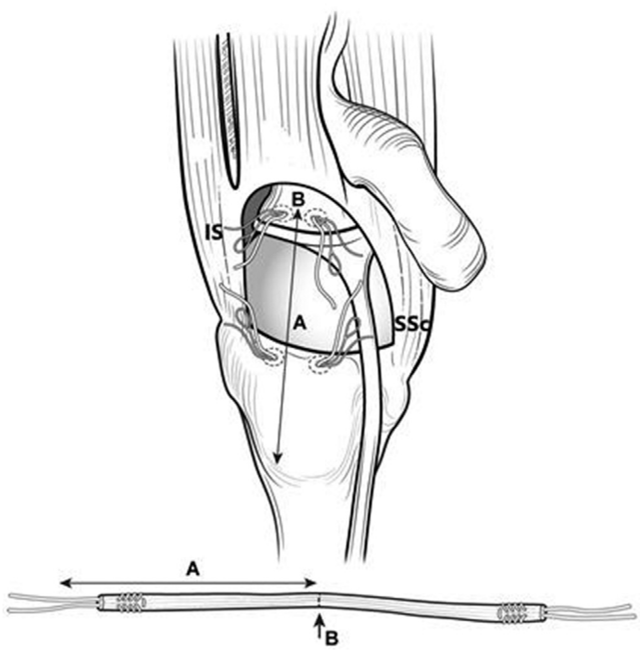

Fig 1. The glenoid anchors and medial tuberosity anchors are preplaced. One of the suture repair limbs from the glenoid anchors is retrieved out the lateral cannula and used to measure the distance from the glenoid to the lateral aspect of the greater tuberosity (A). This length is doubled and used to size a semitendinosus allograft, which is prepared on the back table. The center point (B) of the graft is marked. IS, infraspinatus; SSc, subscapularis.

Attention is turned back to the subacromial space. Two knotless anchors (2.6-mm knotless FiberTak) are placed in the greater tuberosity, adjacent to the articular margin. These anchors are used for subsequent medial fixation of the graft to the tuberosity. These anchors are placed via separate percutaneous portals just lateral to the acromion so that the angle of insertion is optimized and their sutures are kept separated. One of these anchors should be placed near the center of the greater tuberosity to maximize the restraint to superior translation. In the setting of a primary anterior cable disruption, the anterior anchor is placed just posterior to the biceps tendon, and the next anchor is placed in the center of the greater tuberosity. In the setting of a primary posterior cable disruption, the anterior anchor is placed in the center of the greater tuberosity, and the posterior anchor is placed near the posterior aspect of the greater tuberosity.

The #5 repair suture and looped end of the shuttling suture from the glenoid anchor are retrieved out the lateral cannula. The repair suture is passed around the midpoint of the graft and passed through the looped end of the shuttling suture. A 2-mm tape-like suture (FiberTape; Arthrex) can be added as an internal brace by either laying it against the allograft or weaving the suture through the graft. Then, the other end of the shuttling suture is pulled to deliver the graft into the subacromial space and secure it to the glenoid (Figs. 2 and 3). The anterior whipstitch limbs are temporarily retrieved out the ASL portal. The posterior whipstitch limbs and the posterior FiberTape limb are maintained in the lateral portal. Before securing the graft laterally, the repair sutures from the medial tuberosity anchors are each retrieved so that they are positioned on the opposite side of the graft from the shuttling sutures. It is important to perform this step before lateral anchor placement, as tensioning the graft laterally will impair the ability to manipulate the sutures around the graft. The posterior graft limbs are then secured posterolaterally to the greater tuberosity with a knotless anchor (5.5-mm SwiveLock; Arthrex). Lateral fixation is then completed with the anterior limbs that are secured through either the ASL or lateral portal, depending on the best angle of approach (Fig. 4).

