Technical Note

Arthroscopic Superior Capsular Reconstruction with Achilles Tendon Allograft for Massive and Revision Rotator Cuff Tears

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Abstract: Massive irreparable rotator cuff tears (RCT) in younger and active patients remain a significant clinical challenge to orthopaedic surgeons. Superior capsular reconstruction (SCR) has been presented as a way to restore the restraining effect of the superior joint capsule and the balanced force couples necessary for dynamic shoulder function; furthermore, it does not exclude future treatment options. The purpose of this article is to show a technical modification of the SCR in massive and revision RCT using Achilles tendon allograft as an effective static restraint to prevent superior migration of the humeral head due to its thickness and robustness, and performing a side-to-side repair on the greater tuberosity between the graft and the residual infraspinatus tendon to completely restore the superior stability of the shoulder joint.

Introduction

Massive rotator cuff tears (RCT) have traditionally been a challenging clinical problem for shoulder surgeons.[1] A broad variety of treatment options have been proposed to address this problem, but outcomes have been as variable as the techniques themselves.[2]

Biomechanical analysis has found that the effect of the superior capsule on shoulder joint function is very relevant. Mihata et al.[3] introduced the concept of superior capsular reconstruction (SCR) with fascia lata autograft, a procedure that reversed proximal humeral migration, restoring a stable fulcrum for the glenohumeral motion. Maintenance of a stable fulcrum

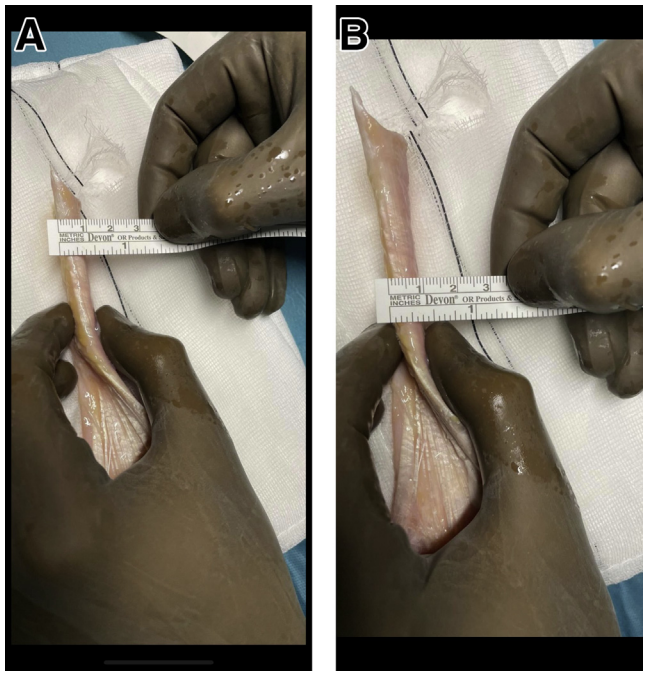

Fig 1. Achilles tendon preparation. The thickness of ~10 mm is checked along the entire length of the graft to be implanted. (A) Thickness at the glenoid end of the graft (GEG). (B) Thickness at the greater tuberosity end of the graft.

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The authors report the following potential conflicts of interest or sources of funding: A.E.-R. reports personal fees from Stryker, outside the submitted work. A.E.-B. reports personal fees from Stryker, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received September 20, 2021; accepted October 21, 2021.

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2212-6287/211356

https://doi.org/10.1016/j.eats.2021.10.017

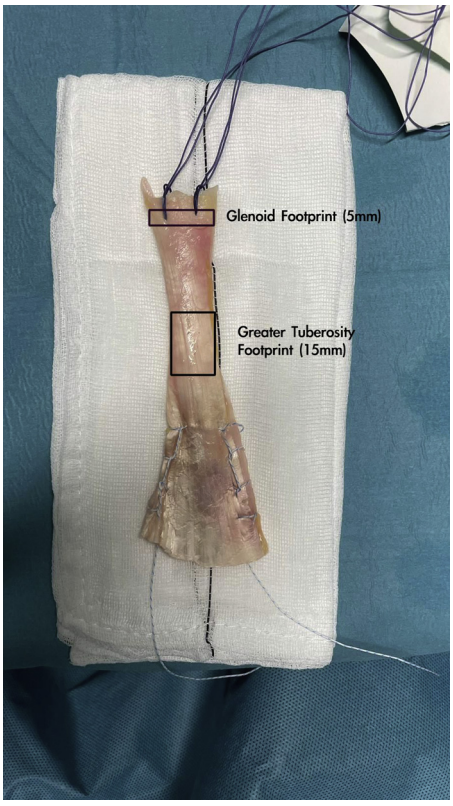

Fig 2. Achilles tendon preparation. From the edge of the graft, the 5 mm corresponding to the glenoid footprint and the 15 mm corresponding to the greater tuberosity footprint are represented. The Krakow suture was also shown, which allows traction from outside the shoulder.

