Technical Note

Combined Arthroscopic-Assisted Lower Trapezius Tendon Transfer and Superior Capsule Reconstruction for Massive Irreparable Posterior-Superior Rotator Cuff Tears: Surgical Technique

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Abstract: Primary or revision irreparable rotator cuff tears remain a challenge. Clear algorithms do not exist. Several joint-preserving options are available, but no technique has been definitely proven to be better than another. Although superior capsule reconstruction has been shown to be effective in restoring motion, lower trapezius transfer can provide strong external rotation and abduction moment. The aim of the present article was to describe an easy and reliable technique to combine both options in 1 surgery, aiming to maximize the functional outcome by getting motion and strength back.

Primary or revision irreparable rotator cuff tears remain a challenging treatment impasse. Several strategies have been proposed ranging from partial repair up to reverse prosthesis.[1] Clear algorithms do not exist, and the surgical decision-making process mainly relies on patient age and functional request, as well as surgeon experience.

Superior capsule reconstruction (SCR) represented a revolutionary strategy in the last decade. After the first description by Mihata et al.,[2] several modifications of the original technique have been proposed mainly aiming to ease the procedure, to reduce the costs, and to improve fixation strength of the selected graft. However, the basics remained unchanged.[3,4] What is currently known is that SCR is a good option to get a full range of motion (ROM) back, even in cases of pseudoparalysis.[5,6]

Tendon transfers represent an option that has been highly criticized in the past because of its complexity and invasiveness and was usually proposed as a salvage procedure with controversial and limited functional outcomes.[7] In the last decade, indications to tendon transfers, as well as surgical techniques, have been rethought, with better reported outcomes.[8] Particularly, lower trapezius tendon transfer (LTT) can replicate the infraspinatus fibers better than latissimus dorsi transfer (LDT), and therefore it seems that lower trapezius (LT) is the best transfer option in cases of posterosuperior irreparable rotator cuff tears because it can provide strong external rotation and abduction arm movement.[9,10] It goes without saying that combination of SCR and LTT might be the best option to get motion and strength back in cases of primary or revision irreparable posterosuperior rotator cuff tears. The aim of this Technical Note was to describe an easy and reliable technique to combine both options in one surgery.

Surgical Technique

Indications

Decision must be mainly based on functional request. Indications for a combined procedure are the following:

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- Irreparable posterosuperior cuff tears (primary or revision cases)
- Supraspinatus and infraspinatus fatty infiltration $\geq$ grade 3 (Goutallier classification[11])
- Supraspinatus and infraspinatus muscle atrophy $\geq$ moderate (Warner classification[12])
- Positive external rotation lag sign
- Pseudoparalysis

Age represents only a relative contraindication. Absolute contraindications are:

- Rotator cuff tear arthropathy $\geq$ stage 3 (Hamada classification[13])
- Irreparable subscapularis tendon tear
- Fatty infiltration of teres minor ($\geq$grade 3)
- Deltoid deficiency

Patient Position and Setup

Surgery is usually performed with general anesthesia combined with an interscalenic block for postoperative pain management. A standard operating room table is set up, and the patient is positioned in a beach-chair position as laterally as is safely possible so there is an easy access to the medial aspect of the scapula for the lower trapezius harvesting (Fig 1). The involved arm is placed in a pneumatic arm holder (Trimano; Arthrex, Naples, FL) to facilitate different arm positions during grafts fixation (Fig 2). Because the procedure starts with a standard shoulder arthroscopy and the first operative step is the SCR, the arm is positioned in 60° of forward flexion and slightly abducted.

If a semitendinosus autograft is used, a second operating field should be prepared for harvesting the tendon graft, usually from the ipsilateral lower limb. The leg is placed in a figure-of-four position, and a side support is usually used. A tourniquet is then placed on the proximal thigh and used only during the harvesting.

Fig 2. Right shoulder. Beach-chair position. The involved arm is placed in a pneumatic arm holder to facilitate different arm positions during grafts fixation.

