

All-Arthroscopic Latissimus Dorsi Transfer



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Abstract: Massive irreparable rotator cuff tears are often associated with severe functional impairment and disabling pain. One viable treatment option is a latissimus dorsi tendon transfer. We propose an all-arthroscopic technique that we believe avoids insult to the deltoid musculature while reducing morbidity from open harvest of the tendon. The operation is performed with the patient in the lateral decubitus position, by use of a combination of viewing and working portals in the axilla. The initial viewing portal is placed along the anterior belly of the latissimus muscle in the axilla. The latissimus and teres major are identified, as is the thoracodorsal neurovascular pedicle. The tendons are carefully separated, and the inferior and superior borders of the latissimus are whipstitched using a suture passer, which helps facilitate subsequent mobilization of the muscle. The interval deep to the deltoid and superficial to the teres minor is developed into a sub-deltoid tunnel for arthroscopic tendon transfer. The latissimus tendon is then transferred and stabilized arthroscopically to the supraspinatus footprint with suture anchors. Our preliminary data suggest that this surgical technique results in improvement in pain, range of motion, and function.

Massive rotator cuff tears pose a difficult problem for surgeons, especially in young high-demand patients in whom arthroplasty options are limited. A massive rotator cuff tear is defined as one that involves 2 or more cuff tendons and, according to Cofield,¹ is greater than 5 cm in diameter.² Typically, this means that both the supraspinatus and infraspinatus tendons are ruptured. Massive cuff tears 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 unchecked, 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.”

Our preference for the treatment of younger patients with massive irreparable cuff tears without arthroplasty

is a latissimus dorsi tendon transfer. To date, these transfers have relied on open incisions to harvest the latissimus tendon and either open incisions or arthroscopic techniques for its subsequent transfer and fixation to the humeral head.⁴⁻⁷ We describe an all-arthroscopic technique of mobilizing, whipstitching, and releasing the latissimus tendon, with subsequent transfer and attachment to the greater tuberosity (Tables 1 and 2).

Operative Technique

The operative technique is demonstrated in Video 1.

Positioning

The patient is positioned in the lateral decubitus position. A Spider 2 Limb Positioner (Smith & Nephew, London, England) is applied contralateral to the operative limb and placed in a vertical position, which allows for a full degree of movement of the operative shoulder. Draping of the arm is performed, with care taken to ensure access to both the shoulder and axilla. By applying the Spider 2 sterile shoulder connection bar (Smith & Nephew) to the radial border of the patient's forearm (Fig 1), rather than the usual ulnar border, a greater degree of internal rotation of the shoulder can be achieved, thereby improving access to the latissimus dorsi tendon insertion.⁸

Tendon Harvest

For the purpose of harvesting the latissimus tendon, the arm is placed in maximal abduction and internal

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Table 1. Risks

The radial nerve is at significant risk during mobilization and release of the latissimus dorsi tendon. Care must be taken to ensure the nerve is protected during this part of the procedure.
The axillary nerve is at risk when preparing the subdeltoid tunnel. The surgeon should take care to ensure that the switching sticks are running comfortably in the subdeltoid plane. Abduction and extension of the arm will take tension off the deltoid and help in protecting the nerve when passing the switching sticks.

rotation. The first portal placed, the N portal (Fig 2), is positioned on the anterior margin of the latissimus dorsi muscle, approximately 8 cm caudal to the tendon’s attachment to the humerus. The N portal serves primarily as a viewing portal (Fig 3). Anatomic studies have shown that the average length of the latissimus dorsi tendon to its humeral insertion is approximately 8 cm,⁸ and as such, this portal usually allows immediate visualization of the tendon in this subcutaneous position on placement of the 30° C-mount arthroscope (Stryker Orthopaedics, Kalamazoo, MI). It is worth noting that the latissimus dorsi tendon wraps around the underlying teres major muscle at this level; therefore, it is crucial to have the viewing portal on the anterior border of the muscle to allow visualization of the entirety of the tendon.