would provide the added benefit of optimizing the remaining intact force couples, thereby, increasing objective measures of strength. The same group demonstrated that the fascia lata autograft, typically 6 to 8 mm thick, undergoes less elongation and provides better stability and thinning compared with dermal allografts, typically 3 to 4 mm thick.

To avoid the donor site morbidity of the fascia lata graft, an Achilles tendon may be a reasonable option to restore a stable fulcrum of the glenohumeral joint. The Achilles tendon can provide an approximately 10-mm-thick graft in its most distal part and, because of its length, it allows one to regulate the fixation tension in the greater tuberosity by pulling the graft from outside the shoulder. Both the thickness of the graft and the possibility of controlling the tension of its fixation have been shown to be important factors for biomechanically restoring shoulder stability during SCR.[4]

The objective of this Technical Note was to describe an arthroscopic SCR with Achilles tendon allograft (ATA) for massive tears and revision surgery of the rotator cuff.

Surgical Technique (with video illustration)

A detailed step-by-step description of the surgical technique is demonstrated in Video 1.

Preparation of the Graft

The entire distal part of the Achilles tendon from its bony insertion is used as a graft in order to achieve maximum thickness. In this way, a thickness of 10 mm throughout the length of the graft is achieved (Fig 1). Two holes are created 5 mm apart from the most glenoid end of the graft (GEG), with a 14-gauge spinal needle to pass the suture threads from two glenoid anchors that will be further placed, to allow the ATA to slide easily into the joint. The ATA will be further introduced into the joint via a percutaneous pathway keeping its proximal and thinner part outside the shoulder to allow for applying traction; therefore, the entire proximal part of the graft, where the traction will be applied, is fixed with a Krakow suture (Fig 2). Finally, the ATA is presoaked in a vancomycin solution of 5 mg/ml to prevent infections.[5]

Patient Position, Arthroscopic Portals, and Initial Exploration

Under general anesthesia, the patient is placed in beach-chair position. Usually, the following 6 standard arthroscopic portals are necessary: posterior, posterolateral, lateral, anterolateral, anterior, and Neviaser (Fig 3). The joint is routinely examined with a 30° scope; at this point; subscapularis repair and biceps tenotomy are made if necessary. Then the arthroscope

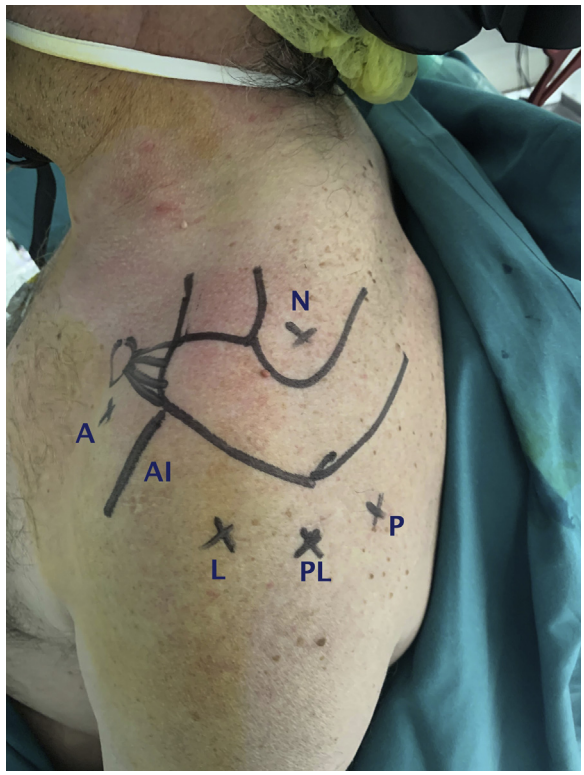

Fig 3. Standard arthroscopic portals in beach chair position for the left shoulder with posterior (P), posterolateral (PL), lateral (L), anterolateral incision (AI), anterior (A), and Neviaser (N) portals.