Finally, the repair sutures from the medial tuberosity anchors are tensioned to secure the graft to the greater tuberosity with knotless loops. Two sutures are passed

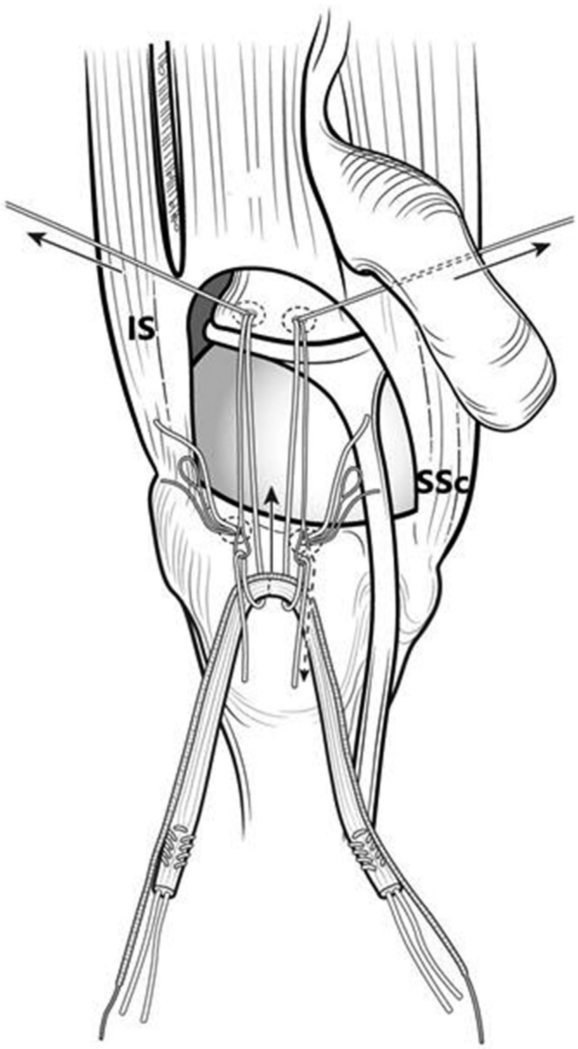

Fig 2. Shuttling the allograft into the joint. The glenoid sutures are used to shuttle the graft into the joint. First, the repair sutures and corresponding shuttling limbs are retrieved out the lateral cannula. Second, the repair limbs are passed around the midpoint of the graft and then through the corresponding loop of each shuttling suture. Tensioning the knotless mechanism of each anchor delivers the graft to the glenoid. Note: A 2-mm tape suture has been laid along the graft to provide additional stability at time 0. IS, infraspinatus; SSc, subscapularis.

through the infraspinatus and around the posterior limb of the graft and tied to secure the infraspinatus to the graft and provide additional biomechanical and biologic support. Fig. 5 demonstrates the final construct. Fig. 6 and the Video 1 summarize the entire technique.

Postoperatively, patients are placed in a sling for 6 weeks with hand, wrist, and elbow motion only. At 6 weeks, the sling is remove,d and passive range of motion (ROM) is allowed. At 12 weeks, strengthening begins. Full activity, including contact sports, are allowed at 6 months. Pearls and pitfalls are highlighted in Table 1.

Discussion

A variety of techniques have been described for treatment of the massive irreparable rotator cuff tear. Mihata et al.[9] originally reported on outcomes of SCR with tensor fascia lata autograft. Twenty-four patients underwent the procedure with tensor fasciae latae (TFL) autograft and partial cuff repair, with a mean follow-up of 31 months. Active shoulder elevation improved by 64°, and active external rotation improved by 14°. The acromiohumeral distance also improved, from 4.6 to 8.7 mm. On postoperative magnetic resonance imaging (MRI), 83% of the grafts demonstrated healing.[9] Since then, Mihata et al.[10] reported on 5-year outcomes, with great improvement in American Shoulder and Elbow Surgeons (ASES) shoulder scores in those patients with a healed graft. Additionally, patients with an intact graft had preservation of glenohumeral joint space compared with those with a failed graft repair.[10]