The next portal, the O portal, is positioned at the same axial level as the N portal but slightly posterior to the anterior axillary wall to avoid iatrogenic injury to the brachial plexus as it runs under the pectoralis major muscle within the anterior axillary wall.⁸ The third portal, the P portal, is positioned 2 to 3 cm more distal than the N portal along the posterior axillary wall. During tendon harvest, the N portal serves as the primary viewing portal. The O portal is used for whipstitching the superior border and the P portal is used for whipstitching the inferior border of the latissimus dorsi tendon.

Once the 3 portals have been established, the next step is to identify the axillary nerve (Figs 4 and 5), which lies approximately 1.4 cm (range, 0.8 to 2 cm) proximal to the humerus, passing obtusely above the superior border of the latissimus dorsi tendon and teres major muscle.⁸ Conversely, the radial nerve is identified coursing obliquely over the inferior border of the latissimus dorsi tendon at an average distance of 2.7 cm (range, 2 to 4 cm) medial to the anterior border of the humerus.⁸

The superior and inferior borders of the latissimus dorsi tendon are carefully dissected free, releasing any fibrous connections that may be present while protecting the radial and axillary nerves. In two-thirds of cases, separation of the latissimus dorsi tendon from the teres major is easy, whereas in one-third of cases, separation requires sharp dissection.⁸

A 70-mm, 8.6-mm-diameter Caps-Lock Ultra Cannula (ArthroCare [Smith & Nephew]) is placed into the O portal. By use of a Firstpass suture passer (ArthroCare [Smith & Nephew]), a No. 2 FiberWire suture (Arthrex, Naples, FL) is whipstitched along the superior margin of the latissimus dorsi tendon (Fig 6). Whipstitching of the tendon is achieved by using the Firstpass suturing device to place a stitch in the tendon; after this suture is withdrawn through the cannula, it can be reloaded into the Firstpass device, which is then reintroduced and used to place a further suture. Suturing is started near the tendon insertion, works retrograde to a distance of 3 to 4 cm from the humeral insertion, and then proceeds antegrade back toward the humeral attachment. A locked Krackow stitch can be reliably performed by taking care to loop the suture passer once around the in-use suture after the suture passer is placed through the cannula. The direction of the loop maneuver required to lock the stitch changes when the direction of suturing changes from antegrade to retrograde (Video 1).

This process is repeated through the P portal using a No. 2 Force Fiber suture (Tornier, Montbonnot-Saint-Martin, France) for the inferior border of the latissimus tendon. Using a different-colored suture for the 2 whipstitches facilitates surgical orientation later in the procedure. Placement of these sutures may be challenging on occasion. We have found that the use of an accessory portal for suture management, placed slightly distal to the midpoint between the N and P portals, aids this process.

Table 2. Pearls

The described procedure is technically demanding. It is wise to obtain consent from the patient for an open transfer if the arthroscopic procedure becomes too difficult to complete safely.
If a significant amount of bursal work is required, it may be wise to stage the procedure—first removing old anchors, performing releases, and decompressing the subacromial space and then returning, at a later date, to perform the transfer.
Switching sticks may be placed through accessory portals to hold open the tissue planes when performing the latissimus dissection. We identify these accessory portals using a heavy needle or guidewire to ensure that they are placed in an optimal position.
Given the extensive nature of the dissection, excellent visualization is key. Our anesthetist aims for a systolic blood pressure of 100 mm Hg, with careful fluid pressure management to ensure a bloodless field while minimizing swelling of the shoulder. We use cerebral oximetry (Invos; Medtronic, Minneapolis, MN) to monitor our patients’ cerebral perfusion during the procedure.
We use the Firstpass suturing device because it is auto-retrieving, speeding up the whipstitch in the latissimus tendon.
It is vital that all tendon suturing is performed through a well-placed arthroscopic cannula because soft-tissue bridges are particularly difficult to deal with safely when using this technique.
It is essential that the patients selected for this procedure have a functional subscapularis or have a subscapularis that is easily repairable. In the case of a repairable subscapularis, we would elect to repair and rehabilitate this tendon first, coming back to perform the latissimus transfer at a later date.