Shoulder Arthroscopy: First Step

Bony landmarks are essential. Before the procedure is started, a marking pen is used to identify the spine of the scapula, the incision for the lower trapezius harvest,

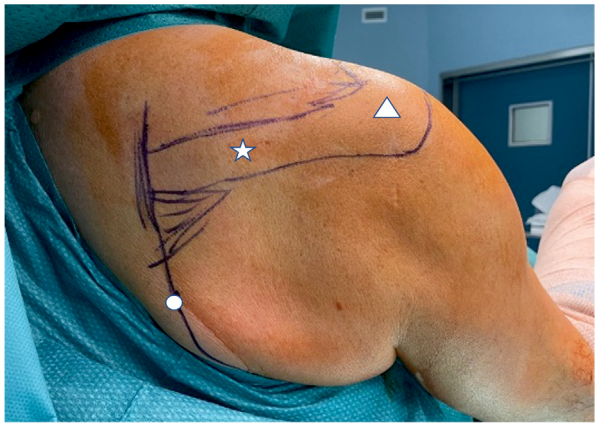

Fig 1. Right shoulder. The patient is positioned in beach-chair position as laterally as is safely possible. Medial border of the scapula is clearly marked and accessible (oval). (The star marks the spine of the scapula; the triangle identifies the acromion.)

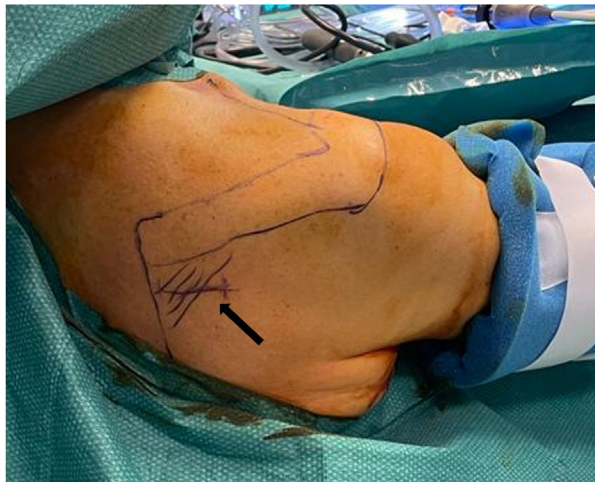

Fig 3. Right shoulder. Beach-chair position. Posterior view. The incision for the lower trapezius harvest has been drawn just lateral to the medial border of the scapula.

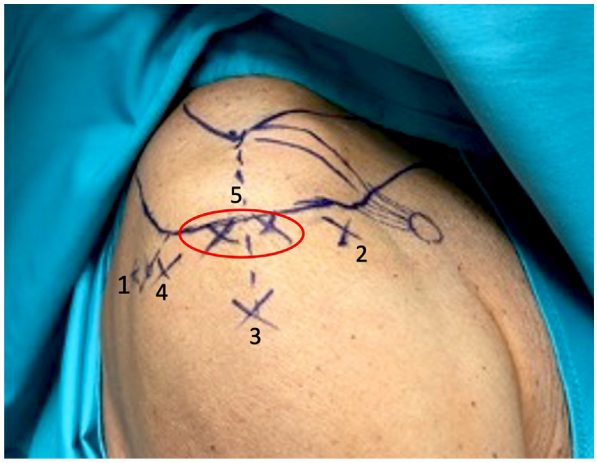

Fig 4. Right shoulder. Beach-chair position. Lateral view. Portals: (1) posterior; (2) anterosuperior; (3) lateral; (4) posterolateral; (5) superolateral.

Fig 6. Left shoulder, beach-chair position. A 4 cm transverse incision lateral to the medial border of the spine of the scapula and just 1 cm inferior to the scapular spine is performed.

the acromion, the clavicle, and the coracoid process. A horizontal incision just inferior to the scapular spine, 4 cm in length laterally to the medial border of the scapula, is marked for lower trapezius harvesting, as previously described (Fig 3).[14]

Five portals are usually enough for the entire procedure. Additional portals might be somehow necessary for the optimal positioning of suture anchors (Fig 4).

