Technical Note

Technical Guide and Tips to Anterior Arthroscopic Latissimus Dorsi Transfer for Irreparable Subscapularis Tears

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Abstract: In young patients, irreparable subscapularis tears can be managed by latissimus dorsi (LD) transfer on the lesser tuberosity. We provide a technical guide for isolated LD anterior transfer. The surgical procedure begins with glenohumeral exploration and release of the remaining subscapularis. Then, we dissect the LD tendon below the subscapularis. At the upper and inferior borders, we dissect the LD from the teres major, protecting the radial nerve anteriorly and inferiorly. Next, we detach the LD. Inferiorly, we cut the aponeurotic expansion for the triceps. A Foley catheter is used as a shuttle relay, anterior to the axillary nerve and medial and posterior to the radial nerve. We continue with an open dissection of the LD, posterior to the axillary fossa, to release the LD from the skin and tip of the scapula. The LD is transferred on the lesser tuberosity after retrieved by the Foley catheter, with care taken not to twist the tendon. It is fixed with 2 lateral anchors and 1 medial anchor. A shoulder brace is worn for 6 weeks. Physiotherapy begins thereafter.

Massive rotator cuff tears are 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 tendon to the greater or lesser tuberosity.[1] Tendon transfers to restore function around the shoulder have been used for decades to treat impaired shoulder mechanics after brachial plexus birth palsy.[2] The indications for tendon transfer in the shoulder were expanded to the treatment of irreparable posterior-superior rotator cuff tears by Gerber[3] in 1988.

The technique of latissimus dorsi (LD) tendon transfer for the treatment of anterior-superior rotator cuff deficiency was first described by Elhassan.[4] We have experience performing LD transfer using different techniques, ranging from open harvest and transfer to all arthroscopic. Through this experience, we have developed a specific technique, mixing arthroscopy, endoscopy, and open surgery built from the pearls and pitfalls of our experience. This article intends to summarize our tendon transfer technique using the LD to address anterior-superior rotator cuff deficiency. Technical tips will be outlined to provide a guide for surgeons to safely perform the procedure (Table 1).

Anatomy

The LD inserts below the lesser tuberosity, medial to the bicipital groove. It is close to two other internal rotators: the pectoralis major (PM) laterally and teres major (TM) medially and posteriorly. The axillary and radial nerves course nearby.

The posterior cord divides in the retro-coracoid area. The axillary nerve runs anterior to posterior and enters the quadrangular space under the inferior border of the subscapularis and then under the teres minor. The radial nerve has a direction parallel to the anterior face of the subscapularis and passes inferior and anterior in relation to the axillary nerve. It runs anterior to posterior through the humero-tricipital triangle just below the LD and TM tendons.

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The authors report 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 April 26, 2020; accepted July 18, 2020.

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2212-6287/20805

https://doi.org/10.1016/j.eats.2020.07.021

Table 1. Pearls and Pitfalls of Surgical Technique

Stage	Procedure	Pitfalls	Pearls
1	Exploration	Irreparable cuff tear	Degenerative muscle and/or fatty infiltration
			Retracted muscles
			No arthropathy
2	Anterior preparation	Working space posteriorly to PM and deltoid and/or anteriorly to SSC	Open RI and dissect widely
			Apply slight flexion and traction to arm
			Use lasso loop on LPB as retractor
		Dissection of remaining inferior SSC	Locate anterior circumflex artery
3	Nerve dissection	Axillary and radial nerves injury at stake during whole procedure	Identify posterior cord and axillary and radial nerves in retro-coracoid area after opening retro-coracoid bursa
		Axillary and radial nerve impingement with LD transfer	Axillary nerve: anterior SSC enters quadrangular space under SSC
			Radial nerve: anterior SSC, LD, and TM enter humero-tricipital triangle under LD and TM
4	Arthroscopic LD dissection	Exposure	Apply forward elevation and IR
			Use switching stick (avoiding radial nerve compression) for retraction on deltoid (portal I)
		Lateral dissection: detachment of LD too medial	Release upper third of PM
			Dissect upper and lower borders of LD
			Locate the LBP in its groove (lateral to the LD)
			Visualize humeral shaft
			Detach LD from laterally to medially, from proximal to distal
		Posterior dissection: risk of damage to TM tendon insertion	TM tendon insertion just posterior to LD
			TM tendon is shorter, wider, and thicker
			Muscular belly insertion
			Dissect as far medially as possible following anterior TM muscle
		Inferior dissection: radial nerve damage (motor branch to LHT)	Cut aponeurotic band between triceps and LD
		Shortening of LD transfer course	Don not take TM with LD
			Cut aponeurotic band between triceps and LD
			Cut the adhesions of the LD to the skin and the scapula to obtain a good course of the muscle
5	Anterior transfer	Impingement with radial or axillary nerve	Push Foley catheter toward axillary area following previous path of LD, along TM
6	Open LD dissection	Skin maceration in postoperative period and infection	Lower and tilt table, and place arm in abduction
			Make skin incision posterior and distal to axilla (lateral edge of scapula)
			Palpate switching stick to locate level of incision
			Load tendon with sutures
		Shortening of LD transfer course	Dissect LD from skin, TM, triceps, and tip of scapula
		Damage to LD pedicle	Pedicle enters LD anteriorly between 5 and 10 cm proximally to musculotendinous junction
			Close dissection not necessary
		Creation of torsion within tendon when passing sutures	Prepare tendon with running locking suture
			Use 2 different colors
			Attach only superior suture to Foley catheter
7	LD fixation	Poor LD healing tuberosity	Fix sutures with knotless anchors
			Use medial and lateral anchors to maintain tendon flat to bone
			Use biodegradable sub acromial spacer to maintain humeral head centered
			Perform biceps tenodesis to LD (posterior transfer)

IR, internal rotation; LD, latissimus dorsi; LHT, long head of triceps; LPB, long portion of biceps; PM, pectoralis major; RI, rotator interval; SSC, subscapularis; TM, teres major.

