Technical Note

Modified Arthroscopic Latissimus Dorsi Transfer at the Infraspinatus Footprint With Anterior Extracortical Fixation

Gonzalo de Cabo, M.D., David González-Martín, M.D., Ph.D., Alberto Martínez de Aragón, M.D., Juan A. Rubio, M.D., and Manuel Leyes, M.D., Ph.D.

Abstract: Massive irreparable cuff tears may represent as many as 20% to 40% of total cases of operated rotator cuff tears and can be a challenging clinical problem. Many treatment options have been proposed for their treatment. Among these options, latissimus dorsi tendon transfer can be considered a good alternative, especially in young patients before they develop glenohumeral arthritic changes. This technique aims at rebalancing the shoulder with a functioning subscapularis muscle and restoring both active external rotation and elevation with the aid of a properly functioning deltoid muscle. The modified arthroscopic latissimus dorsi transfer at the infraspinatus footprint with anterior extracortical fixation rebalances the pair of forces acting on the shoulder, stabilizing it in the transverse plane, minimizing the risk of latissimus dorsi transferred rupture and associated complications.

Introduction

Massive irreparable cuff tears may represent as many as 20% to 40% of total cases of operated rotator cuff tears (RCTs) and can be a challenging clinical problem.[1] A massive RCT is characterized as irreparable when the muscles have evolved to fatty degeneration or if perioperatively there is an inability to achieve a direct repair of the native tendons to the greater or lesser tuberosity.[2]

In addition, massive RCT may result in pseudoparalysis of the limb, with an inability to elevate the arm because of loss of restraint of the humeral head.[3] If left unrepaired, the high-riding humeral head and associated abnormal loading of the joint surfaces lead to arthritis of the shoulder joint, known as "rotator cuff arthropathy."[4]

Reverse total shoulder arthroplasty is an effective option for elderly patients with massive irreparable rotator cuff tears but may not be an optimal treatment in a younger patient population.[5] As an alternative, tendon-transfer procedures are a good option to restore function in younger and active patients.[6]

Tendon transfers have been used for decades to treat impaired shoulders in brachial plexus birth palsy.[7,8] In 1988, Gerber et al.[9] expanded the indications to irreparable posterior superior rotator cuff tears, and, since then, many authors described arthroscopic and open techniques.[4,8,10-13]

The modified arthroscopic latissimus dorsi (LD) transfer at the infraspinatus footprint with anterior extracortical fixation aims to rebalance the force pairs acting on the shoulder, stabilizing it in the transverse plane, minimizing the risk of LD transferred rupture and associated complications.

Surgical Technique (With Video Illustration)

Our surgical technique is demonstrated in Video 1. The indications and contraindications are shown in Table 1 and the pearls are summarized in Table 2.

From the Department of Orthopedic Surgery and Traumatology, Olympia, Quirón Salud, Madrid (G.d.C., D.G.-M., A.M.d.A., M.L.); Department of Orthopedic Surgery and Traumatology, Origen, Grupo Recoletas, Valladolid (D.G.-M.); and Hospital Puerta del Sur Móstoles, Madrid (J.A.R.), Spain.

The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received January 25, 2023; accepted March 20, 2023.

Address correspondence to David González-Martín, M.D., Ph.D., Department of Orthopedic Surgery and Traumatology, Origen, Grupo Recoletas, Valladolid, Spain. E-mail: drdavidglezmartin@gmail.com

2212-6287/23157

https://doi.org/10.1016/j.eats.2023.03.014

Table 1. Indications and Contraindications for Modified Arthroscopic Latissimus Dorsi Transfer at the Infraspinatus Footprint With Anterior Extracortical Fixation

Indications	Contraindications
• Massive irreparable posterosuperior rotator cuff tear with intact subscapularis tendon and function • Chronic tendon tear with retraction to level of glenoid • Combined loss of active forward flexion and external rotation with positive external rotation lag sign and horn-blower sign • Proximal migration of humeral head with acromiohumeral interval <7 mm • Stage 3 or 4 fatty infiltration of posterosuperior rotator cuff musculature • The best candidates for surgery are patients with active flexion to horizon and preserved passive flexion similar to contralateral side and with ability to hold arm up without assistance	• Tear of subscapularis with positive liftoff and/or belly-press test • Deltoid dysfunction • Glenohumeral arthritis • Stiffness with passive forward flexion <100º • Unable to hold arm up at maximal forward flexion • Active infection • Unable to cooperate with postoperative rehabilitation protocol • Parkinson disease • Brachial plexus injury

Patient Positioning and Preparation

The surgical procedure is performed with the patient under general and locoregional anesthesia (interscalene block). The patient is placed in the beach-chair position with the arm parallel to the body; no traction is used (Fig 1).

Step 1: Diagnostic Arthroscopy and Management of Concomitant Shoulder Pathologies

As we routinely do, we first perform an arthroscopic anterior shoulder approach.[14,15] We begin by placing lateral and anterolateral portals (D and E portals, according to Lafosse's nomenclature[16]). Quick arthroscopic assessment is performed of the irreparability of the RCT and confirmation of the LD transfer indication. A general arthroscopic examination is performed to assess additional pathologies of the labrum, cartilage, and long head of the biceps. Tenodesis or tenotomy (in a stiff shoulder) of the long head of the biceps might also be done.