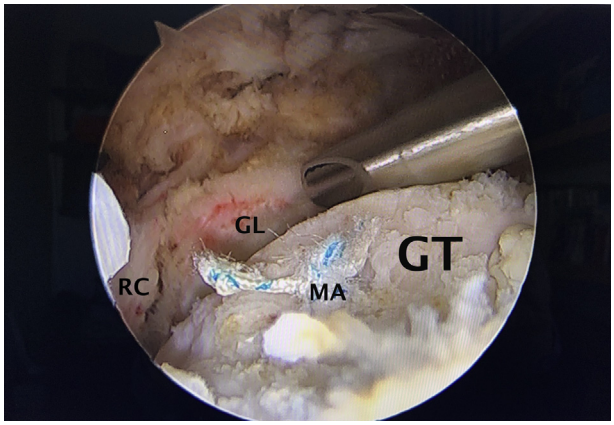

Fig 4. Arthroscopic visualization of the right shoulder from the lateral subacromial portal with the patient in the beach chair position, the shaver is through the anterolateral portal. Revision surgery of an irreparable rotator cuff tear is shown. GL, glenoid cavity; GT, greater tuberosity; MA, medial anchor of prior surgery; RC, rotator cuff.

is introduced inside the subacromial space through the posterior portal, and a bursectomy is performed using a shaver through the lateral portal. An evaluation of rotator cuff (RC) retraction and degeneration is also done (Fig 4). Attempted repair of the posterosuperior cuff includes performing careful excavation of the cuff and anterior interval slide to increase mobilization and the chance for partial repair of the native cuff over the graft if irreparable. In case of superior head migration of the humeral head on radiography and MRI, an arthroscopic capsular release is performed.

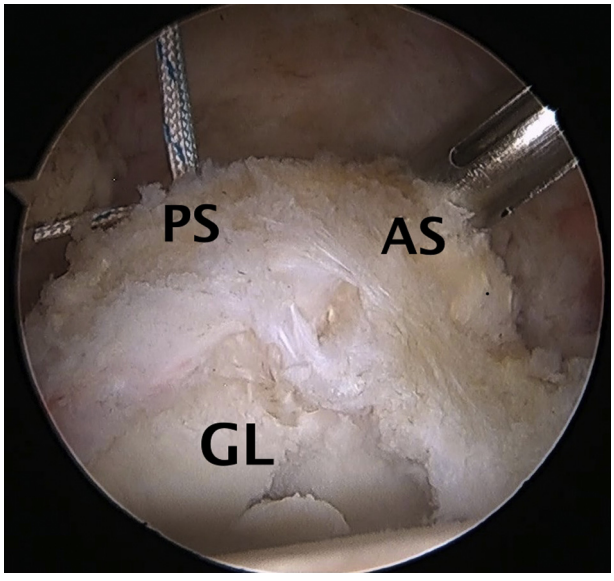

Fig 5. Arthroscopic visualization of the right shoulder from the lateral subacromial portal with the patient in the beach chair position. Through the Neviaser portal, the 11 o'clock position anchor is placed while the 1 o'clock anchor is placed through a modified anterosuperior portal. The anchors are drilled at the edge or the articular margin, at 60° to the glenoid face for good fixation. GL, glenoid cavity; PS, posterosuperior glenoid anchor; AS, anterosuperior glenoid anchor.

