SUBSPECIALTY PROCEDURES

NOVEL ARTHROSCOPIC TENDON TRANSFERS FOR POSTEROSUPERIOR ROTATOR CUFF TEARS LATISSIMUS DORSI AND LOWER TRAPEZIUS TRANSFERS

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Abstract

Background: Massive irreparable rotator cuff tears in both the primary and the revision setting are challenging problems. There remains controversy over the ideal treatment methods for these patients. In the case of an irreparable posterosuperior rotator cuff tear, tendon transfers¹⁻¹² have emerged as a reliable option, with a durable outcome. The most commonly used tendon transfer options are the latissimus dorsi (LD)¹⁻⁶ and the lower trapezius (LT)¹².

Description: The LD transfer is performed by first harvesting the LT tendon from the humeral shaft. It is critical to release the many adhesions to the muscle belly as well as to separate it from the teres major muscle. The tendon is then transferred intra-articularly, in an interval between the deltoid and the teres minor. The tendon is anchored arthroscopically after preparation of the anterolateral aspect of the tuberosity. The LT transfer is performed by harvesting the LT muscle and tendon off its insertion on the medial aspect of the scapular spine. It should be mobilized to maximize excursion by releasing adhesions. An Achilles tendon allograft is anchored into the anterior aspect of the greater tuberosity arthroscopically. The Achilles tendon is then secured to the LT tendon.

Alternatives: In addition to tendon transfer, options include:

- Partial or complete attempted repair¹³⁻¹⁷.
- Augmentation or bridging with allografts¹⁸⁻²³.
- Superior capsular reconstruction²⁴.
- Subacromial balloon²⁵.

Rationale: There remains a paucity of literature comparing tendon transfers with alternatives. However, when considering a tendon transfer, certain principles are critical in order to achieve an optimal outcome:

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- The recipient and transferred tendons must have similar musculotendinous excursion.
- The recipient and transferred tendons should have similar lines of pull.
- One tendon (the transferred) should be designed to replace 1 function (of the recipient).
- The function of the transferred tendon and muscle should be expendable without substantial donor site morbidity.
- The strength of the transferred muscle must be at least grade 4.

When deciding between the LT and LD transfer, certain considerations should be taken into account. The LD transfer has a proven history of successfully treating massive irreparable posterosuperior rotator cuff tears in studies with long-term follow-up¹⁻⁶. Alternatively, although the LT transfer has only recently gained popularity, it has the advantage of “in-phase” muscle function, since the trapezius naturally contracts during shoulder external rotation. Furthermore, its line of pull almost completely mimics the infraspinatus.

Introductory Statement

When performing the arthroscopically-assisted latissimus dorsi or lower trapezius transfer, it is critical to maximize the respective muscle excursion and anchor the tendon on the anterior aspect of the greater tuberosity with the arm in external rotation.

Indications & Contraindications

Indications

- Persistent pain and shoulder dysfunction with limitations in elevation and external rotation.
- Irreparable massive posterosuperior rotator cuff tear.
- For a primary procedure, the indications, as identified using preoperative magnetic resonance imaging (MRI)²⁶, include^{13,15,16,26-31}:
 - Goutallier grade of ≥ 3 for supraspinatus and ≥ 2 for infraspinatus.
 - Patte grade of ≥ 2 .
 - Combination of infraspinatus Goutallier grade of ≥ 2 and Patte grade of ≥ 2 is 96% specific for identifying irreparability of the tear²⁶.
 - Acromiohumeral interval (AHI) of < 7 mm.
- For a revision procedure, the indications include:
 - Previous failed rotator cuff repair.
 - Physiologically young patient (relative indication).

Contraindications

- Chronic subscapularis deficiency.
- Deltoid deficiency.
- Glenohumeral arthritis.
- Inability to comply with rigorous rehabilitation protocol.
- Physiologically advanced age (relative indication).

Step 1: Preoperative Evaluation and Planning

Take an accurate history, perform a detailed physical examination, and order appropriate imaging to confirm the best method of treatment for a massive posterosuperior rotator cuff tear.