Surgical Technique

The procedure is performed using shoulder arthroscopy for site preparation, tendon harvest, and graft fixation; shoulder endoscopy for tendon release; and mini-open surgery for graft release from the subcutaneous layer of the skin, TM, lateral border, and inferior angle of the scapula (Video 1). The operation is performed with the patient under general anesthesia

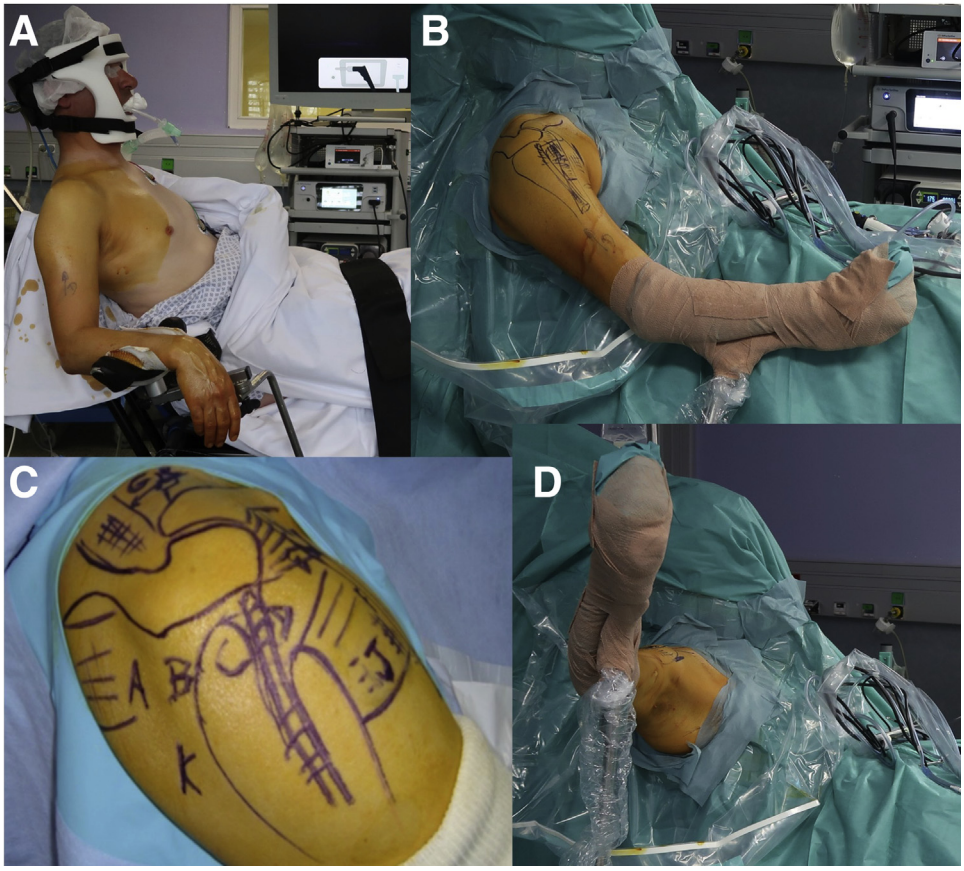

Fig 1. Patient position and endoscopic portals in right shoulder. (A) Beach-chair position. (B) Arm and entire hemithorax draped free. (C) Endoscopic portals. (D) Arm abduction for open latissimus dorsi dissection.

with an interscalene regional block. Complete muscle relaxation and low stable systemic blood pressure are provided by the anesthetic team.

The patient is placed in the beach-chair position with head support. The arm and the entire hemithorax are draped free.

The scope is standard with a 30° view. For coagulation, a VAPR VUE device (DePuy Synthes) is used; the nonabsorbable wire used is ORTHOCORD (DePuy Synthes). The suture anchors are 4.75-mm Healix Advance knotless (DePuy Synthes) for the lateral row and 2.3-mm Iconix (Stryker) for the medial row. The following endoscopic portals are used[5] (Fig 1): A, portal at the posterior soft point; C, lateral portal; D, portal under the anterolateral angle of the acromion and parallel to the upper border of the subscapularis, also used for lateral visualization during anterior dissection; E, anterior portal through the rotator interval; I, inferior and anterior portal, used for anterior visualization; and J, portal between portals I and D, used for lateral dissection and manipulation.