Portals used are the following:

- Posterior portal (primary viewing portal)
- Anterosuperior portal. It is used for:
  - outflow
  - sutures management
  - to retrieve the graft
  - to place anterior anchors for fixation of tendon extension graft
- Standard lateral portal. It is used as a viewing portal, as well as an operative portal. If an allograft is used for the SCR, the graft will be placed intra-articularly through this portal.
- Superolateral portal: suture anchor placement for lateral SCR fixation.
- Posterolateral portal:
  - viewing portal if an allograft is used for SCR
  - operative portal used for suture anchor placement for posterior fixation of tendon extension graft

A diagnostic arthroscopy is always the first step to confirm irreparability of the posterosuperior cuff and eventually to repair a subscapularis tendon tear. A very important trick to smoothen the entire procedure is to carefully clean up the subacromial space from bursal

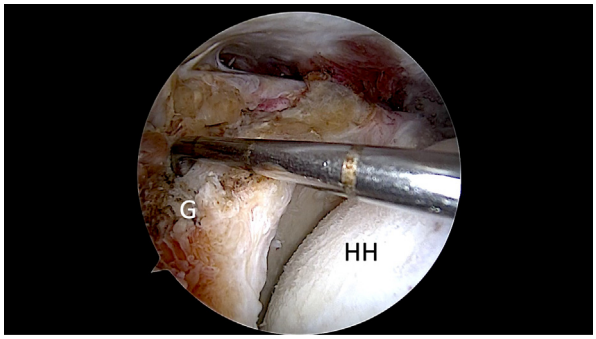

Fig 5. Right shoulder. Beach-chair position. Posterolateral view. A probe is inserted in the lateral portal, so the distance between the superior pole of the glenoid (medial graft fixation point) and the greater tuberosity (lateral graft fixation point) can be measured. G, glenoid; HH, humeral head.

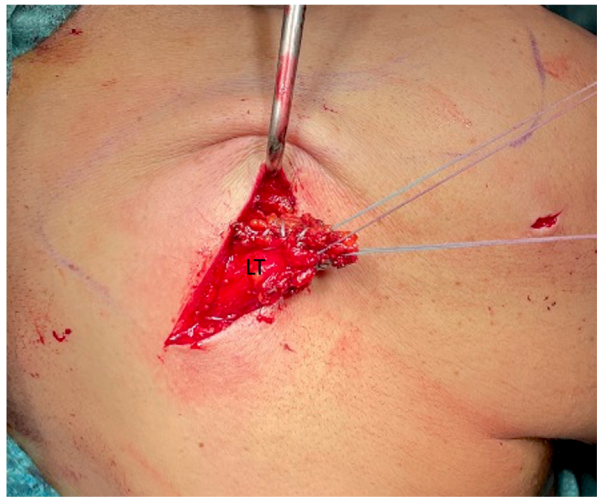

Fig 7. Right shoulder. Beach-chair position. Adequate tendon dissection does not exceed 2 to 3 cm in length. The edge of the tendon is secured with a high-strength suture. LT, lower trapezius.

Fig 8. Anterior tibialis tendon allograft. One extremity has been whipstitched by using 2 different-colored, high-strength sutures.

tissue and greater tuberosity from residual soft tissue by using an electrocautery device or a shaver.

If the long head of the biceps tendon (LHBT) is present and not too degenerated, it can be used for the SCR at this time, as previously described.[15] Alternative options are semitendinosus graft[16] or a proximal portion of the autograft or allograft used as a tendon extension graft for the transfer. If an alternative graft option is selected, measurement for graft length should be performed at this stage. By keeping the camera in the posterior portal, a radiofrequency device is used to clean the superior pole of the glenoid of any residual soft tissue and to mark where to fix the new graft. A probe is then inserted in the lateral portal so the distance between the superior pole of the glenoid (medial graft fixation point) and the greater tuberosity (lateral graft fixation point) can be measured. It usually requires around 3 cm (Fig 5).

LT Harvesting

A 4 cm transverse incision lateral to the medial border of the spine of the scapula and just 1 cm inferior to the scapular spine is performed (Fig 6). The lateral border of the LT is identified above a triangular fat area, and dissection is performed to free the tendon from the deep fascial tissues and from its insertion in the lower aspect of the spine of the scapula. Adequate tendon dissection does not exceed 2 to 3 cm in length (Fig 7). Any neurological issue with the accessory nerve is avoided by not going medial to the medial border of the scapula. The accessory nerve lies within the fascial layer that lies on the undersurface of the LT, approximately 2 cm medial to the medial border of the scapula.[17] After dissection, the edge of the tendon is secured with a high-strength suture (no. 2 FiberWire; Arthrex).