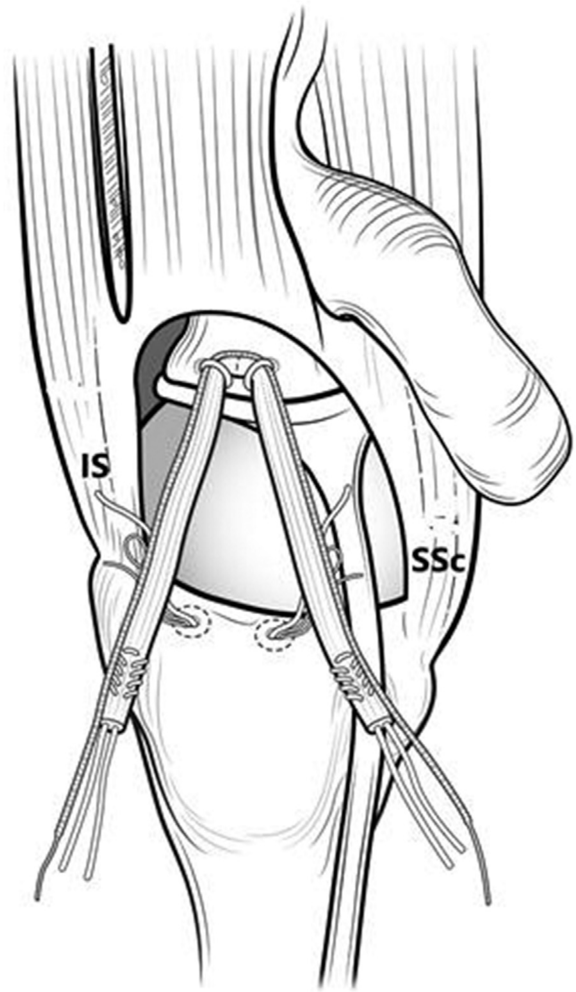

Fig 3. The V-shaped graft has been secured to the glenoid with 2 knotless anchors. Superior = rotator cuff; inferior = humerus. IS, infraspinatus; SSc, subscapularis.