Stage 1: Arthroscopic Glenohumeral-Subacromial Evaluation and Preparation

The procedure is commenced with placement of the camera and immediate wide extra- and intra-articular assessment of the cuff tear, along with an evaluation of the quality of the cuff muscles (Fig 2, portal C). The rotator cuff is assessed. The perioperative indications to proceed with a transfer of the LD include irreparability of the tendons, degenerative aspect of the cuff muscles bellies, and absence of glenohumeral arthropathy.

Stages 2 and 3: Anterior Preparation and Nerves Dissection (With Visualization in Portal D and With Portals E and J as Working Portals)

At the beginning of the second stage, the most challenging parameter is to create a working space large enough to enable the identification, preparation, and detachment of the tendon (Figs 2 and 3). The space between the deltoid and humeral head, subscapularis, lower third of the lesser tuberosity, and LD tendon is difficult to open. The deltoid and PM should be released and left anteriorly while the operator can comfortably work on the humeral shaft and LD tendon.

A tip regarding this aspect of the procedure is that positioning the arm and dissecting widely enough will ensure the increase in the retro-pectoralis space. The arm is placed in flexion with manual traction applied by the assistant. The arthroscope is moved to the anterolateral (D) portal, and the instruments are switched to portals E and J. The rotator interval and

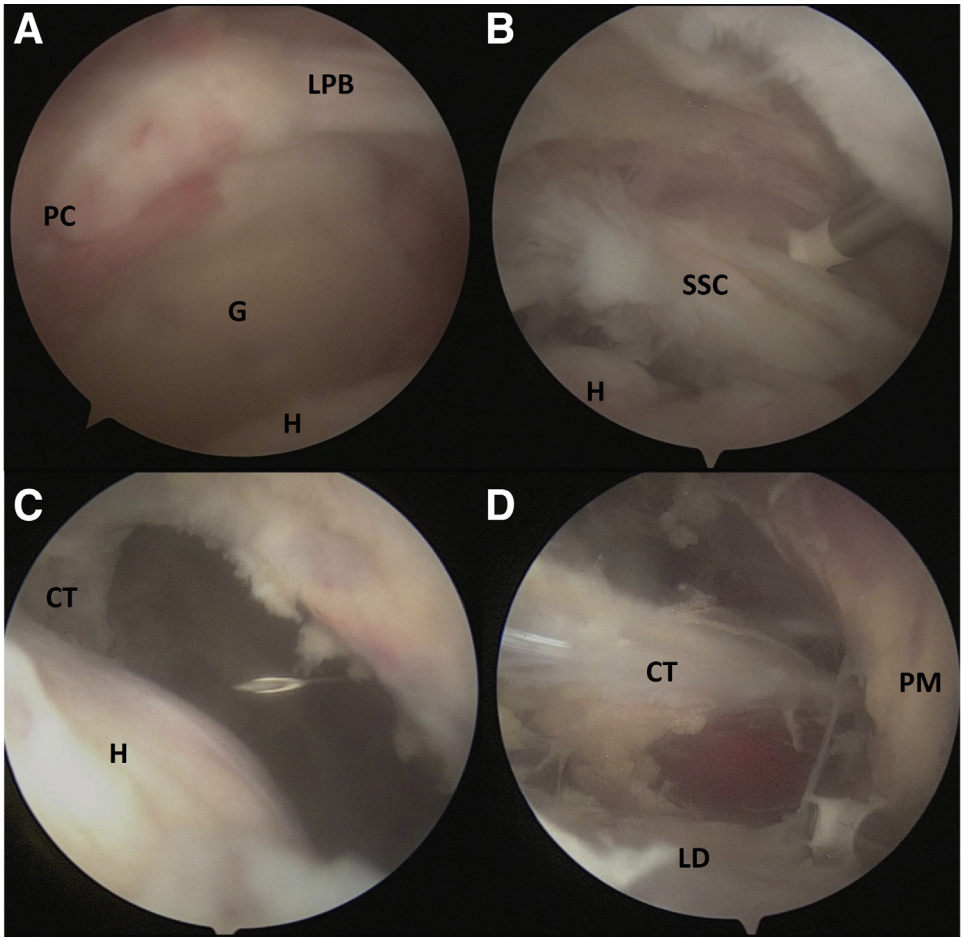

Fig 2. Exploration and anterior and inferior dissection (right shoulder with patient in beach-chair position; visualization from lateral portal in A and from anterolateral portal in B-D). (A) Exploration of irreparable massive cuff tear. (B) Anterior debridement of remaining subscapularis tendon (SSC). (C) Anterior and anterolateral portal for further dissection of latissimus dorsi. (D) Exposure of latissimus dorsi (LD): inferior dissection below subscapularis and posterior to pectoralis major (PM) and conjoint tendon (CT). (G, glenoid; H, humerus; LPB, long portion of biceps; PC, posterior cuff tear.)

clavipectoral fascia are debrided to provide sufficient visualization of the anterior border of the remaining subscapularis. The biceps is identified, and a stay suture with a suture lasso can be placed to aid in the identification of the tendon during dissection. The 3 sisters (anterior humeral circumflex artery and veins) are located to identify the lower border of the subscapularis and move the dissection forward to the lower third of the lesser tuberosity where the LD is attached (Fig 3 A and B). Working in the area anterior and inferior to the subscapularis puts the axillary and radial nerves at risk.