Step 2: Glenohumeral and Subacromial Arthroscopic Preparation

After subacromial bursectomy and resection of the remaining rotator interval, we clean the entire rotator interval and expose the base of the coracoid, using a shaver, to avoid postoperative pain and stiffness (Fig 2). Preparation of the posterior workspace is mandatory. Infraspinatus fascia must be widely opened. If not, the muscle body may limit the course of the tendon when transferred from its anatomic insertion to the infraspinatus footprint.

Table 2. Pearls and Pitfalls of Using the Modified Arthroscopic Latissimus Dorsi Transfer at the Infraspinatus Footprint With Anterior Extracortical Fixation

• Tenodesis or tenotomy (in a stiff shoulder) of the LHB might also be done.
• Clean the entire rotator interval and expose the base of the coracoid to avoid postoperative pain and stiffness.
• Preparation of the posterior workspace is mandatory. The infraspinatus fascia must be opened wide. If not, the muscle body may limit the course of the tendon when transferred to the infraspinatus footprint.
• Dissection must be kept medial to the long head of triceps to avoid injury to the axillary nerve.
• Proper release is a must to prevent impingement of the transferred tendons and possible failure.
• Avoid any injury to the axillary nerve, and the radial nerve, the 3 sisters, and the musculocutaneous nerve.
• The bicipital groove (LHB) is a landmark in anterior dissection.
• During detachment of LD/TM insertions, it is highly recommended to take the tendon as long as possible.
• Dissection and detachment should be started from laterally to medially following the upper and lower borders. This allows detachment of the LD tendon, achieving the optimal length while preserving the insertion of the TM.
• Once the tendon of the LD is detached, it should be released from its adhesions to the surrounding structures: the TM posteriorly and the triceps inferiorly.
• The insertional part of the latissimus dorsi is removed and tubulated using 2 high-strength sutures.
• A mark is placed at 3-3.5 cm, which we will use as a reference when we bring the LD up to the insertion area of the infraspinatus, to know how much tendon we have introduced into the humeral head.
• We use a Foley catheter for the passage of the LD to the posterior region.
• The humeral tunnel should be blind, without breaking the anterior cortex of the humerus.
• Fixation of the transferred tendons at infraspinatus to prevent the killer turn effect.
• Bone quality may be not good, so take care of anchor failure.

LD, latissimus dorsi; LHB, long head of the biceps; TM, teres major.

Fig 1. The surgical procedure is performed with the patient under general and locoregional anesthesia (interscalene block). The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used.

Step 3: Endoscopic Anterior Preparation and Harvest of the LD

As described by Lafosse,[8] a challenging step is to create a working space large enough to enable the identification, preparation, and detachment of the tendon. The space between the deltoid and humeral head, subscapularis, lower third of the lesser tuberosity, and LD tendon is difficult to open. Anteroinferior, and, when necessary, inferior portals are used for the radiofrequency probe and the shaver. Progressive debridement is performed to expose the LD tendon. Medial to the pectoralis major insertion, the circumflex vessels ("3 sisters") are identified, marking the inferior border of the subscapularis tendon. Just underneath, the superior border of the LD tendon is visible. Care must be taken during the release to damage neither the axillary nerve, which passes just above the superior border of the LD tendon around the humerus, nor the radial nerve, as it passes obliquely over the inferior border of the LD tendon. Both nerves can be arthroscopically visualized if needed.

LD dissection and detachment should be started from laterally to medially following the upper and lower borders. This allows detachment of the LD tendon, achieving the optimal length while preserving the insertion of the teres major. Once the tendon of the LD is detached, it should be released from its adhesions to the surrounding structures: the teres major posteriorly and the triceps inferiorly (Fig 3)

Step 4: Foley Catheter Placement in the Posterior Area

We place a Foley catheter in the posterior area that we had previously prepared, after dissecting the infraspinatus fascia without injuring the axillary nerve. The Foley catheter is inflated and left for a later step. We will use it for the subsequent passage of the LD to the posterior region (Fig 4A-D).

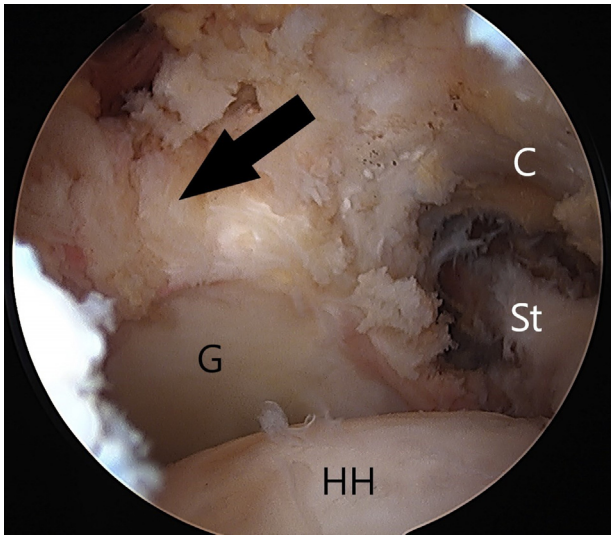

Fig 2. After subacromial bursectomy and resection of the remaining rotator interval using a shaver, we clean the entire rotator interval and expose the base of the coracoid to avoid postoperative pain and stiffness. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used. Black arrow: supraspinatus remnants (C, coracoid; G, glenoid; HH, humeral head; St, Subscapularis tendon.).