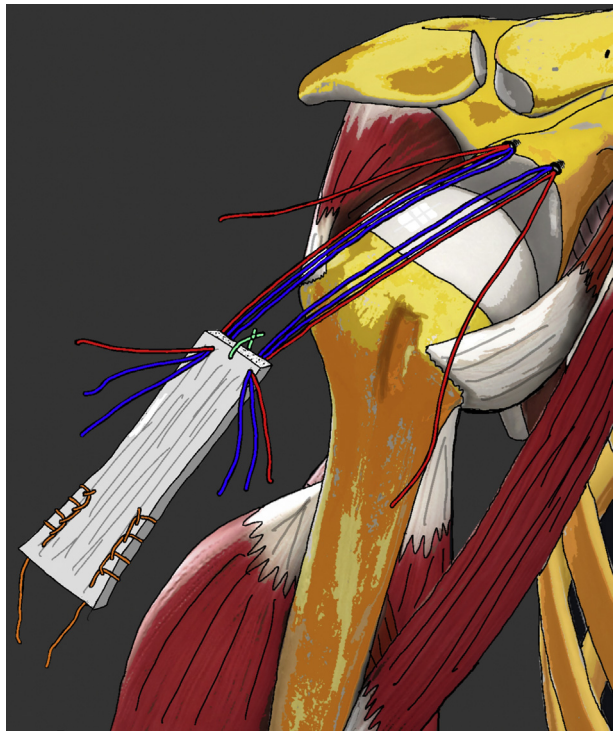

Fig 6. Right shoulder. Illustration showing how graft fixation sutures are passed through the graft extracorporeally, while one limb from the anterosuperior anchor is passed through the anterior portal, and one limb from the posterosuperior anchor is passed through the posterior portal. An independent suture knotted in the distal part of the graft (green color) is used to deliver the Achilles allograft into the shoulder with the help of a suture retriever.

Placement of Glenoid Suture Anchors

Usually, 2 anchors are placed in the superior glenoid neck for medial fixation (Figs 5 and 6). The bone bed on the superior glenoid is prepared to a bleeding bone by means of motorized shaver blades and electrocautery ablation. The superior labrum is completely debrided.

The anterosuperior glenoid anchor (Iconix 2.3 mm, Stryker, San José, CA) is placed at the base of the coracoid, just anteromedial to the origin of the long head of the biceps tendon. This anchor is placed through a modified anterosuperior portal, which is often made just anterior to the acromion. The posterosuperior glenoid anchor is placed through the Neviaser portal (Fig 5). Care must be taken that the trajectory of anchor placement is from lateral to medial, so that the anchor does not penetrate the articular surface.

Each anchor has 4 limbs, one limb from the anterosuperior anchor is passed through the anterior portal, and one limb from the posterosuperior anchor is passed

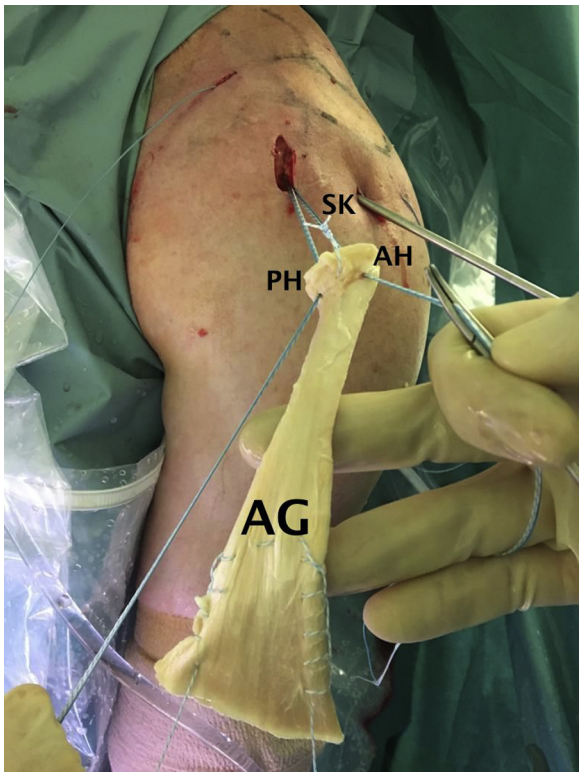

Fig 7. Left shoulder, patient in beach chair position. Three limbs of the posterosuperior anchor are passed through the most posterior hole of the graft while three limbs of the anterosuperior anchor are passed through the most anterior hole of the graft. The independent suture knotted is also represented. AG, Achilles tendon allograft; PH, posterior hole; AH, anterior hole; SK, suture knotted.

through the posterior portal. The remaining six limbs are passed together through the anterolateral portal through which the graft will be passed (Fig 6).

Graft Implantation

The passage of the graft will be performed through an incision in the anterolateral portal. Because of the thickness of the graft, it is necessary to enlarge the anterolateral portal with a length that allows the lesser finger of the surgeon to be inserted, to decrease the risk of graft disruption and avoid the need to insert a cannula.

An independent suture knotted in the GEG is used to deliver the Achilles allograft into the shoulder with the help of a suture retriever (Figs 6 and 7).