Stage 4: Arthroscopic LD Tendon Dissection (With Scope in Portal D, Instruments in Portal J, and Retractor in Portal I)

Lateral Release of LD: Exposure of PM Tendon and Long Portion of Biceps. The biceps tendon overlies the lateral margin of the insertion of LD insertion and may hide it (Figs 3 and 4). The operator may detach the LD at a too medial level, thereby shortening the tendon.

A tip regarding this aspect of the procedure is that forward elevation and internal rotation will decrease the tension on the deltoid and PM. The upper border of the PM tendon is identified. It attaches on the humeral shaft, laterally to the bicipital groove (Figs 2D and 4A). The biceps tendon and LD lie beneath. At this stage, to increase the space beneath the PM and anterior deltoid, a switching stick is introduced from an inferior and lateral portal (portal I) and directed medially under the conjoint tendon. Gentle retraction on the conjoint tendon is performed, avoiding compression of the radial nerve (Figs 3E, 3F, and 4A). Internal rotation of the arm will allow identification of the long portion of the biceps, which is immediately lateral to the LD insertion.

The LD is thus exposed inferiorly and medially, and endoscopic dissection of the space in front of the LD is continued to identify the position of the radial nerve crossing the muscle anteromedially. The upper third of the PM can be released if necessary.

Before the LD is detached, its upper and lower borders should be identified (Fig 3C-F). It then becomes possible to visualize the humeral shaft and the beginning of the LD tendon. Dissection and detachment should be started from laterally to medially following the upper and lower borders. This allows detachment of