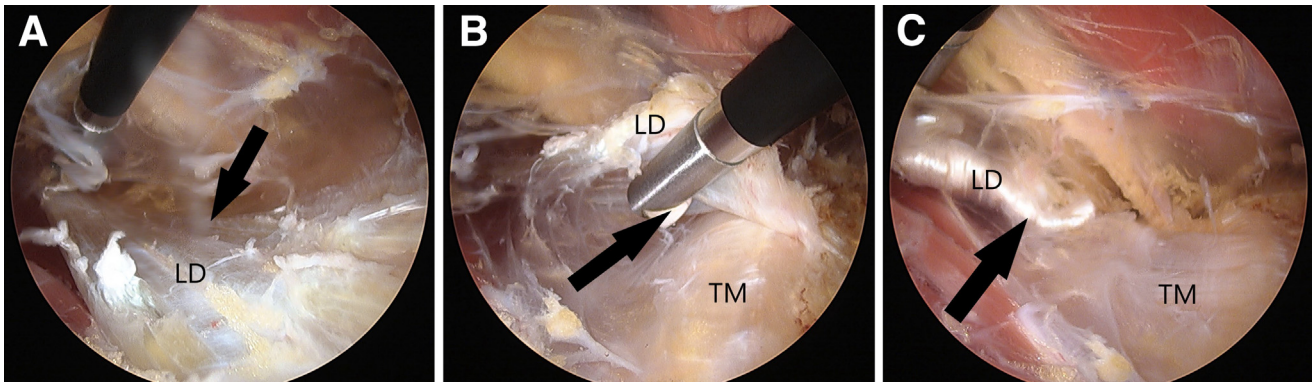

Fig 3. (A) Latissimus dorsi (LD) dissection and detachment should be started from laterally to medially following the upper and lower borders. (B) This allows detachment of the LD tendon, achieving the optimal length while preserving the insertion of the teres major (TM). (C) Once the tendon of the LD is detached, it should be released from its adhesions to the surrounding structures: the TM posteriorly and the triceps inferiorly. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used.

Step 5: Preparation of the LD Using the Posterior Mini-Open Approach

A 4- to 6-cm straight vertical incision is performed in the middle of the posterior and distal half of the axillary fold (Fig 5A) The subcutaneous tissue is divided until the "white tissue" of the LD is found and followed anteriorly to the LD border (Fig 5B). Then, dissection is continued superiorly until the previously arthroscopically released tendon is visible. If the tendon has been properly liberated during arthroscopy, it will "pop out" easily without the need for dissection at its humeral insertion (Fig 5C).

The insertional part of the LD is removed and tubulated using 2 high-strength sutures (Fig 6A). A mark is placed at 3 to 3.5 cm from the distal end of the tendon (Fig 6B), which we will use as a reference when we bring the LD up to the infraspinatus insertional area, to know how much tendon we have tunneled into the humeral head.

Step 6: LD Tendon Transfer

The triceps fascia is bluntly opened through the mini-open approach until the Foley catheter, which was previously left inflated, is palpated. It is deflated and pulled