- Take an accurate history to ascertain:
 - Whether the patient has undergone a previous rotator cuff repair.
 - The chronicity of the injury, and whether it was traumatic or atraumatic in origin.
 - Demographic factors, including age and body mass index.
 - Social factors, including tobacco use and occupational demands.
 - Comorbidities, including diabetes mellitus, renal failure, and poor nutritional status.
- Perform a physical examination that includes:
 - Assessment of preoperative shoulder motion: i.e., abduction, forward flexion, and external rotation.
 - Testing for external rotation lag signs, the drop arm test, and the hornblower test.
 - Subscapularis tests, including assessment of internal rotation strength, the belly press test, and the lift-off test.
 - Focused strength testing in abduction, as well as in external rotation with the arm at the side and with the shoulder in 90° of abduction.
 - Scapular examination, including testing the integrity and strength of the trapezius and serratus anterior muscles.
- Obtain shoulder radiographs and MRI for every patient with a massive rotator cuff tear. Computed tomography arthrography can be used for patients who are unable to undergo MRI.
 - Radiographs include:
 - Anteroposterior view to assess for glenohumeral arthritis (inferior osteophyte), humeral head elevation (AHI), critical shoulder angle, and “acetabularization” of the greater tuberosity.
 - Axillary view to assess for glenohumeral arthritis and humeral head subluxation.
 - Scapular Y view to evaluate humeral head subluxation.
 - MRI includes:
 - Coronal T1 and T2-weighted images to assess supraspinatus and infraspinatus tendon integrity, tendon length and retraction, and cartilage lesions.
 - Axial T1 and T2-weighted images to evaluate subscapularis, infraspinatus, and teres minor tendon integrity, biceps subluxation, and cartilage integrity.
 - Sagittal T1-weighted image to assess for fatty atrophy in the subscapularis, supraspinatus, infraspinatus, and teres minor muscle bellies.

- Negative prognostic factors that suggest that a primary rotator cuff repair will not be successful (Table I) include previously failed rotator cuff repair, a chronic tear, older age (>65 years old), tobacco use, poorly controlled diabetes, chronic steroid use, pseudoparalysis, marked weakness with lag signs, a hornblower sign, arthritis, an AHI of <7 mm, a critical shoulder angle of >35°, “acetabularization” of the greater tuberosity, tendon length of <15 mm, and grade-2+ fatty atrophy^{13,15,16,27-32}. Moreover, subscapularis insufficiency, as identified by anterior humeral head subluxation, and biceps subluxation can be negative prognostic factors.
- The decision to perform either the latissimus dorsi (LD) or the lower trapezius (LT) tendon transfer is currently based on surgeon preference given insufficient evidence of superiority of 1 technique with respect to the other. Theoretically, based on biomechanical study³³, a patient whose main functional deficit is external rotation, particularly with the arm at the side, would benefit more from an LT transfer than an LD transfer; conversely, a patient whose main deficit is external rotation with the arm at 90° of abduction would benefit more from an LD transfer. Another biomechanical study showed LT transfer to be superior to LD transfer at restoring native glenohumeral kinematics and joint reaction forces³⁴.

TABLE I Negative Prognostic Factors for Rotator Cuff Repair

Previous failed rotator cuff repair
Chronic tear (>6 mo)
Older age (>65 yr)
Tobacco use
Diabetes mellitus (poorly controlled)
Pseudoparalysis
Marked weakness with lag signs
Hornblower sign
AHI <7 mm
Critical shoulder angle >35°
Acetabularization of greater tuberosity
Tendon length <15 mm
Grade-2+ fatty atrophy
Subscapularis insufficiency (anterior humeral head subluxation ± biceps subluxation)
Arthritis

Step 2: Patient Setup (for Both LD and LT Transfer Procedures)

Perform the surgery with the patient in the beach-chair position.