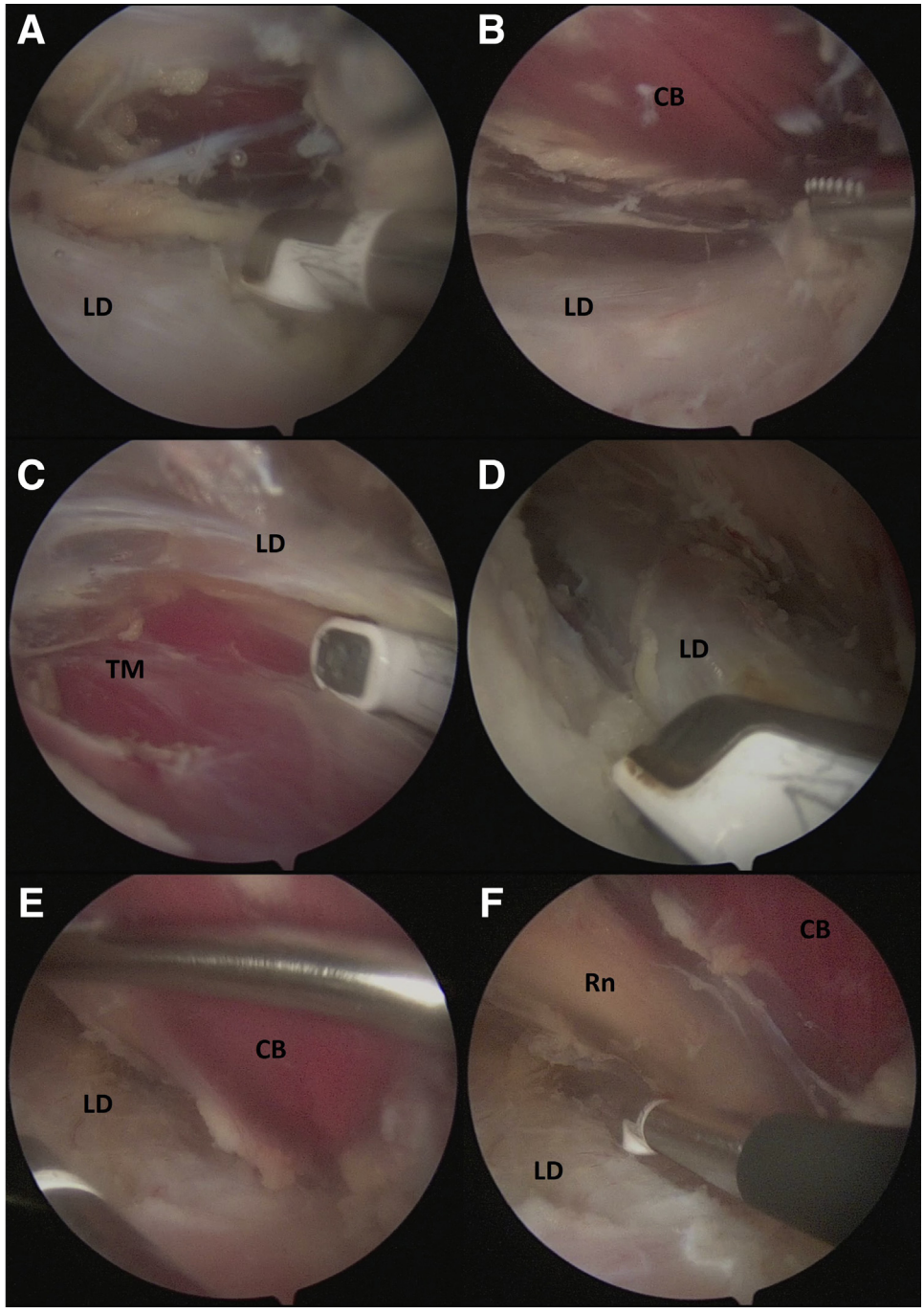

Fig 3. Latissimus dorsi (LD) dissection (right shoulder with patient in beach-chair position; visualization from anterolateral portal). (A) Anterior dissection of LD posterior to conjoint tendon. (B) Lower border of LD dissection. (C) Upper border of LD dissection and teres major (TM) dissection. The TM tendon is shorter, wider, and thicker. (D) Upper border of LD visualization. (E) LD exposure with switching stick. Care should be taken to protect the radial nerve. (F) Inferior border of LD and radial nerve (Rn) dissection. (CB, coraco-biceps muscle.)

the LD tendon, achieving the optimal length while preserving the insertion of the TM.

Posterior and Inferior Release of LD: Exposure TM Tendon and Triceps. 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 (Figs 3 and 4). The TM tendon should not be harvested with the LD in our experience, because its course is shorter, leading to less excursion on transfer and impingement with the axillary nerve.

The TM tendon is shorter, wider, and thicker, and its muscular belly is immediately seen beneath the LD tendon as it is elevated and released (Fig 3C). The plane of dissection must be pushed medially, inferiorly, and posteriorly following the anterior aspect of the TM, while the assistant pulls on the LD (Fig 4C-F), holding it with a smooth grasper. It is continued as far medially as possible with caution to maintain adequate vision and