Preparation of Tendon Extension Graft

LTT requires a graft extension. Two main options have been described: a semitendinosus autograft[18] and Achilles tendon allograft with[19] or without a calcaneus bone block.[17] It is the authors' preference to use a semitendinosus autograft or a tibialis anterior or peroneus longus allograft.

If the semitendinosus autograft is used, a 3 cm oblique skin incision is performed over the pes anserinus on the ipsilateral knee; soft tissues are dissected down to the sartorial fascia, and the semitendinosus is palpated. The fascia is then incised, and the semitendinosus is identified, bluntly dissected, and then sharply released from its insertion on the proximal tibia. On an appropriate workstation, the graft is debrided of any residual muscular tissue.

Regardless of graft choice, its proximal part can be cut out depending on previous measurements and whipstitched on both ends with a high-strength suture (two no. 2 FiberWire; Arthrex) so it can be used as a graft for SCR.

The residual proximal end of the graft is then whipstitched by using 2 different-colored, high-strength sutures (no. 2 FiberWire and no. 2 Tigerwire; Arthrex) with a Krackow configuration. Different colors will help to understand the graft orientation during the arthroscopic passage and fixation (Fig 8).

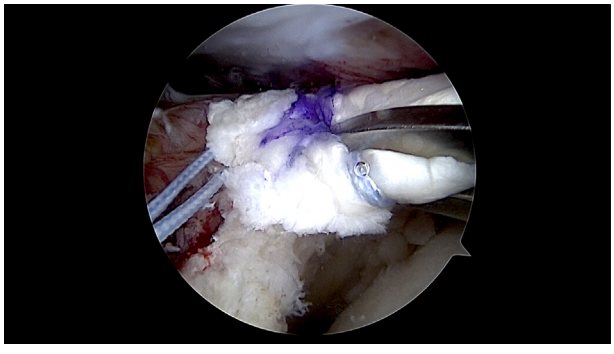

Fig 9. Right shoulder. Beach-chair position. Posterolateral view. The extra-articular tendon allograft is introduced from the lateral portal. The sutures can be retrieved from the posterior portal.

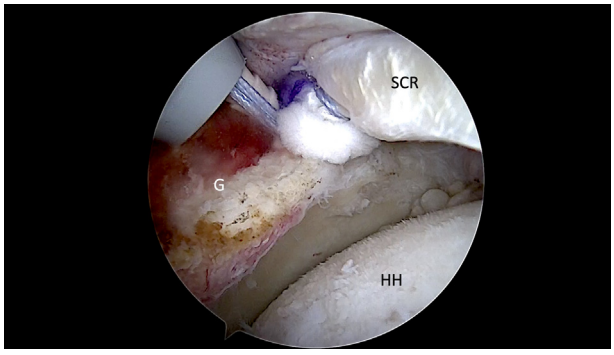

Fig 10. Right shoulder. Beach-chair position. Posterolateral view. A knotless PEEK (polyether ether ketone) anchor (2.9 mm Pushlock; Arthrex, Naples, FL) is used to fix the graft on the glenoid (G). HH, humeral head; SCR, graft used for the superior capsule reconstruction.

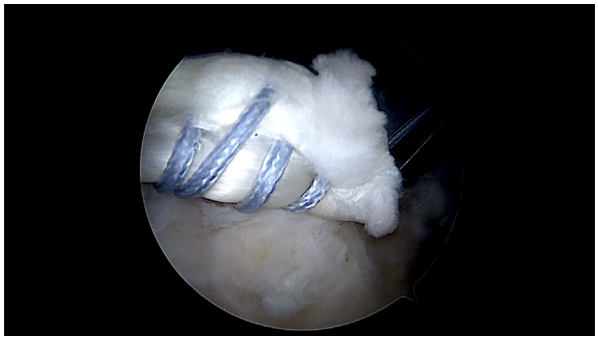

Fig 11. Right shoulder. Beach-chair position. Posterolateral view. Lateral fixation on the greater tuberosity is performed by implanting a knotless PEEK (polyether ether ketone) anchor (4.75 mm Swivelock; Arthrex, Naples, FL) through the superolateral portal.