- Position the patient in the standard beach-chair position, with adequate padding of the lower extremities, hip rests to secure the patient, and a padded head-holder.
- Position and drape the patient so that it is possible to obtain adequate exposure for either the LT (4 to 6 cm medial to the medial scapular border) or the LD (entire anterior aspect of the body exposed) (Fig. 1).
- It is helpful to mark the surface anatomy of the LD or LT prior to draping to ensure adequate exposure.
 - LD: The tendon and muscle belly can be palpated as part of the posterior fold of the axilla. The incision then follows the anterior edge of the muscle belly inferiorly.
 - LT: The muscle travels from its origin along the spine (inferiorly down to T12) up to its insertion 3 to 4 cm lateral to the medial spine of the scapula.
- Our preference is to use 2 Spider arm-holders (Tenet Medical) to help with the harvest and transfer. Without such a holder, the arm must be held in the appropriate position by an assistant during tendon harvest.
- Use the ipsilateral Spider arm-holder:
 - LT: for tendon harvest, arthroscopic-assisted transfer, and graft tensioning.
 - LD: for tendon harvest and arthroscopic-assisted transfer.
- Use the contralateral spider arm holder (Fig. 2) for the LD tendon harvest, as it keeps the arm in abduction and internal rotation during this step.

Fig. 1

Fig. 2

Fig. 1 The patient should be draped with adequate exposure possible for either the LT transfer procedure (4 to 6 cm medial to the medial scapular border) or the LD transfer procedure (entire anterior aspect of the body exposed).

Fig. 2 A contralateral Spider arm-holder is used during the harvest to keep the arm in abduction and internal rotation.

Step 3: Tendon Harvest (Videos 1 and 2)

Adequate mobilization of the muscle belly is critical for the LD harvest, whereas identifying the inferior edge of the muscle is the key to the LT harvest.

- To perform an LD harvest:
 - Use a curved incision from the axilla over the posterior border of the LD body.
 - Base the incision along the anterior border of the LD muscle, curving it anteriorly in the axilla to facilitate tendon harvest.
 - Use sharp dissection to create full-thickness flaps to expose the fascia overlying the LD and teres major. Proximally in the incision, the LD is the long tendon, compared with the short wide tendon of the teres major. When dissecting in the posterior axillary fold, the tendon visualized in this incision is usually the LD and the muscle belly belongs to the teres major, distinguishing these 2 muscles (Fig. 3).
 - It is critical to identify the anterior and posterior aspects of the LD tendon as well as to develop the interval between the LD tendon and the teres major muscle belly.
 - Anterior to the LD tendon in the axillary fold lie branches of the posterior cord, including the axillary nerve proximally and the radial nerve distally.
 - Develop the interval and trace the LD tendon up to its insertion on the humerus with sharp dissection. Long retractors are critical for visualizing up to the humeral insertion.
 - As dissection continues toward the humeral insertion, the anterior circumflex humeral artery lies superior to the LD insertion and should be protected.
 - Separate the LD tendon and teres major muscle completely, prior to releasing the LD tendon from its insertion on the humerus. In 30% of patients, the LD tendon is confluent with the teres major tendon at its insertion on the humerus³⁵.
 - Sharply release the LD tendon from its insertion on the humerus.
 - Then prepare the LD tendon with nonabsorbable sutures for the transfer (Fig. 4). Place 2 number-2 nonabsorbable sutures along the superior and inferior edges of the tendon. Then start a long, nonabsorbable suture tape at the musculotendinous junction and weave it down each side of the tendon over the sutures.

Fig. 3

Fig. 4

Fig. 3 Posterior view of the shoulder. The axillary nerve travels through the quadrangular space between the teres major and teres minor before innervating the deltoid. The LD is just inferior to the teres major before joining tendons. (Published with permission of the Boston Shoulder Institute.)

Fig. 4 LD preparation. Two number-2 nonabsorbable sutures are placed along the superior and inferior edges of the tendon. Then, a nonabsorbable suture tape is woven from the musculotendinous junction down each side.

Video 1 LD transfer.

Video 2 LT transfer.