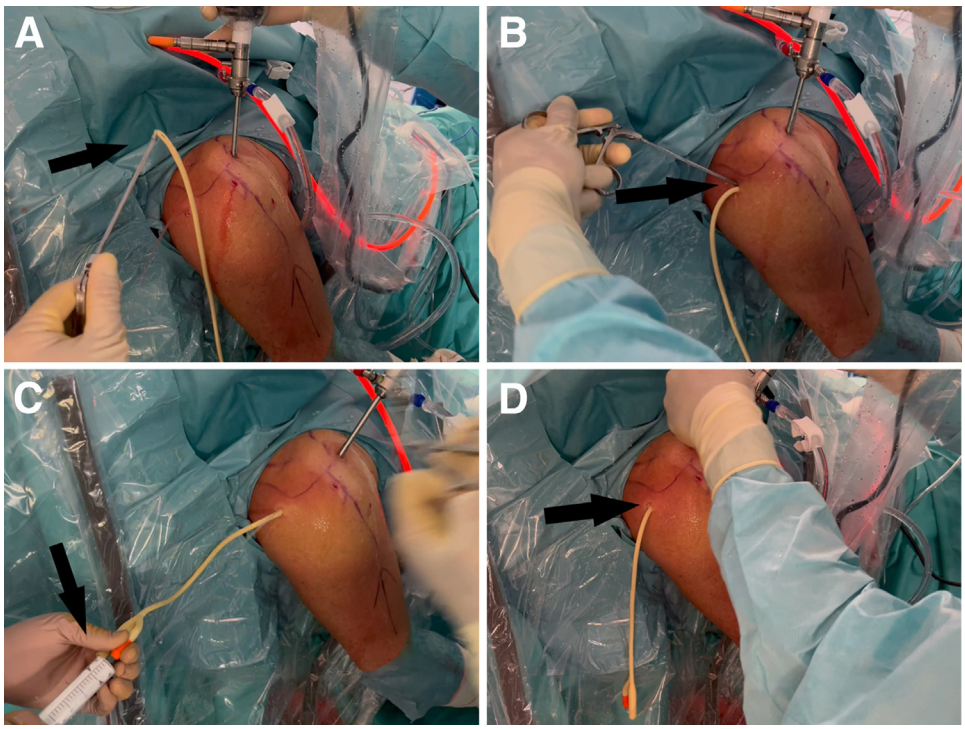

Fig 4. (A-B) We place a Foley catheter in the posterior area that we had previously prepared, after dissecting the infraspinatus fascia without injuring the axillary nerve. (C) The Foley catheter is inflated and left for a later step. (D) We will use it for the subsequent passage of the Latissimus dorsi to the posterior region. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used.

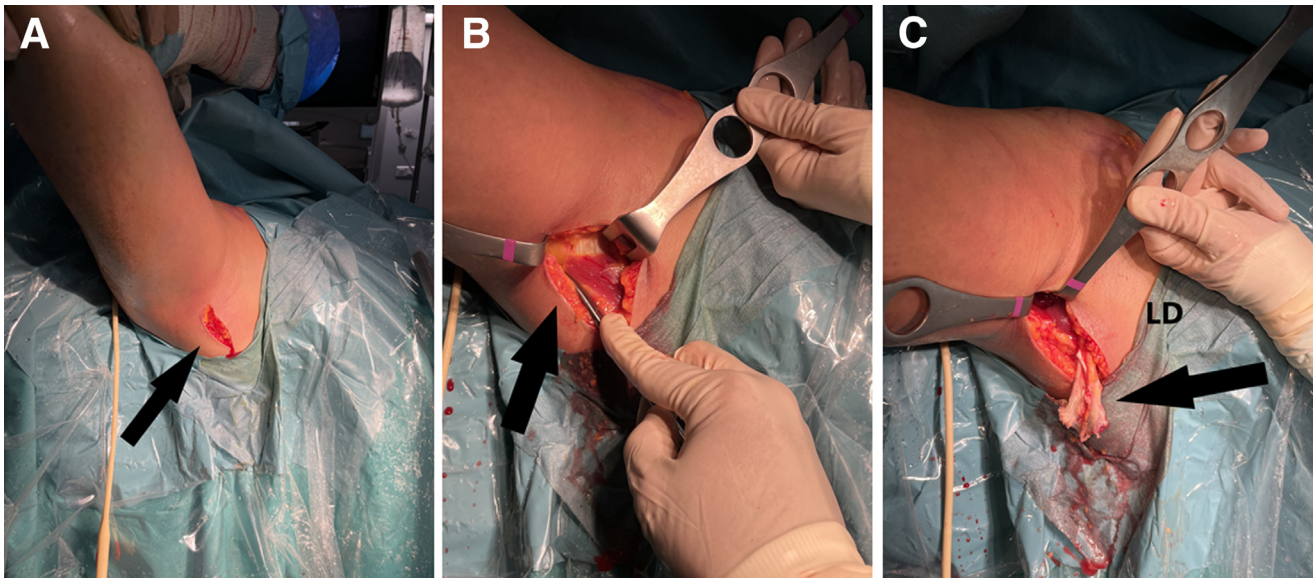

Fig 5. (A) A 4- to 6-cm straight vertical incision is performed in the middle of the posterior half and distally to the axillary fold. (B). The subcutaneous tissue is divided until the "white tissue" of the LD is found and followed anteriorly to the LD border. (C) Then, dissection is continued superiorly until the previously arthroscopically released tendon is visible. If the tendon has been properly liberated during arthroscopy, it will "pop out" easily without the need for dissection at its humeral insertion. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used. (LD, latissimus dorsi.)

out through the axillar mini-open approach (Fig 7A). The sutures are tied to the Foley catheter and pulled proximally between the triceps and deltoid (Fig 7B) (care must be taken not to injure the axillary nerve).

Step 7: Arthroscopic LD Tendon Fixation at Infraspinatus Footprint

Arthroscopic preparation of the infraspinatus footprint on the humeral head, "just in front of subscapularis" is performed (Fig 8A). Using anterior cruciate ligament reconstruction instruments (VersiTomic; Stryker, Kalamazoo, MI), we pass a Beath pin from posterior to anterior and then drill a 20- to 25-mm deep blind tunnel in the humerus with an 8-mm thick drill bit (Fig 8B).