Shoulder Arthroscopy: Second Step

The posterolateral portal is now used as viewing portal. If an extra-articular tendon graft has been chosen for SCR, the selected graft is now introduced from the lateral portal (Fig 9). The use of an operative cannula (8 mm or larger) is advised to avoid soft tissue interposition. Proximal sutures can be retrieved either way from an anterior or posterior portal, based on the best selected position for knotless anchor fixation. A knotless PEEK (polyether ether ketone) anchor (2.9 mm Pushlock; Arthrex) is used to fix the graft on the glenoid (Fig 10). Lateral fixation on the greater tuberosity can be performed by implanting a knotless PEEK anchor (4.75 mm Swivelock; Arthrex) through the lateral or the superolateral portal according to graft length (Fig 11). The SCR procedure is complete (Fig 12).

The camera can be now switched to the lateral portal. It is important to visualize a clear space between the residual posterior cuff and the posterior deltoid for the graft passage. A suture retriever can be introduced into the anterosuperior portal, advanced between residual posterior cuff and posterior deltoid up to the harvest incision for the LT (Fig 13). A small opening of the superficial infraspinatus fascia is performed to allow graft passage. A clamp from the medial side can be used to enlarge the opening of the fascia, if needed. Sutures of the proximal end of the graft are then retrieved from the anterosuperior portal.

Fig 13. Right shoulder. Beach-chair position. Posterior view. A standard suture retriever can be easily introduced into the anterosuperior portal and advanced between residual posterior cuff and posterior deltoid up to the harvest incision for the lower trapezius to retrieve the sutures of the tendon extension graft.

The graft is fixed right posterior to the bicipital groove, but slightly anterior to the SCR by using two 4.75 mm Swivelock anchors (one medial and one lateral; one for each Krackow suture) through the anterosuperior portal. To ensure a correct graft placement on the greater tuberosity and to avoid an overlap between the central portion of the SCR and the graft, thus reducing their potential combined effects, the graft is also fixed by using a third anchor on the posterolateral side of the greater tuberosity. A high-strength

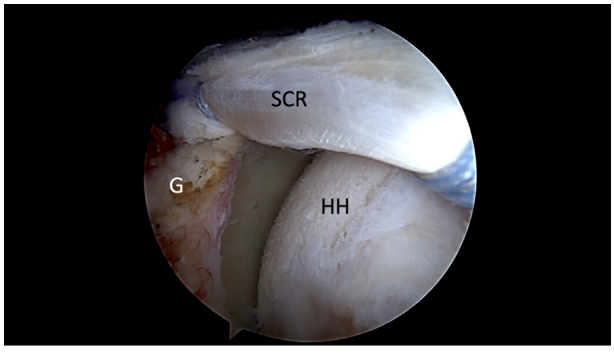

Fig 12. Right shoulder. Beach-chair position. Posterolateral view. Finale view of the SCR. G, glenoid; HH, humeral head; SCR, graft used for the superior capsule reconstruction.

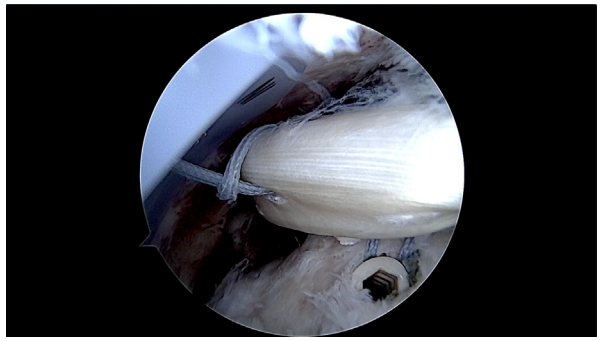

Fig 14. Right shoulder. Beach-chair position. Lateral view. A high-strength suture (No. 2 FiberWire, Naples, FL) is passed into the graft by using a direct suture passer through the posterolateral portal in a lasso-loop configuration.