- Dissect the LD muscle belly out from proximal to distal. In-line traction of the LD enables easier dissection into the body of the LD muscle for adequate mobilization.
- Identify the neurovascular pedicle as it enters the LD muscle approximately 5 cm medial to the deep aspect of the musculotendinous border (Fig. 4). It is important to visualize and define the pedicle, while releasing the deep LD adhesions to the chest wall.
- To enable adequate mobilization, release the LD muscle from all of its surrounding adhesions, including adhesions to the chest wall (deep), teres major muscle (posterior), subcutaneous tissue (superficial), and inferior angle of the scapula (posterior). It is critical to release the LD muscle from the inferior angle of the scapula, which forms an adhesion that often is the limiting factor preventing adequate excursion.
- Adequate mobilization occurs when the tendon can be brought to the top of the posterior aspect of the acromion (Fig. 5).
- Once the tendon has been harvested and prepared, it is important to develop the interval needed for the tendon transfer, inferior to the deltoid and superficial to the teres minor.
- To perform an LT harvest:
 - Make a horizontal incision just inferior to the scapular spine, from 1 cm medial to the medial edge of the scapula to 3 to 4 cm lateral to the medial edge of the scapula. If needed, a hockey-stick-type incision can be utilized by extending the medial aspect of the incision inferiorly.
 - Dissect through skin and subcutaneous tissue until the fascia overlying the LT and/or the infraspinatus is exposed.
 - Once the LT muscle fibers traveling toward the medial spine of the scapula are identified, it is important to expose the inferior edge of the muscle belly. Blunt dissection can be utilized to mobilize the inferior edge of the muscle, separating the muscle from the underlying infraspinatus fascia.
 - Trace the inferior edge of the LT muscle belly to its musculotendinous junction and tendon, adjacent to a fat triangle (Fig. 6). The LT tendon forms a triangle with an approximate height of 23 mm, length of the footprint of 30 mm, and length of the tendinous portion of the LT of 49 mm¹¹.

Fig. 5

Fig. 6

Fig. 5 LT mobilization. Adequate mobilization of the LD tendon occurs when the tendon can be brought to the top of the posterior part of the acromion.

Fig. 6 The LT is visualized with its triangular tendon inserting on the spine of the scapula, while the middle trapezius drapes over the LT, inserting more laterally on the spine. When harvesting the LT, the surgeon can encounter a nerve to the middle trapezius if the level is too superior. Asterisk = spinal accessory nerve branch to the middle trapezius. (Published with permission of the Boston Shoulder Institute.)

- Detach the tendon from the scapular spine, along with underlying periosteum. The fascia of the deltoid can be included to reinforce the size of the tendon.
- Mobilize the LT muscle superiorly to separate it from the middle trapezius.
 - A fat stripe separates the LT from the middle trapezius muscle belly.
 - The superficial fascia can be sharply dissected toward its medial origin on the spine.
 - Deep fascial dissection should be performed with caution to avoid injury to the neurovascular pedicle.
 - The neurovascular pedicle usually lies 2 cm medial to the scapula on the undersurface of the LT muscle fascia.
- If impingement is suspected on the medial spine of the scapula, resect this edge.
- Prepare the LT tendon with nonabsorbable sutures in a running or Krackow fashion to help with the transfer.
- Then prepare the Achilles tendon allograft, after it has been removed from its osseous attachment to the calcaneus (Fig. 7).
 - Place 2 number-2 nonabsorbable sutures along the superior and inferior edges of the Achilles tendon.
 - Then start a long nonabsorbable suture tape at the musculotendinous junction, and weave it down each side of the tendon over the sutures.
 - Mark 1 side of the allograft as dorsal.
 - Place 1 tagging suture in the opposite end of the tendon to assist with tensioning during articular preparation.

Fig. 7

Fig. 7 The Achilles tendon allograft is prepared by removing the calcaneus and then placing running nonabsorbable sutures on each side of the tendon.

Step 4: Arthroscopic-Assisted Transfer

Developing the interval and optimal placement facilitate the success of the transfer.