Fig 1. The sterile arm holder of the Spider 2 Limb Positioner is applied on the radial border of the forearm to provide a greater degree of internal rotation.



The latissimus dorsi tendon insertion in the floor of the bicipital groove is exposed with elevation of the biceps tendon using a switching stick (DePuy Mitek, Raynham, MA). Once visualized, the tendon insertion may be released with electrocautery using a VAPR Tripolar 90 Suction Electrode (DePuy Synthes, Raynham, MA) while preserving the humeral insertion of the teres major muscle.

After release of the latissimus dorsi tendon, attention is turned to mobilization of the muscle more caudally. At this stage, the thoracodorsal neurovascular pedicle is identified (Fig 7). This neurovascular bundle typically enters the anteromedial border of the latissimus dorsi muscle at an average distance of 13 cm (range, 11.0 to 15.3 cm) caudal from the humeral attachment of the tendon.⁸ It is imperative to protect the pedicle while mobilizing the latissimus dorsi muscle as the dissection extends caudally.

Dissection progresses over the subcutaneous aspect of the latissimus muscle until the posterior border is reached at the level of the scapular inferior pole. Once this point is reached, dissection is continued along the posterior border of the latissimus superiorly. This plane of dissection is continued until the posteroinferior border of the deltoid overlying the teres minor muscle is identified. The axillary nerve has already been identified immediately above the superior border of the latissimus dorsi tendon at an average of 1.4 cm lateral to the humerus and is well away from this plane of dissection. At this point, the deltoid muscle is separated

from the teres minor using electrocautery, thereby creating a subdeltoid tunnel for the transfer of the tendon. This tunnel is further established by elevating the deltoid using a switching stick and continuing the dissection toward the subacromial space, thereby creating an interval between the deltoid and the teres minor and infraspinatus. This dissection is aided by the placement of a further portal, the Q portal, which lies at the same axial level as the initial N portal at the posteroinferior border of the deltoid. The Q portal lies below the standard posterior viewing portal in shoulder arthroscopy (the A portal).



Fig 2. Position of the O, N, P, and Q portals in the axilla. The arm is abducted, and the head is to the left of the image.



Fig 3. Visualization of the latissimus tendon on first pass of the endoscope through the N portal. The patient's head is to the left of the image, and the surgeon is standing to the patient's back.

Tuberosity Preparation

The next step is to bring the arm into adduction and create a standard shoulder posterior viewing portal (A portal).⁹ A working portal is established in

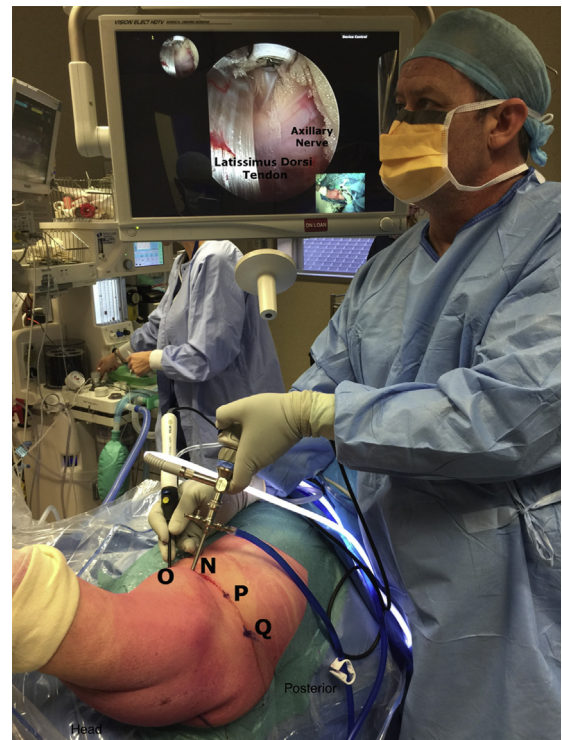


Fig 5. Dissection of the axillary nerve using the O working portal and the N viewing portal.