The high-strength sutures prepared in the LD are passed through the Beath pin. Recovering them through the anterior cortex of the humerus. Using the ProCinch plate (ProCinch; Stryker), we pass the sutures through it and place it on the anterior cortex of the humerus. We then tie the knot (Fig 9 A and B).

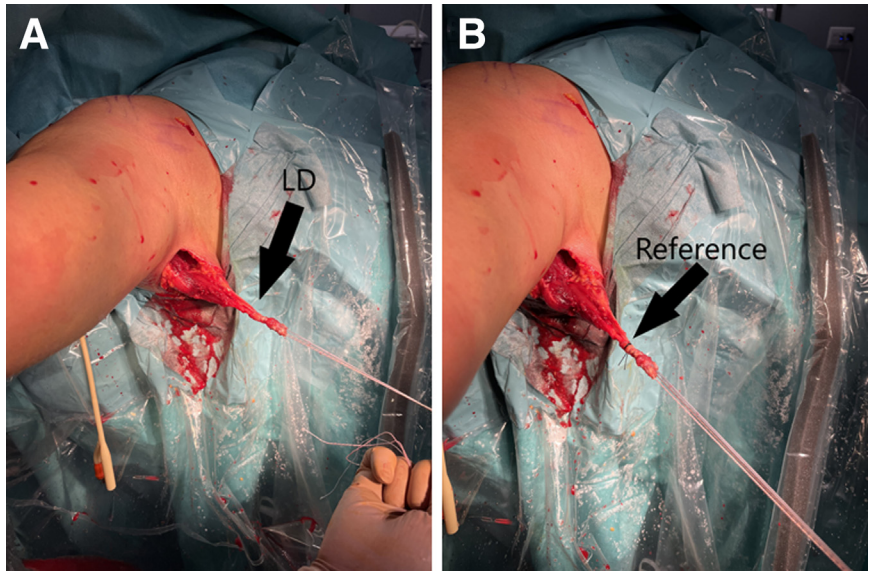

Fig 6. (A) The insertional part of the LD is removed and tubulated using 2 high-strength sutures. (B) A mark is placed at 3 to 3.5 cm with a No. 0 Sofsilk, which we will use as a reference when we bring the LD up to the infraspinatus insertional area, to know how much tendon we have tunneled into the humeral head. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used. (LD, Latissimus dorsi.)

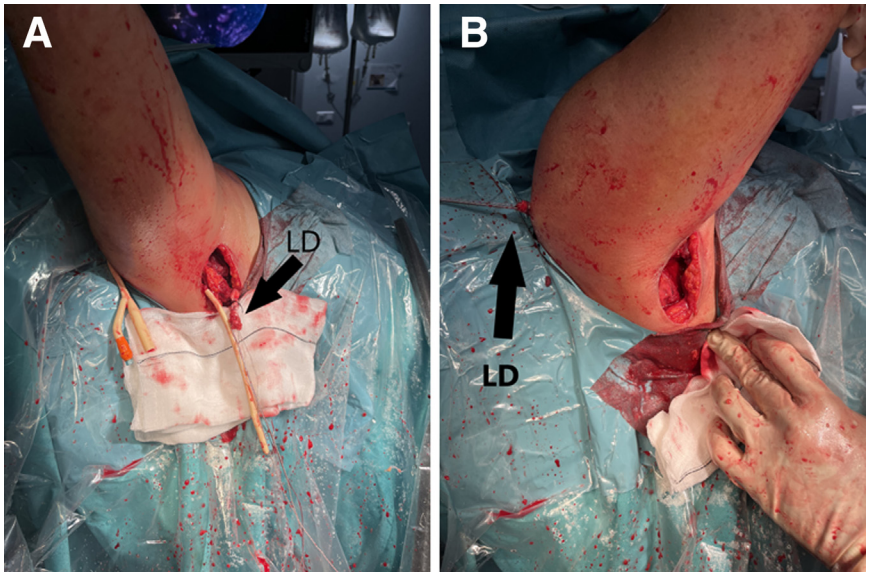

Fig 7. (A) The triceps fascia is bluntly opened through the mini-open approach until the Foley catheter, which was previously left swollen, is palpated. It is deflated and pulled out through the axillar mini-open approach. (B) The sutures are tied to the Foley catheter and pulled proximally between the triceps and deltoid (care must be taken not to injure the axillary nerve). The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used.

Step 8: Anteroposterior (Subscapularis-LD) Force Balancing

We use a double suture-loaded Iconix anchor (Stryker) on the anterior aspect of the humeral head and ascend the subscapularis tendon (Fig 10 A-C), leaving its insertion totally in front of the area where the LD (infraspinatus footprint) has been transferred. In this way, we manage to lower the humeral head, so that the deltoid is the one that raises the arm, compensating for the absence of the supraspinatus (Fig 11).