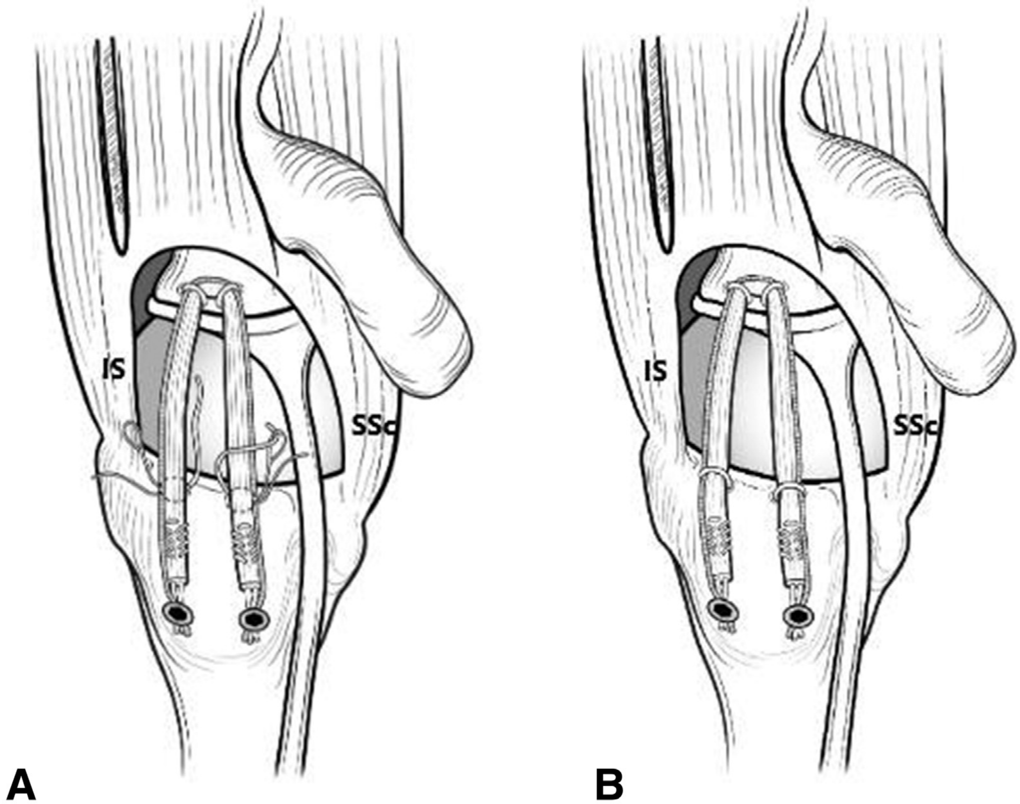

Fig 4. (A) The whipstitched ends of the allograft are secured laterally in the greater tuberosity with two 5.5-mm anchors. Note: Before securing the graft laterally, the repair limbs of the medial anchors are retrieved opposite the shuttling limbs for subsequent tensioning. This step is difficult to perform after the graft has been secured laterally. (B) The medial tuberosity limbs are then cinched down with the knotless mechanism of each anchor to increase graft-tuberosity contact. IS, infraspinatus; SSc, subscapularis.