line with the posterior border of the clavicle (C portal),⁹ and a subacromial bursectomy is performed using a Dyonics Powermax Elite Resection system with a 5.5-mm Incisor blade (Smith & Nephew). The axillary nerve is identified through the C portal, and

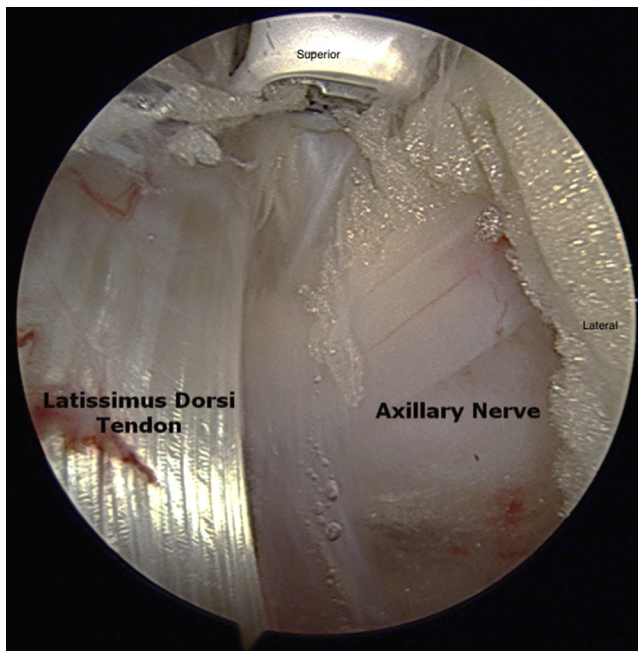


Fig 4. Axillary nerve as it traverses the superior border of the latissimus dorsi tendon.

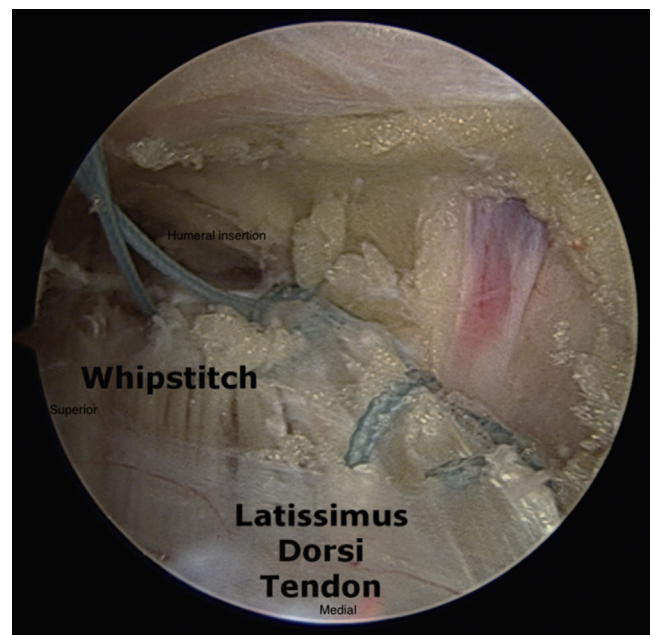


Fig 6. Arthroscopic whipstitching of the superior border of the latissimus dorsi tendon.

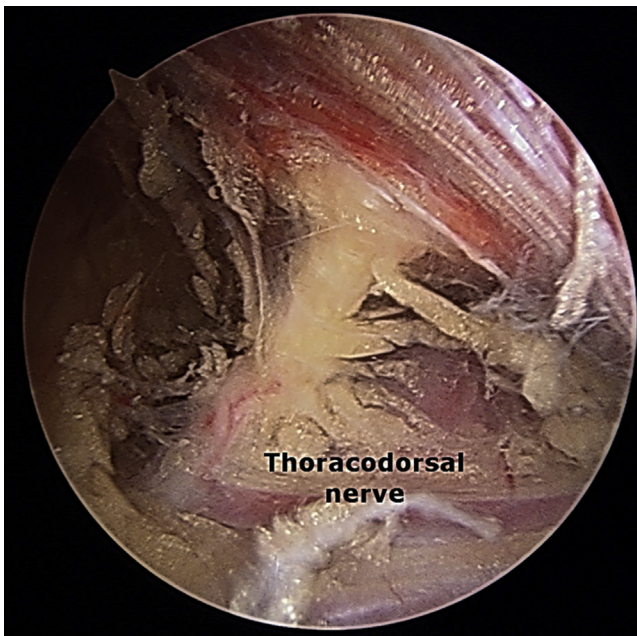


Fig 7. Thoracodorsal neurovascular pedicle viewed through the N portal.