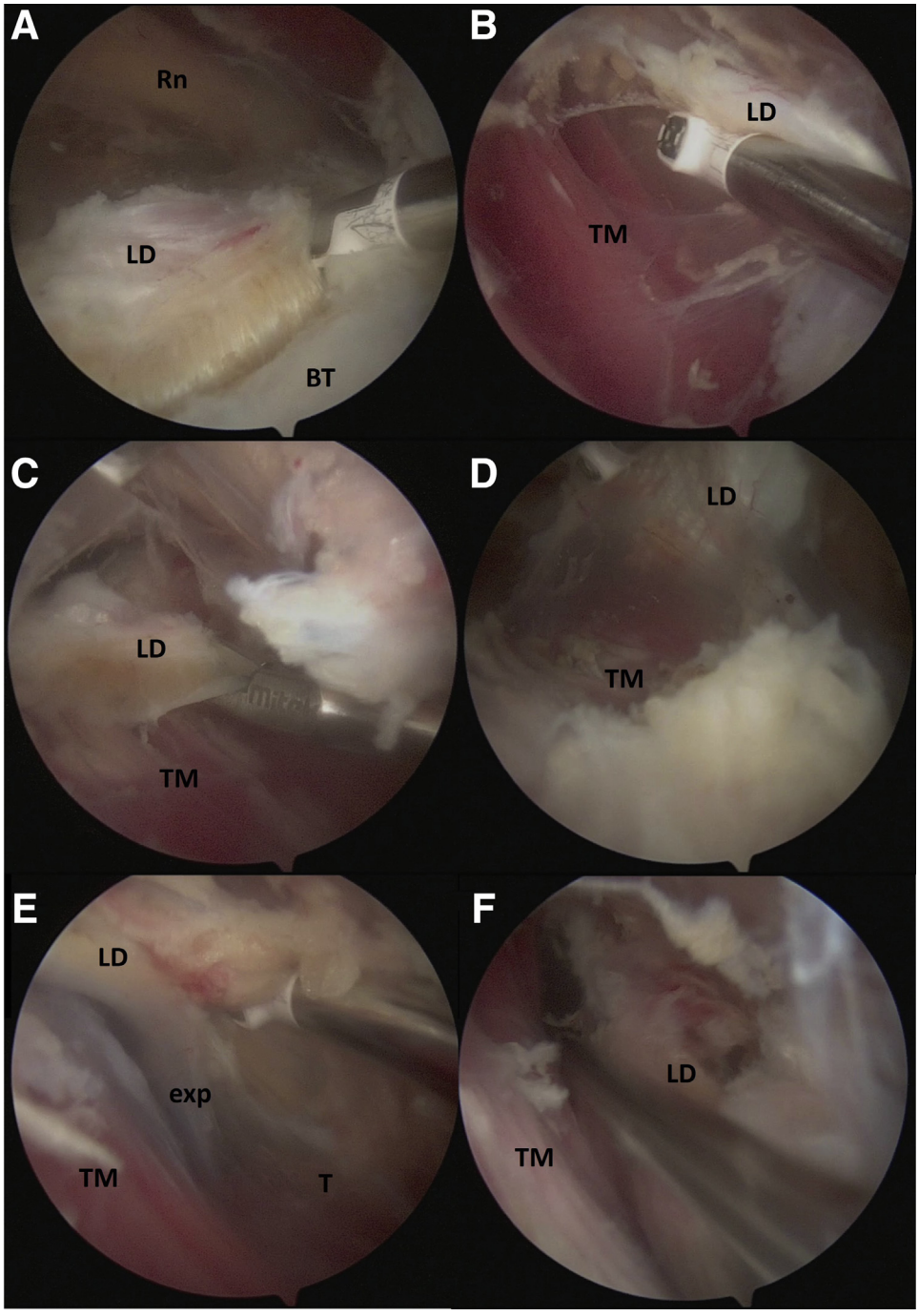

Fig 4. Latissimus dorsi (LD) detachment (right shoulder with patient in beach-chair position; visualization from anterolateral portal). (A) LD detachment from lateral to medial. (B) Teres major (TM) visualization to preserve its insertion. (C) Slight traction on LD tendon to continue posterior dissection after LD detachment. (D) Posterior LD dissection with TM still inserted. The aponeurotic expansion is visualized. (E) Inferior border detachment from aponeurotic expansion (exp) to triceps (T) to not shorten LD transfer course. (F) Medial dissection between TM and LD with switching stick pushed far medially and inferiorly to mark skin incision posterior to axillary fossa. (BT, biceps tendon; Rn, radial nerve.)

protection of the radial nerve (Fig 3F) and particularly the motor branch to the long head of the triceps, which lies immediately anterior to the LD.

A trick regarding this aspect of the procedure is that the retractor introduced previously from the inferior portal (portal I) elevating the deltoid and PM can be harmful to the nerve if too aggressively pressed upward against the nerve (Fig 3F). A tip is that the aponeurotic band between the triceps and the LD (Fig 4 D and F) must be cut or the course of the transferred tendon will be shortened. This aponeurotic band is taut between the inferior border of the LD and the triceps, which lies immediately behind and laterally.

Stage 5: Anterior Transfer

Once the dissection is complete, a Foley catheter with a suture loop is pushed toward the axillary area and used as a shuttle relay (Fig 5A), following the previous path of the LD, at the anterior aspect of the TM. This Foley catheter has 2 main advantages. First, it helps to