Postoperative Management

The patient must wear a sling for 2 weeks, which can be removed for eating and grooming. Two weeks after surgery, the rehabilitation is started. Passive and self-assisted exercises are started after 15 days, active exercises after 4 weeks, and, stretching and muscle strengthening after 3 months.[17]

Discussion

LD tendon transfer is a well-established method for the treatment of massive irreparable posterosuperior cuff tears in young patients without significant glenohumeral arthritis. However, initially reported results were variable, with inconstantly positive outcomes.[10] Gerber et al.[18] have published their long-term results of LD tendon transfer for treatment of posterosuperior RCTs and concluded that LD tendon transfer offers an efficient treatment with substantial improvement in shoulder function and pain relief.

Burkhart et al.'s biomechanical studies[19-21] have established the importance of maintaining the balance of force pairs acting on the shoulder, stabilizing it in the transverse plane. Correct shoulder biomechanics requires the existence of a resultant parity between the anterior (subscapularis) and posterior (infraspinatus and teres minor) force vectors. Applying this concept, with our modified technique we do not aim to

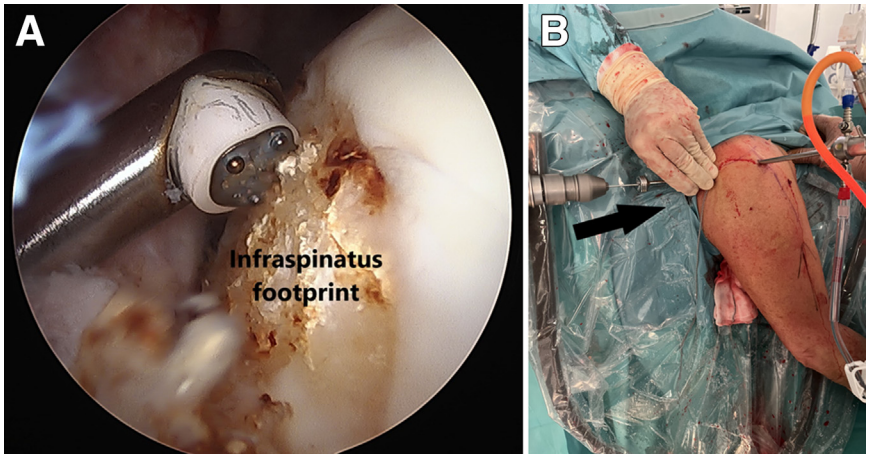

Fig 8. (A) Arthroscopic preparation of the infraspinatus footprint on the humeral head, "just in front of subscapularis" is performed. (B) Using anterior cruciate ligament reconstruction instruments (Versi-Tomic; Stryker, Kalamazoo, MI), we pass a Beath pin from posterior to anterior and then drill 20- to 25-mm deep with an 8-mm thick drill bit. The drill bit is used to create a blind tunnel. The humeral cortex is drilled to a thickness of 8 mm and a depth of 20 to 25 mm. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used.

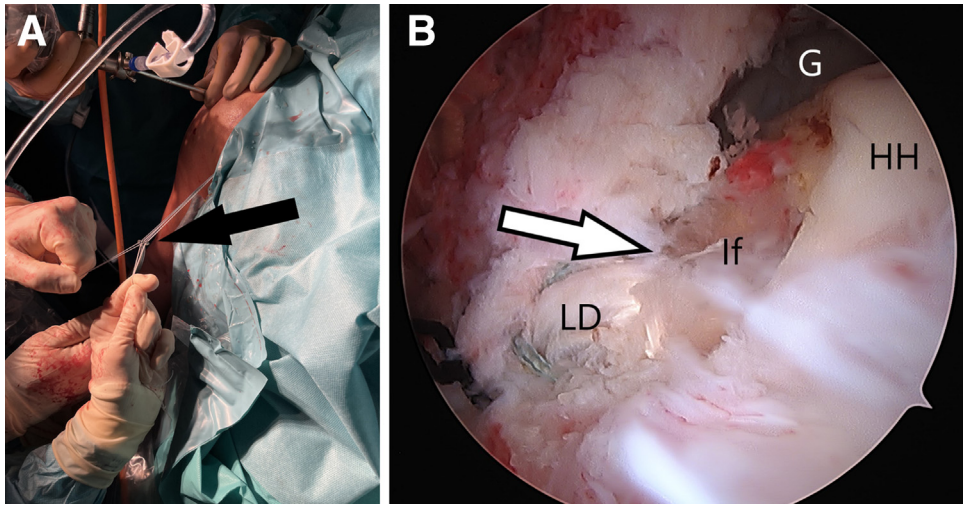

Fig 9. (A,B) The high-strength sutures prepared in the LD are passed through the beath pin. Recovering them through the anterior cortex of the humerus. Using the ProCinch plate (ProCinch; Stryker, Kalamazoo, MI), we pass the sutures through it and place it on the anterior cortex of the humerus. We then tie the knot. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used. (HH, humeral head; If, infraspinatus footprint; LD, latissimus dorsi.)

reconstruct the functionality of the supraspinatus but to rebalance the force pairs acting on the shoulder in the transverse plane. Therefore, we transfer the tubulized LD to the infraspinatus footprint and, when necessary, we repair the subscapularis tendon (Table 1).