on occasion, further dissection is required through an accessory posterolateral portal (B portal),⁹ thereby ensuring the axillary nerve is protected. On completion of this step, 2 cannulated switching sticks are inserted through the anterior deltoid into the subacromial space. They should be placed so that they lie under the deltoid and exit under the posterior-inferior border of the deltoid over the teres minor muscle.

Tendon Transfer

The arthroscope is then placed in the Q portal, and the ends of the cannulated switching sticks are identified. A SutureLasso nitinol loop (Arthrex) is introduced through each cannulated switching stick and used to retrieve the whipstitches. The use of 2 cannulated switching sticks and different-colored sutures for the superior and inferior border helps to avoid inadvertent twisting of the tendon during transfer. [Figure 8](#) shows the tendon transferred under the deltoid.

Tendon Insertion

The arm is then adducted, and the arthroscope is placed in the posterolateral portal (B portal). Each whipstitch is secured to the greater tuberosity at the level of the insertion of the supraspinatus tendon, posterior to the insertion of the subscapularis tendon, using a 6.5-mm Healix Advance Knotless Anchor (DePuy Mitek), as shown in [Figure 9](#). The sutures are then cut, and the transferred tendon is examined to confirm it has full unencumbered excursion.

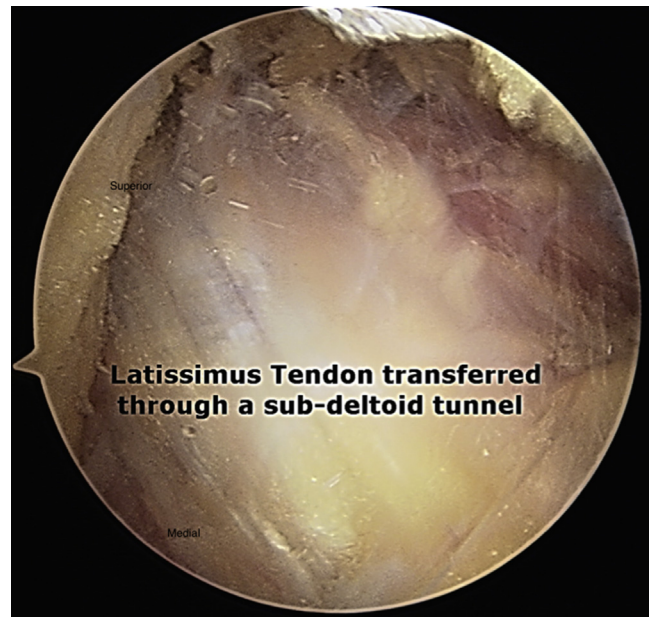


Fig 8. Transferred latissimus dorsi tendon through the sub-deltoid tunnel.

Postoperative Regimen

Postoperatively, the patient is placed in a DonJoy ER UltraSling (DJO, Vista, CA) for 6 weeks. Pendulum exercises are commenced on day 1 postoperatively. At 6 weeks, progressive range-of-motion exercises are started. From 12 weeks, therapy aimed at activating the latissimus dorsi muscle is commenced. Ultrasound is used to confirm that the transferred latissimus dorsi tendon transfer remains intact at 6 and 12 weeks.