The three limbs of the posterosuperior anchor that pass through the anterolateral portal are introduced through the most posterior hole of the graft, while the three limbs of the anterosuperior anchor are passed through the most anterior hole of the graft (Figs 6 and 7). The goal is to secure the medial portion of the graft to the glenoid by means of a double-pulley technique. Therefore, a suture limb of the posterosuperior anchor is tied securely together with a suture limb of the anterosuperior anchor. Then the 2 corresponding limbs (to those that were tied) are tensioned, while the graft is carried to the glenoid with the suture retriever (Fig 8), pulling the surgeon's knot down tightly over the medial part of the graft. The 2 free limbs will be later tied together; before that, the limb of the anterior hole of the graft is recovered with its corresponding partner found in the anterior portal, and the same process is carried out with the limb of the posterior portal. The 2 limbs of suture through the anterior and the posterior portal are then tied down, securing the graft to the glenoid footprint via the anchors. At this time, the 2 free limbs of those which were tied together are now knotted with static surgeon's knots.

At this point, the stability and the effect on the tension of the graft exerted can be checked by its traction from outside the shoulder (Fig 9).

Placement of Tuberosity Suture Anchors

While keeping the arthroscope in the lateral portal, the decortication of the bone bed of the footprint is performed through the anterolateral portal with a burr. A two-stranded anchor (Iconix 2.3 mm, Stryker, San José, CA) is inserted in the medial aspect of the footprint (Fig 10).

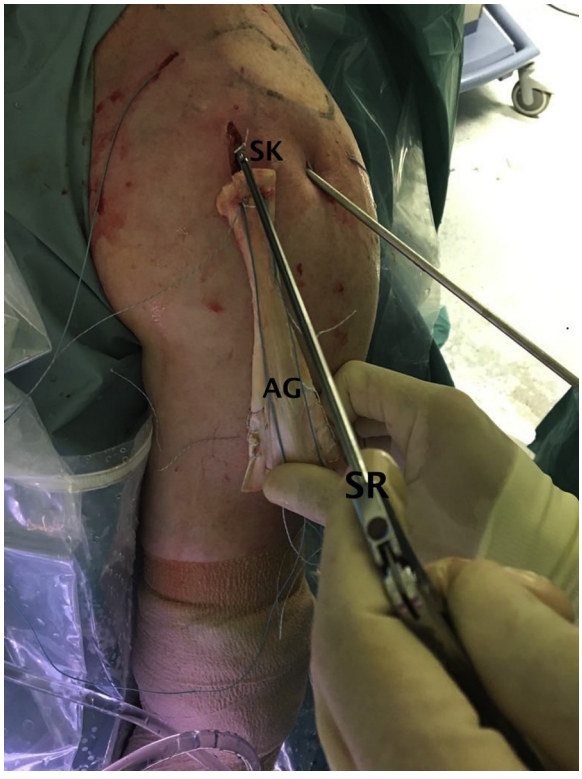

Fig 8. Left Shoulder, patient in beach chair position. The Achilles tendon allograft is carried to the glenoid with the suture retriever through the independent suture knotted. AG, Achilles tendon; SR, suture retriever; SK, suture knotted.

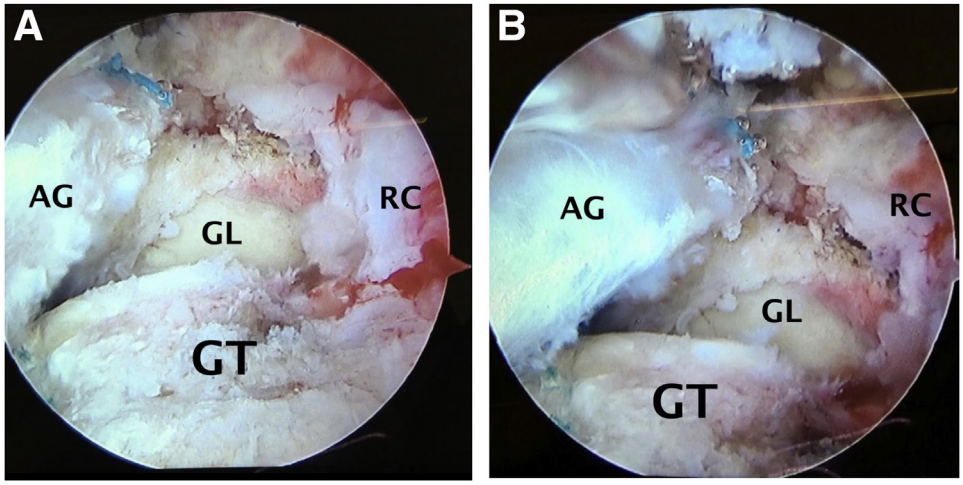

Fig 9. Arthroscopic visualization of the left shoulder from the lateral subacromial portal with the patient in the beach chair position. The Achilles tendon is located through the anterolateral incision. Appearance of the Achilles allograft once its medial portion has been attached to the glenoid by means of a double-pulley technique. Checking stability and the effect on the tension of the graft exerted by its traction from outside the shoulder. (A) Without traction. (B) With traction. AG, Achilles tendon allograft; GT, greater tuberosity; MA, medial anchor; RC, rotator cuff.