Because of the morbidity and increased operative time with obtaining a TFL autograft, much interest has been pursued in using other graft sources, including acellular dermal allografts. In the Denard et al.[3] study outcomes of SCR with the use of dermal allograft, 59 patients underwent the procedure, with 1-year follow-up. At 1 year, 62.9% of patients had returned to normal activity. Complete graft healing was observed in only

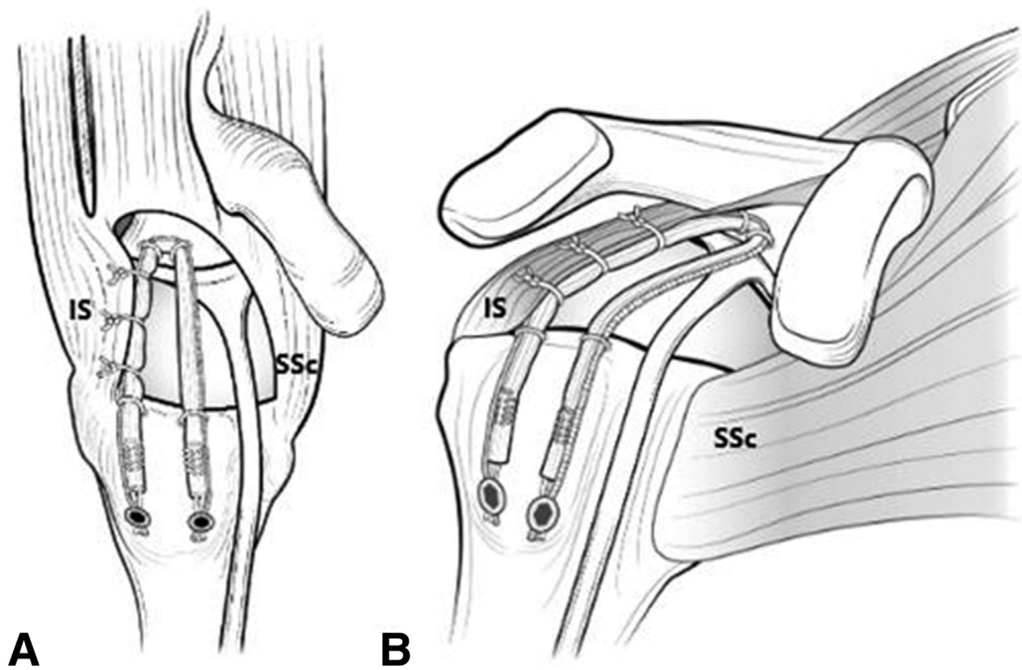

Fig 5. Final cable allograft construct viewed from top-down (A) and oblique (B) views. Note: The posterior graft limb has been sutured side-to-side to the infraspinatus for additional support. IS, infraspinatus; SSc, subscapularis.