- To perform the LD transfer:
 - Begin the arthroscopic portion of the procedure by establishing posterior and anterior subacromial portals, using the “to-and-fro” technique, along with a direct lateral portal. The posterior portal is the primary visualization portal, whereas the anterior, anterolateral, lateral, and posterolateral portals are the primary working portals.
 - Visualizing from the posterior portal and working through the anterior and lateral portals, use a combination of a motorized shaver and a radiofrequency device to perform a thorough debridement of the subacromial space. It is important to remove the subacromial bursa to expose the edges of the massive rotator cuff tear and the footprint on the greater tuberosity. The remaining rotator cuff tendons also should be debrided. Any healthy rotator cuff tissue should be either partially repaired or secured to the tendon transfer.
 - Visualize from the direct lateral portal, then identify the teres minor inserting into the posterior aspect of the tuberosity. Develop the interval between the teres minor and the deltoid using the radiofrequency device; this is usually done through the posterolateral working portal. Make sure to stay medial to the axillary nerve as the quadrilateral space is released because the transfer should be medial to the axillary nerve, hugging the teres minor.
 - After the interval is developed, pass a switching stick to mark this interval.
 - Open the interval via blunt mobilization with a number-16 Foley catheter, using the balloon technique described by Laurent Lafosse (unpublished data) (Fig. 8).

Fig. 8

Fig. 8 Foley balloon technique described by Lafosse (unpublished data). A Foley catheter is advanced through the interval between the teres minor and deltoid, attached to a passing suture, to facilitate the transfer.

- Introduce a Foley catheter into the anterolateral portal, pass it to the posterolateral portal, and then advance it through the interval between teres minor and deltoid, attached to a passing suture (Fig. 9-A).
 - Sequentially inflate the catheter and pass it repeatedly from the greater tuberosity to the distal LD harvest incision to bluntly create a passageway for the transfer.
 - It is critical to open the interval enough for an easy, tension-free passage of the tendon and its musculotendinous junction.
- Place the arm in 45° of abduction, 45° of external rotation, and 45° of flexion.
 - Once the path has been opened, pass the sutures attached to the LD tendon into the joint and retrieve them through the anterior portal. This is accomplished using a loop in the Foley catheter tip to shuttle the sutures (Fig. 9-B).
 - Then deliver the LD tendon over the teres minor and onto the greater tuberosity (Fig. 10). Visualization of the tendon being transferred into the joint is usually through the lateral portal.
 - Once the maximum excursion of the LD muscle has been reached, use the motorized shaver to abrade the bone on the greater tuberosity. Anchor the LD tendon into the anterior aspect of the greater tuberosity so that it lies directly on the braided surface of the greater tuberosity.
 - Then use a knotless suture anchor to anchor the superior suture and suture tape in place (Fig. 11).

Fig. 9-A

Fig. 9-B

Fig. 10

Fig. 11

Fig. 9-A LD transfer. The tendon is advanced into the joint with the Foley catheter in the interval between the deltoid and teres minor. The tendon is then anchored in place to the tuberosity with a suture anchor.

Fig. 9-B The Foley catheter is advanced and gradually inflated to create an interval between the deltoid and teres minor. (Published with permission of the Boston Shoulder Institute.)

Fig. 10 Arthroscopic view of the LD transfer. The tendon is transferred between the infraspinatus/teres minor and the deltoid, creating a larger opening with the balloon on the Foley catheter, bringing the tendon into the joint.

Fig. 11 Anchoring the tendon to the tuberosity. A knotless suture anchor is used to anchor the superior suture and suture tape in place.