After anchor insertion and while maintaining tension on the graft from outside the shoulder (Fig 11), a curved soft-tissue penetrator device (Champion Sling-Shot, Stryker, San José, CA) is introduced through the anterolateral portal (the exact point is checked by opening the shoulder to 30° of abduction to ensure a rigid fixation), and two limbs from the anchor are passed through the graft using a lasso-loop tie; the suture is finished with 4-5 knots to fix the Achilles allograft to the greater tuberosity.

Cannulas are not routinely employed by the authors, so the surgeon must make sure to retrieve the limbs

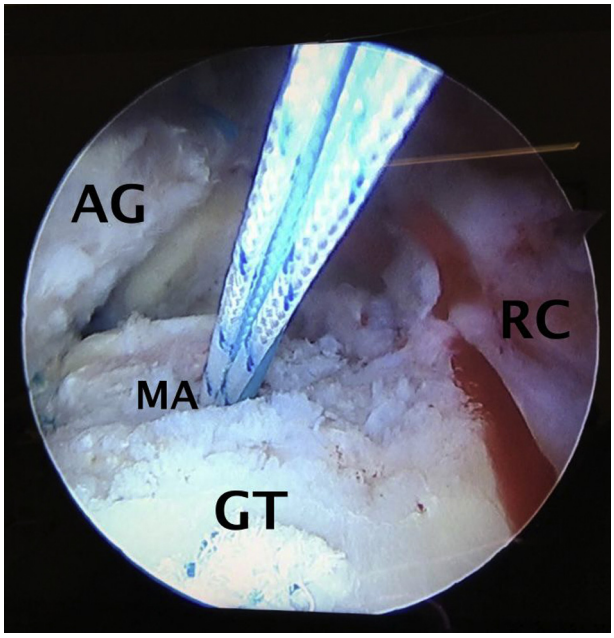

Fig 10. Arthroscopic visualization of the left shoulder from the lateral subacromial portal with the patient in the beach chair position. Image of the medial anchor after decortication of the footprint. AG, Achilles tendon allograft; GL, glenoid cavity; GT, greater tuberosity; MA, medial anchor; RC, rotator cuff.

Fig 11. Left shoulder, patient in beach chair position. Traction performed through the Krakow suture before stitches. The Achilles allograft is held through the anterolateral portal, while the arthroscope is in the lateral portal. AG, Achilles tendon allograft; L, lateral portal; AI, anterolateral incision.

Fig 12. Right shoulder. Illustration showing the appearance of the superior capsular reconstruction once the Achilles allograft has been sutured to the greater tuberosity, and the medial implant, which will be tied to the cuff remnant, closing the graft posteriorly to the native cuff.

with the suture manipulator through the anterolateral incision.

At this stage, another 2-stranded anchor (Iconix 2.3 mm, Stryker, San José, CA) is inserted at the medial aspect of the footprint, closer to the Infraspinatus tendon (Fig 12), and then, the cuff remnant and the Achilles allograft are tied together, closing the graft posteriorly to the native cuff (Fig 13).

The graft is securely fixed again on the lateral side of the footprint with a third anchor by the anterolateral portal (Fig 14), in the same manner, performing a convergence suture with the rotator cuff (Fig 15). The remnant of the graft is cut, and the anterolateral incision and arthroscopic portals are sutured (Fig 16).

Postoperative Care

Postoperative rehabilitation initially focuses on limited and protected passive range of motion. The arm is placed in a brace that is generally maintained for 6 weeks. However, active hand, wrist, and elbow exercises are allowed from the first day, and progressive passive shoulder mobilization and pendulum exercises are commenced 15 days postoperatively. Active range of motion typically starts after 6 weeks after removal of the brace, and strengthening exercises start after 12 weeks.

Discussion

The main feature of this technique is that SCR can be effectively achieved using an ATA, which provides a thick and long graft.