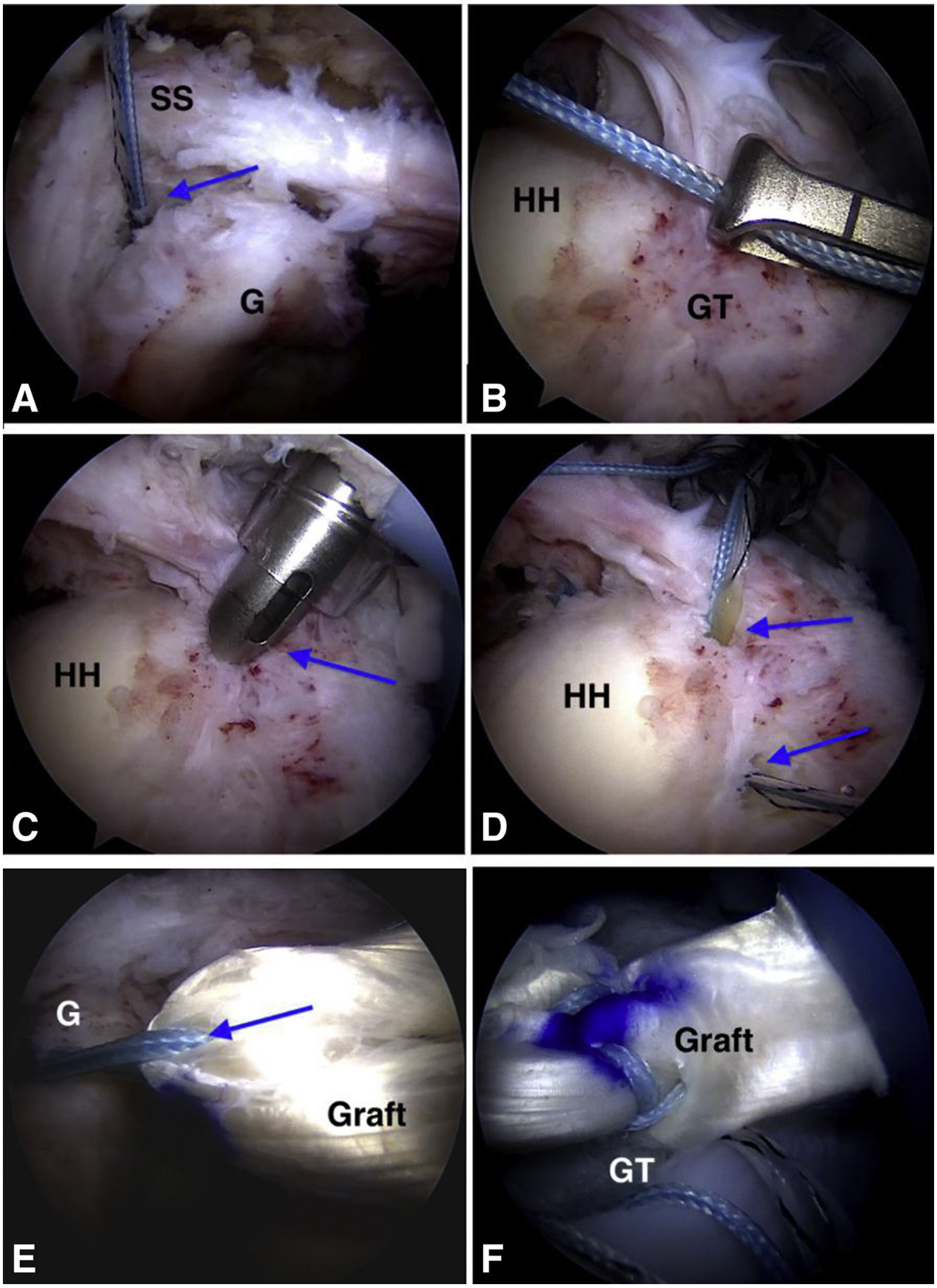

Fig 6. (A) Right shoulder posterior subacromial viewing portal demonstrates placement of a medial anchor (blue arrow) just medial to the superior labrum. In this case, a knotless soft anchor has been placed that will be used to shuttle the graft into the joint and obtain medial fixation. (B) Right shoulder posterior subacromial viewing portal. The repair suture from the glenoid anchor is retrieved out a lateral portal, and an instrument is used to measure the length from the glenoid to the greater tuberosity (GT). (C) Right shoulder posterior subacromial viewing portal. An anteromedial anchor is placed in the greater tuberosity using a guide (blue arrow) adjacent to the articular margin. (D) View after both medial tuberosity anchors (blue arrows) are placed. (E) Right shoulder posterior subacromial viewing portal demonstrates shuttling the midpoint of the graft into the subacromial space using the repair suture (blue arrow) from the glenoid anchor. The suture is tensioned until the graft is secured to the glenoid (G) medially. (F) Right shoulder posterior subacromial viewing portal demonstrates fixation on the greater tuberosity. The posterior limb of the graft is positioned to rest over the GT. G) The whipstitched limbs of the graft (arrow) are secured to the tuberosity with a knotless threaded anchor. (H) Medial tuberosity fixation is completed by securing the repair suture (arrow) from the medial anchor around the graft and back down in the body of the anchor in a knotless fashion. (I) Right shoulder posterior subacromial viewing portal. After the graft is anchored to the tuberosity, the infraspinatus (IS) is advanced to the graft with margin convergence sutures that pass around the graft and through the infraspinatus tendon. (J) Right shoulder lateral subacromial viewing portal demonstrates the final construct. HH, humeral head; SS, supraspinatus.