- The anchor is usually best placed using the anterior and anterolateral portals while visualizing from the posterolateral or lateral portal. The anterior portal is used for the medial sutures, and the anterolateral portal is used for the lateral sutures.
- The arm is held in 90° of abduction and maximal external rotation when the tendon is being anchored.
- If possible, fix the posterior part of the rotator cuff to the footprint and the posterior edge of the LD tendon.
- A biceps tenodesis is also usually performed if the biceps tendon is present.
- To perform the LT transfer:
 - Begin the arthroscopic portion of the procedure by establishing posterior, anterolateral, anterior, lateral, and posterolateral portals. The posterior, posterolateral, and anterolateral portals are the primary visualization portals, whereas the anterior, anterolateral, and lateral portals are the primary working portals.
 - Visualizing from the posterior portal and working through the anterior and lateral portals, perform a subacromial decompression and debride the remaining rotator cuff. Any healthy rotator cuff tissue should be either partially repaired or secured to the tendon transfer.
 - Visualizing from the lateral portal, identify the interval between the infraspinatus muscle belly and develop it by working through the posterolateral portal with shavers and a radiofrequency probe. It is important to stay medial to the axillary nerve, as the transfer should be medial to the axillary nerve, hugging the infraspinatus.
 - After the interval is developed, sharply incise the infraspinatus fascia from the medial incision, creating adequate room for the transfer.
 - Introduce a grasping clamp through the anterolateral (or lateral) portal and out the medial open incision. If needed to open the passageway, a laparotomy sponge can be passed.
 - Then pass sutures attached to the Achilles tendon allograft out the anterolateral portal, transferring the graft into the joint.
 - Alternatively, if the clamp is not long enough, insert the sutures through the posterolateral portal and then re-grasp them through the anterolateral portal.
 - Move the graft back and forth to ensure adequate opening of the passageway.
 - Anchor the graft into the superior and medial aspect of the greater tuberosity using an anchor for the superior and inferior sutures and suture tapes (Fig. 12).

Fig. 12

Fig. 12 The Achilles allograft is anchored into the superior and medial aspect of the greater tuberosity using an anchor for the superior and inferior sutures and suture tape.

- Hold the graft tensioned during the transfer to ensure that it is not fixed in a wrinkled position.
- Visualize the dorsal marks on the graft to ensure that there is no rotation of the graft.
- If possible, fix the posterior part of the rotator cuff to the footprint and the posterior edge of the tendon.
- A biceps tenodesis is also usually performed, depending on the preoperative symptoms and if the biceps tendon is present.
- Place the arm in maximal external rotation and 50° of abduction.
- Then secure the graft to the LT tendon, ensuring adequate tension.
 - Split the Achilles tendon graft in half with dissecting scissors.
 - Weave the inferior half of the allograft tendon into the LT tendon in a Pulvertaft fashion.
 - Oversew the remainder of the graft over the Pulvertaft weave and LT musculotendinous junction.

Step 5: Closure and Postoperative Protocol (for Both LD and LT Transfer Procedures)

It is important to maintain the arm in the tensioned position during closure.

- Close the incisions in a layered fashion with absorbable sutures.
- The patient wears an abduction-external rotation brace (Fig. 13) for at least 6 weeks postoperatively, during which time active elbow, wrist, and hand motion is encouraged.
- Passive and active shoulder motion is begun at 6 weeks postoperatively, with no internal rotation allowed.
- Internal rotation is begun gradually at 12 weeks.
 - For patients who have undergone an LD transfer, a biofeedback physical therapy protocol can be utilized at this time to help with the retraining of the muscles to perform their new functions in shoulder external rotation and elevation.
 - Biofeedback is generally not indicated after the LT transfer, given that it is an “in-phase” transfer.
- Gentle strengthening is not started until 16 weeks.
- Unrestricted activity is permitted by 6 months.

Fig. 13

Fig. 13 An abduction-external rotation brace is applied postoperatively and worn for at least 6 weeks.

Results

Although we are not aware of any studies that directly compared the LD and LT techniques, the short and long-term outcomes found in many series have been promising. There is more evidence regarding the LD procedure than regarding the LT transfer, and the open LD technique has been shown to successfully relieve pain and restore function when used to treat posterosuperior rotator cuff tears²⁻⁶. In a study of 46 open LD transfers followed for a minimum of 10 years (mean, 147 months), Gerber et al. found that patients maintained significant improvements in shoulder flexion, external rotation, and abduction strength as well as pain and Constant shoulder scores³. Authors of other studies^{1,2,5} found worse outcomes in patients with insufficiency of the subscapularis, fatty infiltration of the teres minor, and a critical shoulder angle of $>36^\circ$. In a study of 22 open LD transfers by Warner and Parsons, worse outcomes were seen in patients with a prior rotator cuff repair, deltoid insertion detachment, or fatty infiltration⁵. A recent systematic review by Namdari et al. confirmed these observations, showing that patients maintain significant functional and pain improvements, with worse outcomes predicted by subscapularis insufficiency, teres minor fatty infiltration, and prior rotator cuff repair³⁶.