The idea of using the Achilles tendon as an effective stabilizer is based on the biomechanical study of Mihata,[5] in which the thickness of the graft plays a fundamental role in the stabilization of the humeral head. The ATA can provide a thickness of up to 10 mm both in the glenoid and the in greater tuberosity anchor site, and thanks to its length, it allows one to apply traction from outside the shoulder, avoiding the need to measure the distance between the anchors that can lead to an excess tension or laxity of the interposed graft that can reduce its effectiveness or cause its breakage.

Usually, convergence repair between the graft and the remnant of the infraspinatus tendon is performed in the greater tuberosity based on the different biomechanical studies that suggest a better stabilization of the glenohumeral joint.[5,6] This side-to-side suture is not performed between the graft and the infraspinatus at the midsubstance of the Achilles tendon because they work as different elements. One is a static stabilizer whose function is to center the humeral head, while the

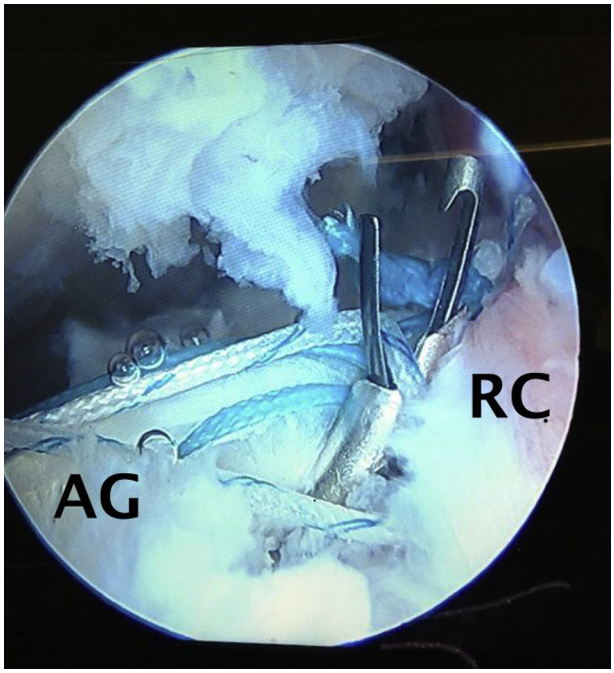

Fig 13. Arthroscopic visualization of the left shoulder from the lateral subacromial portal with the patient in the beach chair position. A curved soft-tissue penetrator device is introduced through the anterolateral portal, and two limbs from the medial anchor are passed through the graft. AG, Achilles tendon allograft; RC, rotator cuff.

Fig 14. Right shoulder. Illustration showing the final result of the repair once the Achilles allograft and the rotator cuff have been sutured together (light blue and green sutures).

infraspinatus tendon has a dynamic function. The suture between the two in this area can increase the breakage of the graft.[7]

The suture between the ATA and the infraspinatus, however, is not considered an essential condition, as sometimes they cannot be repaired together, since the thickest part of the Achilles tendon is not the widest, and it is not possible to perform a side-to-side repair

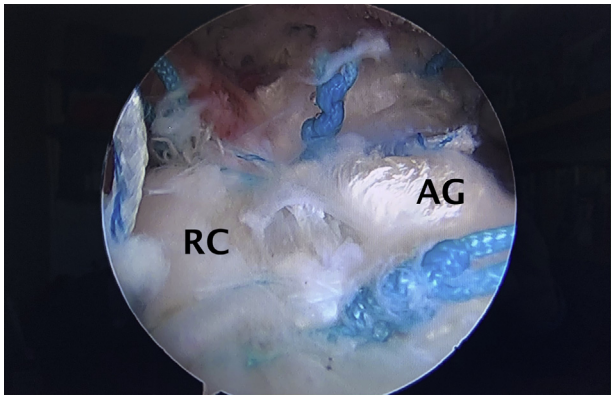

Fig 15. Arthroscopic visualization of the right shoulder from the lateral subacromial portal with the patient in the beach chair position. Achilles tendon allograft appearance after convergence suture with the rotator cuff after placing the second anchor. AG, Achilles tendon allograft; RC, rotator cuff.