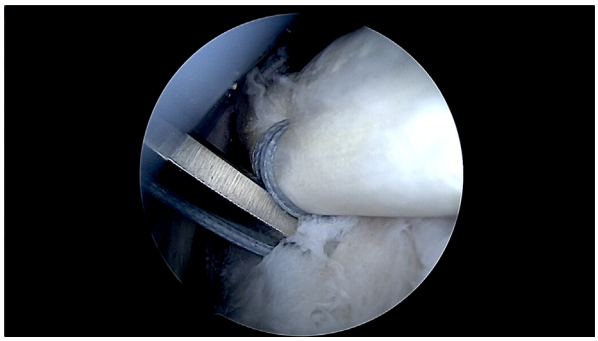

Fig 15. Right shoulder. Beach-chair position. Lateral view. The graft is also fixed by using a knotless anchor on the posterolateral side of the greater tuberosity.

suture (no. 2 FiberWire) is passed into the graft by using a direct suture passer through the posterolateral portal in a lasso-loop configuration (Fig 14). A third 4.75 mm Swivelock anchor is then placed (Fig 15). During intra-articular graft fixation, the extra-articular part of the graft should be kept in slight tension.

The arm is then positioned in slight abduction and maximum external rotation so the graft can be finally secured extra-articularly. The graft is passed through the harvested part of LT, overturned, and sutured on itself and to the LT with high-strength sutures (no. 2 FiberWire) (Fig 16). The technique is shown in Video 1.

Postoperative Management

The arm is placed in an external rotation sling for 6 weeks. The rehabilitation protocol starts 4 weeks after surgery according to the following phases:

Phase 1 (4-8 weeks after surgery): massotherapy and physical modalities for the management of pain, inflammation, and muscle contractures and passive ROM exercises

Phase 2 (9-12 weeks after surgery): active-assisted ROM exercises and closed–kinetic chain exercises to strengthen the residual rotator cuff, subscapularis, biceps, deltoid, pectoralis major, and scapular stabilizers

Phase 3 (13-16 weeks after surgery): active ROM exercises and open–kinetic chain exercises, proprioceptive and plyometric exercises, and postural rehabilitation of the kinetic chain (lumbo-pelvic, thoracolumbar, and scapulothoracic muscles)

Return to heavy manual work or sports activities is allowed 6 months after surgery.

Discussion

The rationale of combining SCR and LTT relies on the idea that SCR restores the coronal force couple while the LTT restores the sagittal force couple. This basic idea found its confirmation in a cadaveric study recently published by Omid et al.[20] The authors clarified that adding SCR to LDT adds static stabilization to a dynamic stabilizer. Therefore SCR plus LDT may provide additional stability.

Main advantage of the present procedure rests on the fact that it is a combination of two well-known and reliable surgeries; therefore a long learning curve is not necessary. Moreover, each step of the procedure has been simplified as much as possible to save intraoperative time (Table 1).

Starting with SCR, among the several modifications reported in the literature,[4] the use of the proximal part of the LHBT currently represents the easiest, fastest, and cheapest way to do it. However, even if an extra-articular graft is needed, only 2 points of fixation are enough for a stable procedure, thus extremely simplifying the original procedure.

On the other side, LTT was selected over LDT for 3 main reasons:

- Anatomy: the lower trapezius tendon attached mimics the vector of the infraspinatus tendon14
- Biomechanics: LTT better restores shoulder kinematics and glenohumeral force couples in the adducted position21
- Surgical technique: tendon harvest is easier with less risk of intraoperative complications or postoperative infections.

A recent retrospective study[9] on 90 patients showed that LTT is superior to LDT in terms of shoulder ROM, functional improvement, and progression of

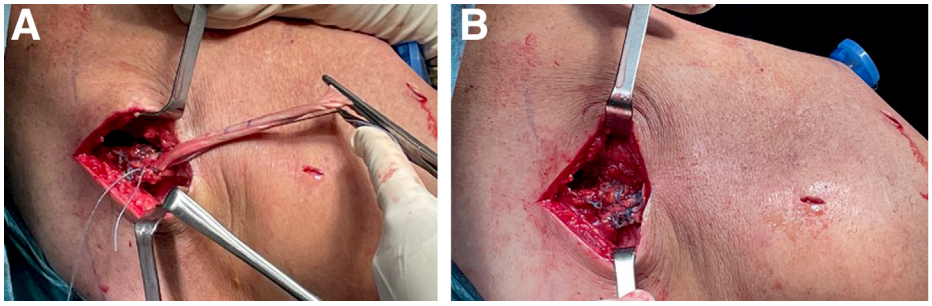

Fig 16. Right shoulder. Beach-chair position. Posterior view. (a) The graft is passed through the harvested part of the lower trapezius, overturned and sutured on itself and to the lower trapezius with high-strength sutures. (b) Finale result.