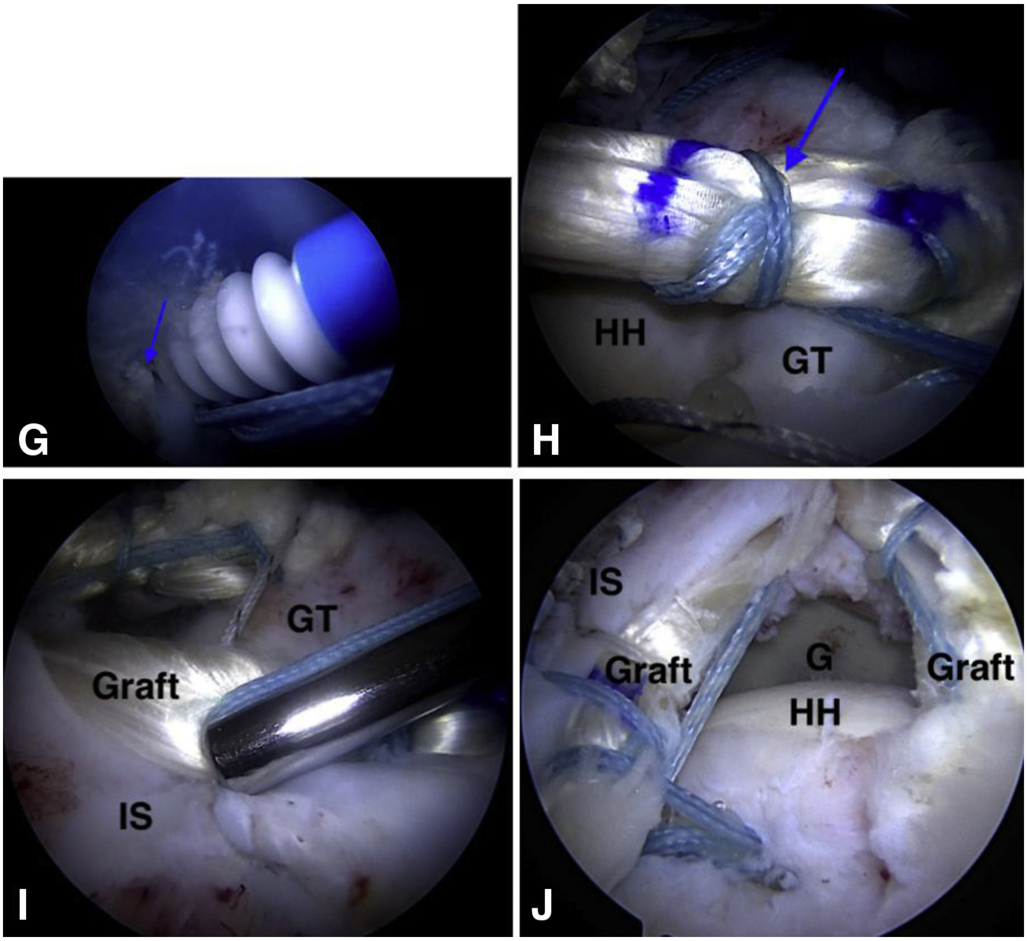

Fig 6. continued

45% of cases, with higher ASES scores observed in those patients with graft healing.[3] Other authors have reported on variable results with dermal allograft.[7,11] Azevedo[12] used hamstring autograft to perform an arthroscopic SCR. They reported a failure rate of 21% at final follow-up. Lacheta et al.[13] reported on SCR with use of a 3-mm dermal allograft in 22 patients and follow-up of 2 years. MRI follow-up was obtained in 95% of the patients at 2.5 months. They reported improvement in postoperative outcome scores.; however, only 57% of the grafts were intact at final follow-up. These results are inferior to the reported healing rates of Mihata et al.[2] with fascia lata autograft. Interestingly, Lacheta et al.[13] found no difference in outcome scores between patients with healed grafts and those with intact grafts.

In addition to variability in graft healing, SCR is limited by its technical difficulty. Suture management and graft shuttling into the joint are critical components of the procedure, as is graft tensioning.[14] In their originally reported technique, Adams et al.[15] placed ≥2 anchors (3 in subsequent descriptions) on the glenoid side and 4 anchors (2 before graft shuttling and 2 to secure the lateral aspect) on the humeral side to secure the graft. This resulted in shuttling suture limbs from 4 or 5 anchors out through a lateral portal when securing the graft down.[15] In our technique, only 1 set of suture limbs from the glenoid anchor is required to shuttle the graft into the joint. Suture management with this technique is thus simplified. Overall, the technique requires only 5 anchors, compared with the 6 or 7 anchors in the former technique, resulting in a cost savings.[3,7] Finally, cost savings is achieved through the graft itself; at the senior author's facility, the use of a semitendinosus allograft is $1200, whereas a 3-mm dermal allograft is $3000. Table 2 highlights the advantages of this technique.

In the United States, there has been a push to avoid the issues of donor site morbidity and increased operative time associated with an autograft harvest. Thinner acellular dermal allografts ≤3 mm in thickness have been popularized because they avoid the harvest issues of autograft and are more readily available.[16] Graft preparation time is reduced as well. The disadvantages of using dermal allografts are the high associated cost and reports of reduced healing rates.[16] Dermal allograft

Table 1. Advantages and disadvantages

Advantages	Disadvantages
• Joint preservation option • Provides cost savings compared with dermal allograft • Reduced graft preparation time with allograft • Semitendinosus graft is thicker than dermal allograft • Avoids donor site morbidity	• Technically difficult • Not applicable to all types of cuff tears • Graft tensioning is a critical part of the procedure • No long-term data available

appears to have the ability to integrate into bone, but histologic evaluations in a rat model suggested poor cellular organization and reduced strength compared with controls.[17] A study by Smith et al.[18] suggested that dermal allograft had a worse ability to integrate into canine bone compared with a bone–tendon allograft option.