Kany et al.[22] use a very similar technique to ours; however, there is a very important difference between the 2 techniques. They transfer the tubulized LD to the supraspinatus footprint (superior) instead of the infraspinatus footprint (posterior).

In another study published by Kany et al.,[22] they described the risk of LD tendon rupture after arthroscopic transfer for posterior superior rotator cuff tear. They explain that, in their opinion, 3 different types of rupture can be described. In particular, the second type of rupture is a rupture located at the interface between the bone tunnel and the tendon (type 2 rupture). At this level, the tendon makes a "killer turn," leading to the so-called guillotine effect.[22] This type of fixation could be responsible for an attrition and/or necrosis of the transferred tendon at the tunnel entrance. With this modified technique, we improve this factor. Because we are not looking to reconstruct the supraspinatus, but to balance the pair of forces, we do not bring the LD superiorly (supraspinatus footprint), but we place it posteriorly (infraspinatus footprint). In addition, we tubulate the insertion of the LD to promote the force vector and achieve greater tendon thickness.

Initially, we performed LD fixation to the humeral head using an interferential screw, although 1 patient suffered a humeral head fracture and we decided to switch to anterior extracortical fixation, which is much safer, as also described by Kany et al.[22] We have already performed more than 30 cases with anterior extracortical fixation without complications.

The main limitation of this technique is its high complexity. It is necessary to be an expert shoulder arthroscopist to be able to perform it reproducibly and safely.

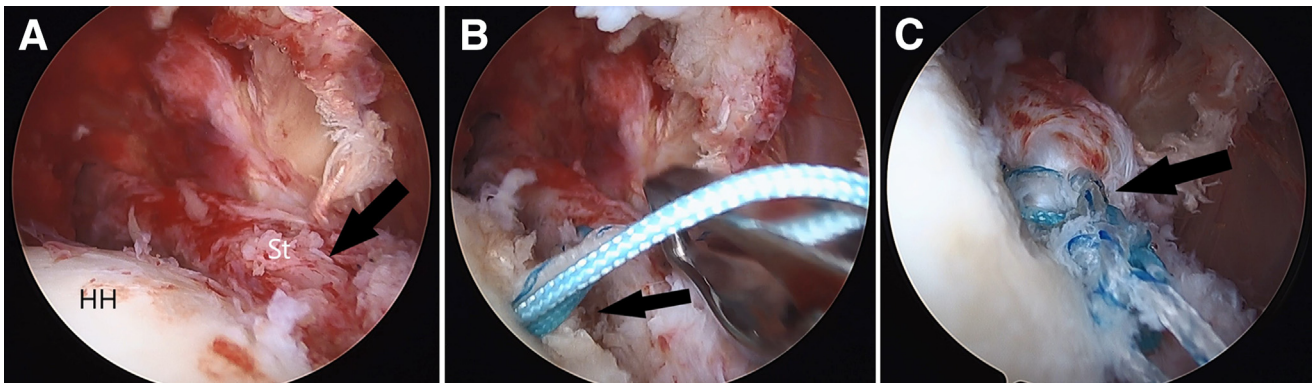

Fig 10. (A-C) With the aim of leaving the subscapularis insertion totally mirrored to the area where we have put in LD (infraspinatus footprint). We use a double suture-loaded Iconix anchor (Stryker, Kalamazoo, MI) on the anterior aspect of the humeral head and ascend the subscapularis tendon (ST). The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used. (HH, humeral head; LD, latissimus dorsi.)

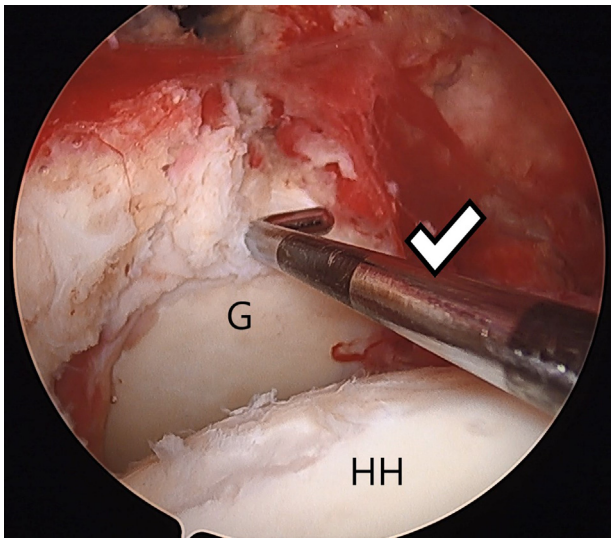

Fig 11. In this way, we manage to lower the humeral head, so that the deltoid is the one that raises the arm, compensating for the absence of the supraspinatus. The patient is placed in the beach-chair position with the arm parallel to the body. Right shoulder, no traction is used. (G, glenoid; HH, humeral head.)

The main advantage of this technique comes from rebalance the force pairs acting on the shoulder in the transverse plane. In contrast, with this modified technique we improve the "killer turn," which has been demonstrated as leading to the so-called guillotine effect.