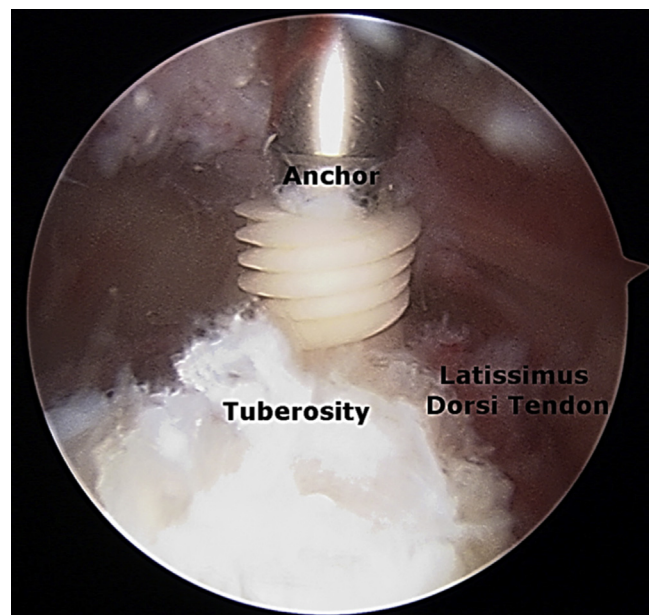


Fig 9. Secure fixation of the transferred tendon onto the prepared greater tuberosity.

Discussion

Massive irreparable rotator cuff tears present a difficult challenge to the clinician. Direct repair of the rotator cuff may not be possible if there is associated irreversible atrophy of the rotator cuff muscles and a significant tear size with substantial retraction of the tendon edge. Furthermore, functional outcomes of such repairs are often poor, with an associated high rerupture rate.¹⁰⁻¹²

The treatment of massive irreparable cuff tears is varied and includes conservative treatment, debridement with or without biceps tenotomy, partial cuff repair, patch augmentation, and superior capsular reconstruction.¹³ However, all of these techniques have limitations regarding restoring normal shoulder kinematics.

L'Episcopo¹⁴ first described transfer of the latissimus dorsi and teres major tendons for the treatment of brachial plexus injuries in children. Later, Gerber et al.^{15,16} described the transfer of the latissimus dorsi in the treatment of massive rotator cuff tears. Long-term follow-up of latissimus dorsi transfer has shown it to be an effective treatment for the restoration of shoulder function, with patient satisfaction of around 86%.^{17,18} It is worth noting that there is an association with poor results should the patient have significant fatty infiltration of the teres minor, subscapularis dysfunction, or a large critical shoulder angle.¹⁹

An anatomic study of latissimus dorsi tendon transfer has suggested that its principal function is in powering external rotation.²⁰ This study suggested that any improvement in abduction is due to a tenodesis effect, depressing the humeral head and allowing the deltoid to function as the principal abductor. Another study has shown, through electromyographic examination, that the transferred latissimus dorsi does work synergistically in shoulder abduction and therefore acts as a functional tendon transfer.²¹

Regardless of the actual mechanics of how the transfer works, the outcomes of latissimus dorsi tendon transfer for massive irreparable rotator cuff tears have been well established, and results are largely good in a properly selected patient population.^{6,16,22-24} Previous studies evaluating the clinical outcomes of latissimus transfer have found that both subscapularis and deltoid function can affect the clinical outcomes of the procedure. Gumina et al.²⁵ found that when treating massive rotator cuff tears, injury to the deltoid muscle may lead to inferior results. Biomechanically, the deltoid is unable to regain pre-existing strength after an open latissimus dorsi transfer procedure.²⁶ Preserving the deltoid through this arthroscopic technique may provide a better clinical outcome in patients while avoiding the rare but catastrophic complication of deltoid detachment.²⁷

Latissimus dorsi transfer is a technically demanding procedure. However, we believe this arthroscopic technique allows for less invasive surgery, possibly resulting in easier recovery for patients, reduced morbidity, and improved functional outcomes. Furthermore, recent biomechanical studies have suggested that arthroscopically assisted latissimus tendon transfer techniques offer better mechanical resistance to traction in comparison with conventional open techniques.²⁸ We believe our proposed all-arthroscopic technique offers a practical alternative to current existing techniques with clear benefits to patients because it preserves deltoid function and reduces morbidity over the harvesting site of the latissimus tendon.

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