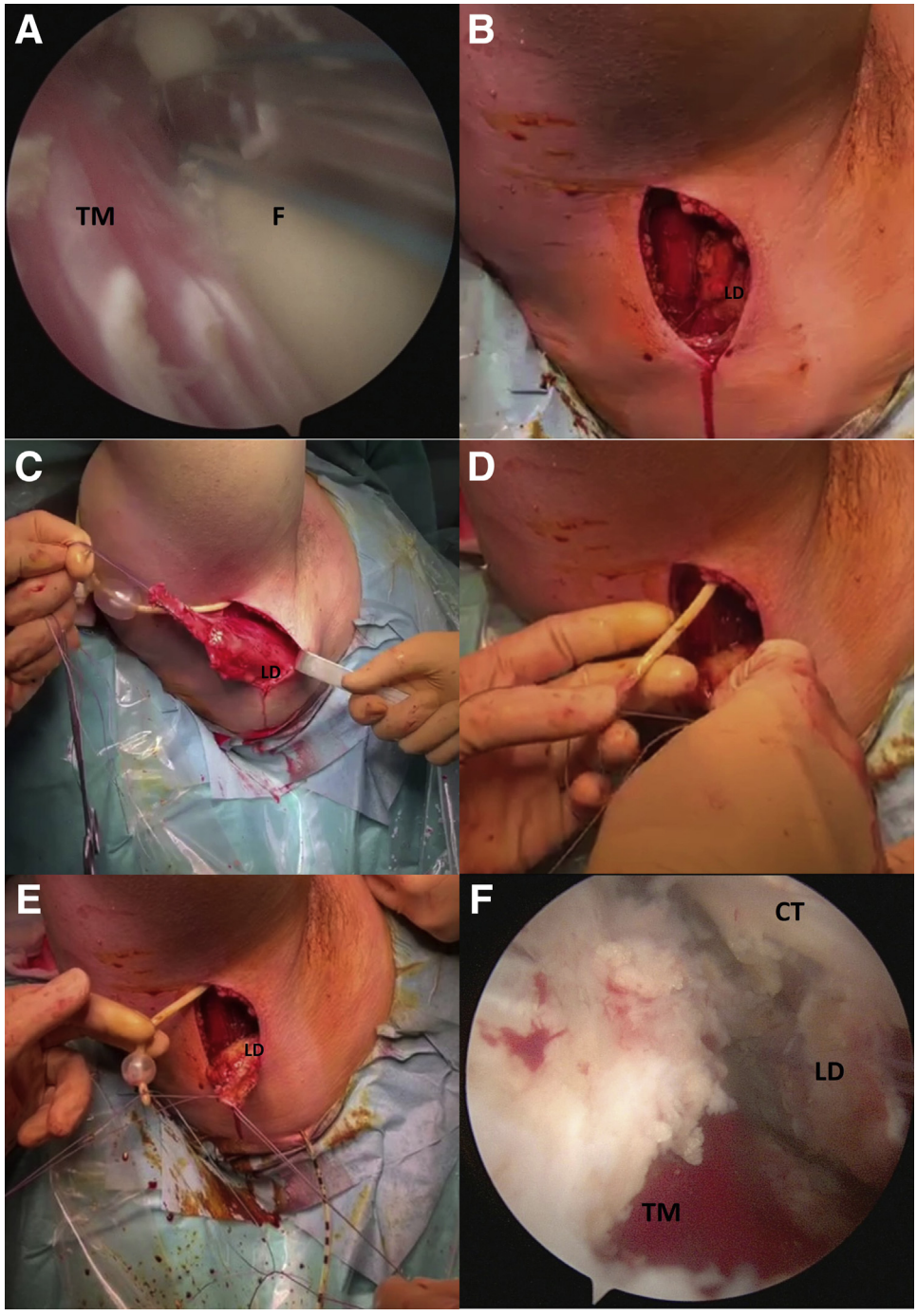

Fig 5. Open latissimus dorsi (LD) dissection (right shoulder with patient in beach-chair position; arm maintained in abduction). (A) Replacement of switching stick by shuttle relay anterior to teres major (TM) and below axillary nerve, posterior to radial nerve (anterolateral view). (B) Skin incision slightly posterior to prevent postoperative infection (open surgery). (C) Release of LD tendon from skin and tip of scapula, with verification of good excursion of transfer (open surgery). (D, E) Only the superior suture is attached to the shuttle relay to prevent tendon torsion; the inferior suture follows secondarily (open surgery). (F) The LD tendon is retrieved anterior to the TM and axillary nerve and posterior to the radial nerve and conjoint tendon (CT) (anterolateral view). (F, Foley catheter.)

identify the area in the axilla where the dissection should be continued and the tendon that has been detached. We commonly push the Foley catheter far inferiorly and palpate it through the skin below the axillary fold before incising the skin at the exact level where the catheter and tendon will be retrieved. This corresponds to the LD muscle location along which the catheter was pushed. The second advantage of using the Foley catheter is that it keeps the correct route in relation to the axillary and radial nerves when the tendon must be brought back to the anterior aspect of the shoulder after being released from its adhesion at the level of the mini-open incision of the axillary fold.

Stage 6: Mini-open Dissection of LD Off Skin and Scapula and LD Transfer Retrieval

The posterior, inferior, and axillary incision used to dissect the belly of the LD is located in a region at risk of