In conclusion, we present a modified arthroscopic LD transfer at the infraspinatus footprint with anterior extracortical fixation. The aim is to balance the force pairs acting on the shoulder, stabilizing it in the transverse plane, minimizing the risk of LD transferred rupture and associated complications.

References

1. Kany J, Grimberg J, Amaravathi RS, Sekaran P, Scorpie D, Werthel JD. Arthroscopically-assisted latissimus dorsi transfer for irreparable rotator cuff insufficiency: Modes of failure and clinical correlation. *Arthroscopy* 2018;34:1139-1150.
2. Lädermann A, Denard PJ, Collin P. Massive rotator cuff tears: Definition and treatment. *Int Orthop* 2015;39:2403-2414.
3. Parsons IM, Apreleva M, Fu FH, Woo SL. The effect of rotator cuff tears on reaction forces at the glenohumeral joint. *J Orthop Res* 2002;20:439-446.
4. Cutbush K, Peter NA, Hirpara K. All-arthroscopic latissimus dorsi transfer. *Arthrosc Tech* 2016;5:e607-e613.
5. Mulieri P, Dunning P, Klein S, Pupello D, Frankle M. Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis. *J Bone Joint Surg Am* 2010;92:2544-2556.
6. Khair MM, Gulotta LV. Treatment of irreparable rotator cuff tears. *Curr Rev Musculoskelet Med* 2011;4:208-213.
7. Hoffer MM, Wickenden R, Roper B. Brachial plexus birth palsies. Results of tendon transfers to the rotator cuff. *J Bone Joint Surg Am* 1978;60:691-695.
8. Lopez-Fernandez V, Mariaux S, Lafosse L, Lafosse T. Technical guide and tips to posterior arthroscopic latissimus dorsi transfer for irreparable posterosuperior rotator cuff tears. *Arthrosc Tech* 2022;11:e755-e762.
9. Gerber C, Vinh TS, Hertel R, Hess CW. Latissimus dorsi transfer for the treatment of massive tears of the rotator cuff. A preliminary report. *Clin Orthop Relat Res* 1988;(232):51-61.
10. Kany J, Selim HA. Combined fully arthroscopic transfer of latissimus dorsi and teres major for treatment of irreparable posterosuperior rotator cuff tears. *Arthrosc Tech* 2019;9:e147-e157.
11. Pagani NR, Cusano A, Li X. Latissimus dorsi tendon transfer with acromial osteotomy for massive irreparable rotator cuff tear. *Arthrosc Tech* 2018;7:e105-e112.
12. Garcia JC Jr, Cordeiro EF, Raffaelli MP, et al. Robotic transfer of the latissimus dorsi. *Arthrosc Tech* 2020;9:e769-e773.
13. Jermolajevas V, Kordasiewicz B. Arthroscopically assisted latissimus dorsi tendon transfer in beach-chair position. *Arthrosc Tech* 2015;4:e359-e363.
14. De Cabo G, Rubio JA, González-Martín D, Martínez de Aragón A, Leyes M. Anterior shoulder ligamentoplasty as a treatment for multidirectional shoulder instability. *Arthrosc Tech* 2022;11:e2219-e2224.
15. de Cabo G, González-Martín D, Martínez de Aragón A, Rubio JA, Leyes M. Anterior shoulder instability treated through an anterior arthroscopic approach. *Arthrosc Tech* 2023;12:e387-e394.
16. Lafosse L, Lejeune E, Bouchard A, Kakuda C, Gobezie R, Kochhar T. The arthroscopic Latarjet procedure for the treatment of anterior shoulder instability. *Arthroscopy* 2007;23:1242.e1-1242.e12425.
17. Arauz S, González-Martín D, Quiroga M, Guillén P. Arthroscopic modified McLaughlin procedure and remplissage for treatment of simultaneous reverse Hill-Sachs and Hill-Sachs lesions. *Arthrosc Tech* 2022;11:e1473-e1478.
18. Gerber C, Rahm SA, Catanzaro S, Farshad M, Moor BK. Latissimus dorsi tendon transfer for treatment of irreparable posterosuperior rotator cuff tears: Long-term results at a minimum follow-up of ten years. *J Bone Joint Surg Am* 2013;95:1920-1926.
19. Burkhart SS, Esch JC, Jolson RC. The rotator crescent and rotator cable: An anatomic description of the shoulder's "suspension bridge. *Arthroscopy* 1993;9:611-616.
20. Burkhart SS, Wesley MN, Ogilvie-Harris DI, et al. Partial repair of irreparable rotator cuff tears. *Arthroscopy* 1994;10:363-370.
21. Burkhart SS. A stepwise approach to arthroscopic rotator cuff repair based on biomechanical principles. *Arthroscopy* 2000;16:82-90.
22. Kany J, Sekaran P, Grimberg J, et al. Risk of latissimus dorsi tendon rupture after arthroscopic transfer for posterior superior rotator cuff tear: A comparative analysis of 3 humeral head fixation techniques. *J Shoulder Elbow Surg* 2020;29:282-290.