Fig 16. Left shoulder, patient in beach chair position. The remnant of the graft is cut with a scalpel. AG, Achilles tendon allograft; AI, anterolateral incision; A, anterior portal.

with the remnant of the infraspinatus (Fig 17). The main objective of the technique is to reinforce the thinnest point of the capsule attachment, which is located 11 mm posterior to the anterior margin of the greater tuberosity[8] with the thickest part of the graft to support structural stability to this zone of weakness

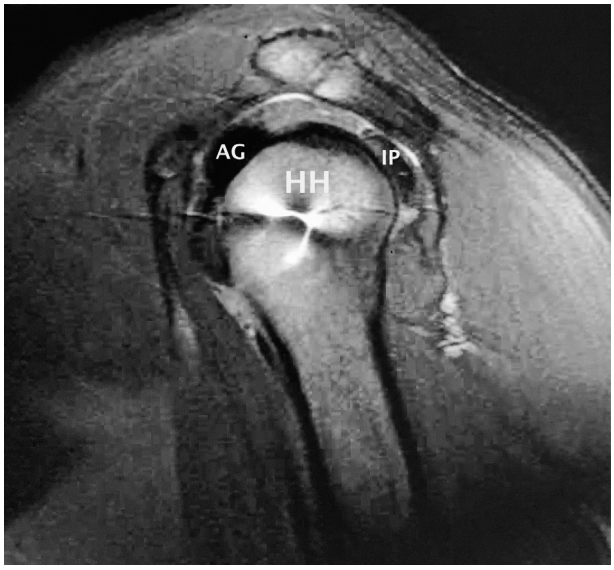

Fig 17. Sagittal view of a T2 fatSAT series of a magnetic resonance imaging of a left shoulder. Two years after rotator cuff repair. The Achilles allograft could not be sutured together with the infraspinatus tendon but the integrity of the allograft and the repair of the remnant of the rotator cuff is appreciated. AG, Achilles tendon allograft; HH, humeral head; IP, infraspinatus tendon.

Table 1. Surgical Steps, Pitfalls, and Pearls

Surgical Steps	Pearls	Pitfalls
Graft preparation	Use the narrow, thicker portion of the graft from its bone insertion to achieve the greatest possible length with the greatest thickness.	Using the thinnest part of the allograft can affect its strength.
Portal creation	The lateral portal is the main vision portal, while the anterolateral portal is used for the passage of the allograft.	Using cannulas or making an insufficient incision in the anterolateral portal can affect the passage of the allograft.
Debridement of soft tissue and mobilization of the remnants of the rotator cuff	Make a capsular release that allows you to fix the graft without excessive tension.	Skip the ascent of the humeral head, which can increase graft suffering.
Placement of glenoid suture anchors	Two anchors are placed at the 11- and 1-o'clock positions. The anterosuperior glenoid anchor is placed through a modified anterosuperior portal. The posterosuperior glenoid anchor is placed through the Neviaser portal.	Care must be taken on the trajectory of the anchor, so it does not penetrate the articular surface.
Graft implantation	Use a suture retriever to deliver the Achilles allograft over the glenoid and secure the medial portion of the graft by means of a double-pulley technique.	In doing medial double-pulley fixation on superior glenoid, observe closely that sutures do not bowstring over the edge of the glenoid.
Placement of tuberosity suture anchors	A lateral anchor row using two 2-stranded anchors is necessary to fully secure the graft onto the greater tuberosity.	In patients with poor bone quality, excessive decortication can cause the loss of the anchor.
Graft fixation to tuberosity anchors	Apply traction to the graft from outside the shoulder to achieve adequate anchoring tension.	An excess tension or laxity of the interposed graft can reduce its effectiveness.

and to promote RC healing without undue tension. In this way, a basic static ligamentous support is provided to the dynamic tendon while helping to limit superior migration without restricting glenohumeral kinematics.

The most commonly used graft for SCR is the fascia lata autograft,[9] which avoids the risks of allografts, namely, immune response and disease transmission in the implants and their price. On the other hand, use of fascia lata autograft comes with increased risks of donor site morbidity and increased operation time. Dermal allografts are also popular[10,11,12] in SCR; however, they result in a thinner graft (3-4 mm) and they costs more.

The idea of using the ATA as a substitute in the case of massive RCT is not completely unprecedented.[13,14,15] Previously presented techniques need to measure the distance between the anchors of the glenoid and the greater tuberosity, which can affect the fixation tension of the graft. Moreover, less thick areas of the Achilles allograft are used in order to cover the entire tendon defect in the humeral head, which is the area where failures occur most frequently because of excessive tension concentrated during active shoulder abduction and elevation.[16]

The present technique has some limitations. The main one is the need of an ATA on which there are concerns about its low viability, graft rejection, and infections. The pearls and pitfalls of this technique are described in Table 1.

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