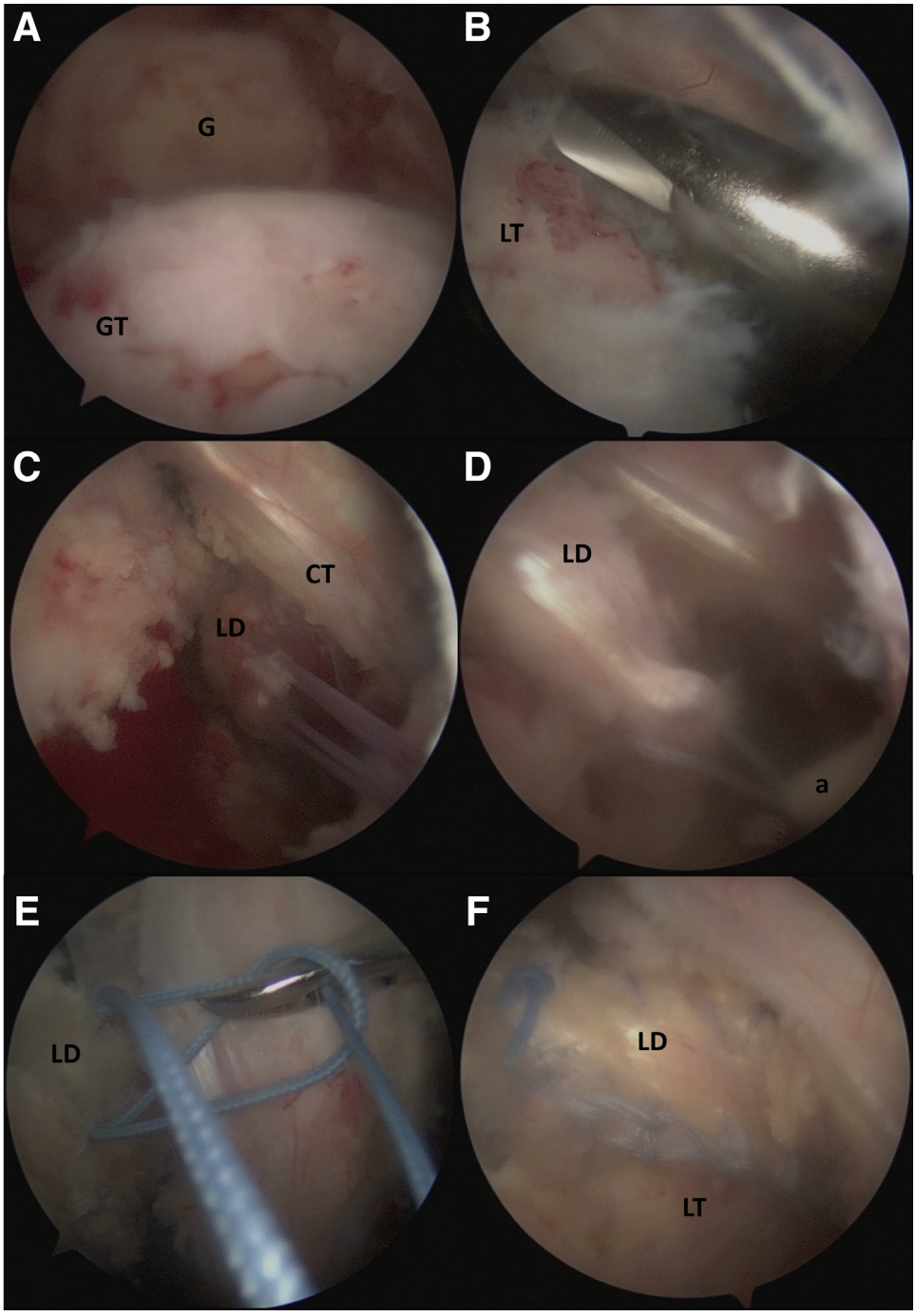

Fig 6. Latissimus dorsi (LD) attachment on lesser tuberosity (LT) (right shoulder with patient in beach-chair position; lateral view). (A) Scope in lateral portal for LD fixation. (B) Preparation of LT with burr. (C) The LD tendon is retrieved to the LT. (D) LD fixation with 2 knotless anchors (a) (lateral row) on superior and inferior sutures. (E) Lasso loop on medial anchor to create third point of fixation on LT. (F) LD transfer fixation on LT for irreparable subscapularis tear. (CT, conjoint tendon; G, glenoid; GT, greater tuberosity.)

maceration in the postoperative period and thus may lead to infection (Fig 5B-E). Moreover, sterility can be compromised while changing the positions of the arm and of the operative team as the operation site is moving into the axillary region.

The tendon must be loaded with strong suture at a fair distance. This process is more easily performed in an open fashion.

A tip regarding this aspect of the procedure is that the table is lowered and tilted toward the contralateral side, and the arm is elevated in full abduction. To prevent maceration, the skin incision is made posterior and distal to the axilla at the level of the lateral edge of the scapula (Fig 5B). Doing so helps to find the space between the LD and TM muscle bellies. Indeed, at this stage, no distal dissection of the tendon is required (because it was performed arthroscopically), and the goal of the mini-open procedure is to separate the muscle belly from the surrounding structures, including the TM muscle, scapula, and triceps, and release the

pedicle. At the level of the scapula, adhesions are released between the anterior and posterior borders of the TM and LD, respectively. The superficial and posterior face of the LD is also released from the skin distally. At the level of the tip of the scapula, the LD often holds fibers that must be detached from the bone.

A trick regarding this aspect of the procedure is that although the posterior and superficial border of the LD can be safely released, its anterior side must be managed with caution because it is where the pedicle enters the muscle. A tip is that the pedicle does not need a close dissection. We recommend to locate it and conserve the fat pad around it. To identify its location, we commonly use nerve stimulation. The anterior side of the LD is exposed by retracting the muscle belly posteriorly with smooth traction. The direction of the pedicle is toward the axillary fossa, and it penetrates the muscle between 5 and 10 cm proximally to the musculotendinous junction. Wide dissection of the pedicle is not mandatory to obtain sufficient muscle excursion.

The tendon is passed toward its aimed insertion site (Fig 5F). There is a risk of creating torsion within the tendon when passing the sutures.

A tip regarding this aspect of the procedure is that the tendon is prepared with a nonabsorbable braided suture in running locking fashion along both borders. Different colored sutures are used on each border to allow orientation of the tendon when the tendon is passed arthroscopically. To limit the risk of mistakes in distinguishing between the 2 loaded sutures, only one of them, the superior one, is attached to the Foley catheter and passed through the tendon's new path (Fig 5E). The second suture naturally follows and is retrieved secondarily through a separate portal.

Stage 7: LD Tendon Fixation and Postoperative Care

The tendon and sutures are fixed to bone with knotless anchors superiorly on the lesser tuberosity (Fig 6). A complementary medial or lateral anchor is placed to maintain the tendon flat to bone (Fig 6E).

The humerus is taken through the range of motion to assess the fixation and excursion of the transfer. After surgery, a shoulder brace is worn for 6 weeks. Physiotherapy begins thereafter.

Discussion

This study aims to describe our preferred surgical technique to transfer the LD tendon to the anterior-superior rotator cuff for the treatment of massive and irreparable rotator cuff tears. Many different techniques for LD tendon transfer have been described, including open surgery and arthroscopy-assisted, mini-open, and all-arthroscopic techniques.[6,7] Overall, LD transfer has good clinical outcomes in the treatment of massive and irreparable rotator cuff tears; however, proper patient selection is very important to achieve good results.[8] The function of the deltoid and posterior cuff muscles can affect the clinical results of this procedure.[9] Arthroscopic techniques have the advantage of allowing for less invasive surgery compared with open techniques, with a lower risk of damage to the deltoid muscle and infection.

The proximal part of the LD muscle is dissected and released with a mini-open technique in this procedure. On the basis of our experience, we believe this approach leads to better mobilization and enables a stronger suture preparation of the tendon compared with all-arthroscopic techniques. The release of the muscle belly increases its course; consequently, a longer transfer to the anterior-superior rotator cuff is possible.

Tendon transfers around the shoulder joint are technically demanding procedures that require improved arthroscopic skills with expert knowledge of the anatomy. There is always a risk of injury to the major anatomic structures such as the radial and axillary nerves or vascular structures during all phases of surgery. However, on the basis of our experience, we believe this procedure can be performed safely by respecting the meticulously described technique.

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