Table 1. Advantages and limitations

Advantages
SCR
Cost-effective
Several options
LHBT: only one point of fixation on GT
Extra-articular graft: one point of fixation on the glenoid and one point of fixation on the GT
LTT
Much easier to harvest compared to LDT
No neurological risks if you do not go medial to the medial border of the scapula
Excessive dissection is not needed (2-3 cm is enough)
LT mimics the vector of the infraspinatus tendon
Limitations
SCR
None
LTT
A graft extension is needed

GT, greater tuberosity; LDT, latissimus dorsi transfer; LHBT, long head of the biceps tendon; LT, lower trapezius; LTT, lower trapezius transfer; SCR, superior capsule reconstruction.

osteoarthritis. However, when LTT is performed, a graft extension is needed. The choice of a semitendinosus autograft clearly relies on the idea to reduce costs while maintaining successful outcomes. On the other hand, in the authors' experience, a better allograft option is the anterior tibialis or peroneus longus tendon rather than the Achilles tendon when SCR and LTT are combined. The main advantages of tibialis and peroneus longus tendon over other possible options are as follows:

- The graft is thicker than a semitendinosus, thus guaranteeing a strong construct.
- The graft is smaller than an Achilles tendon, which can somehow be too large and difficult to manage in the subacromial space when the SCR has already been done.
- The graft is round-like shaped, so it is easy to put a lasso-loop by simply using a direct suture passer to fix the graft posterolaterally on the greater tuberosity. On the contrary, the Achilles tendon is wider and larger and needs at least 2 anchors to be fixed posterolaterally,17 thus making the procedure longer, more challenging, and more expensive.

Arm position during extra-articular fixation of the extension graft deserves few comments. In 2016, Elhassan et al.[17] suggested maximal external rotation with 0° of abduction while reporting maximal external rotation with 60° to 90° of abduction later on in 2020.[14] On the other hand, Valenti et al.[18] suggested 60° of external rotation and 30° of abduction, Stoll et al.[22] suggested maximum external rotation and 90° of abduction, and Ek et al.[19] suggested 45° of abduction and 30° of external rotation. A recent review[21] on surgical techniques for LTT reported 45° abduction and 45° external rotation. The perfect answer may warrant further biomechanical and clinical studies, but it for sure does not exist yet. It is the authors' opinion that, because apparently there is no risk of overtensioning the graft,[17] maximum external rotation can ensure adequate tension to restore strength in external rotation, whereas degrees of abduction may have limited influence on the functional outcome. Because the arm is usually placed in an external rotation sling after the surgery, it is authors' preference to fix it in slight abduction (10° to 20°), mimicking the postoperative position.

Chiu et al.[23] recently proposed a technical note aiming to combine SCR and LTT. The authors suggested the use of LHBT for the SCR and a semitendinosus autograft as a graft extension for the LTT. From a technical standpoint, main differences compared to the present technique rely on the LTT:

- They perform an 8 cm horizontal skin incision to harvest the lower trapezius. However, the LT needs to be dissected only for 2 to 3 cm in length; hence, a wide skin incision would not be necessary.
- A humeral tunnel is needed to place the semitendinosus graft intra-articularly. The graft is then fixed by a suspension device. As stated by the authors, there is a risk of humeral fracture during tunnel preparation. The technique proposed in the present article is somehow easier because every shoulder surgeon is familiar with the use of multiple anchors on the greater tuberosity. Therefore a specific learning curve is not required; and at the same time, it can also be considered safer because there are no risks of fracture at all. Moreover, even from a biomechanical standpoint, 2 points of fixation on the lateral part of the greater tuberosity for the extension graft may allow a more effective external rotation movement, while helping the SCR to keep the humeral head recentered.

In a recent case report, McCormick et al.[24] also proposed the combination of SCR and LTT in a 49-year-old male affected by a massive rotator cuff re-tear. The authors used a dermal graft for SCR and an Achilles tendon allograft as a graft extension for the LTT. The use of a dermal graft is surely an effective option, but it increases costs and operative time.

In conclusion, the described surgical technique is a fast, cheap, and minimally invasive way to maximize treatment options for the treatment of irreparable posterosuperior rotator cuff tears.

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