Regardless of the graft type used, biomechanical data have shown that thicker grafts produce better results compared with thinner grafts.[3,19] There is also biomechanical data suggesting that thinner grafts, such as dermal allografts, are unable to restore superior translation to native levels compared with thicker grafts.[19] The superior capsule has a reported thickness of 3.5 to 9.1 mm.[20] Mihata et al.[9] originally described a technique with a TFL autograft ≥6 mm thick and recommended using thicker grafts to reduce superior translation of the humeral head compared with thinner grafts. In a 2016 biomechanical study, Mihata et al.[21] found that 8-mm grafts lowered peak subacromial pressures and decreased superior humeral translation, whereas 4-mm grafts improved peak subacromial pressure only. Another cadaveric study by Mihata et al.[19] compared an 8-mm TFL allograft with a commercially available dermal allograft in a simulated massive rotator cuff tear model. They reported that the fascia lata allograft restored superior humeral translation, superior glenohumeral joint force, and subacromial contact pressure, whereas the dermal allograft did not restore superior translation.[19] The semitendinosus allograft has an average thickness of 5 to 7 mm and length of 280 mm. This thicker graft may produce an increased spacer effect compared with a 3-mm dermal allograft.

SCR with use of a semitendinosus allograft represents a biomechanical precedent with distinct advantages compared with TFL autograft or dermal allograft. Park et al.[22] were the first to describe this technique using semitendinosus allograft as an anterior cable reconstruction in a biomechanical study of 8 cadavers in 3 groups: intact, large cuff tear (supraspinatus plus anterior half of infraspinatus), and large cuff tear treated with allograft cable reconstruction. Two 3.9-mm corkscrew anchors secured the graft on the glenoid side (12 mm apart), followed by two 5.5-mm SwiveLock anchors placed on the humeral side in a double-row fashion. The graft was reinforced with loop-around sutures and tied to the infraspinatus to retension the posterior capsule. The graft was placed in a box configuration. A custom testing machine was used to measure ROM, superior humeral head migration, and subacromial contact pressures at multiple angles of ROM. They found that the cable reconstruction group showed higher total ROM at all angles and reduced subacromial contact pressures at multiple angles.[22]

A V-shaped semitendinosus cable reconstruction technique has been shown to restore superior stability at different angles of shoulder ROM and restore subacromial contact pressures to native levels.[8] Multiple authors have described anterior cable reconstruction using the biceps tendon.[23-26] Using a semitendinosus allograft allows the surgeon to maintain the long head of the biceps tendon as an additional superior restraint if present.[19] A longer allograft also allows for additional footprint coverage and can be fixed in a single- or double-row fashion. In a biomechanical study by Denard et al.,[8] the V-shaped allograft decreased superior translation at 0° and 20° of abduction and reduced subacromial contact pressures at all angles except 40° abduction and 60° external rotation. Preliminary results of restoration of superior translation at various angles are encouraging, given that the superior cuff is responsible for initiating abduction. It is important to note that these studies examined cuff tear patterns with disruption of the anterior cable only; thus, this technique may not be suited for all massive cuff tear patterns.

Advantages of this technique include the avoidance of donor site morbidity and graft harvest, reduced preparation time, and cost savings compared with dermal

Table 2. Pearls and pitfalls

Pearls	Pitfalls
• Proper graft tensioning is critical • Subscapularis must be intact for this technique • Longer grafts allow additional footprint coverage	• Cannot be used with posterior cable disruption • Cannot be used with an irreparable subscapularis • Suture management is paramount

allograft. Suture management is also reduced as less anchors are used compared with other techniques, and only 1 suture is required to shuttle the graft into the joint. The long head of the biceps tendon can also be preserved with this technique. Disadvantages of this technique include a lack of surgeon familiarity and the technical difficulty of the surgical procedure in general, similar to an SCR with dermal allograft.

Conclusions

A V-shaped semitendinosus allograft is an alternative for the treatment of massive, irreparable rotator cuff tears. Although further clinical studies are required, distinct advantages of the technique are its technical ease and lower cost compared with SCR.

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