In recent years, arthroscopic-assisted LD transfers have shown promising outcomes at short-term follow-up⁷⁻¹⁰. Grimberg et al. examined the results of 55 arthroscopic-assisted LD transfers, including 30 in patients with a prior failed rotator cuff repair³⁷. At a mean of 29 months postoperatively, there were significant improvements in pain scores, Subjective Shoulder Values, and Constant shoulder scores as well as shoulder flexion, abduction, and external rotation. Castricini et al. reported similar results in a series of 27 arthroscopic-assisted LD transfers, with significant improvements in pain and functional outcomes after 27 months of follow-up⁹. As was found with the open technique, worse outcomes were seen in patients with previous surgery. Overall, although we found no direct comparisons, it appears that the short-term results of arthroscopic-assisted LD transfers are similar to those of the open techniques.

The LT transfer was developed much more recently. It was initially used to restore shoulder external rotation in patients with brachial plexus injuries³⁸⁻⁴¹ and, given its success in the paralytic shoulder, surgeons then started to utilize the technique for massive irreparable rotator cuff tears. Recently, Elhassan et al. examined 33 patients who had undergone an open LT transfer for a posterosuperior irreparable rotator cuff tear¹². At a mean 47 months, patients experienced significant improvements in pain, flexion, abduction, elevation, external rotation, the Subjective Shoulder Value, and the Disabilities of the Arm, Shoulder and Hand (DASH) score. More improvement in function was seen in patients with preoperative elevation of $>60^\circ$. We are not aware of any published peer-reviewed reports on the outcomes of arthroscopic-assisted LT transfers.

We do not know of any clinical studies comparing the LD and LT tendon transfers using open or arthroscopic techniques. However, Hartzler et al. performed a biomechanical comparison among LD, LT, and teres major tendon transfers to superior and inferior positions on the greater tuberosity³³. The authors concluded that, in the superior position, the transferred LT had a better moment arm than the transferred LD in 0° of abduction whereas its moment arm was slightly but not significantly better in 90° of abduction. Another biomechanical study, of a massive rotator cuff model, showed that LT transfer was better than LD transfer with regard to restoring native glenohumeral kinematics and joint reaction forces in 0° , 30° , and 60° of abduction³⁴.

Pitfalls & Challenges

- Tendon harvest:
 - *LD transfer*: Circumferential visualization of the LD humeral insertion should be achieved prior to sharp release to prevent injury to the radial or axillary nerve.
 - *LT transfer*: The lower border of the trapezius muscle should be identified and followed to its most lateral insertion to ensure maximum tendon length. This will allow more robust fixation to the allograft.
- Tendon mobilization:
 - *LD transfer*: Failure to release the LD from the inferior angle of the scapula and chest wall may prevent adequate excursion for a tension-free repair to the tuberosity.
 - *LT transfer*: The spinal accessory nerve lies on the undersurface of the trapezius muscle 2 cm medial to the scapula. Deep dissection must be avoided during mobilization. However, it is important to free the superficial and deep fascia to improve muscle excursion.
- Tunnel dilatation:
 - *LD transfer*: The diameter of the LD graft increases substantially after its musculotendinous junction. It is important to adequately dilate the subdeltoid tunnel to prevent restricted excursion.
 - *LT transfer*: Prior to graft fixation, the graft is advanced through the tunnel multiple times with traction sutures on each end to ensure easy passage. Other tips include using a laparotomy sponge, if necessary, to open the passageway and ensuring that the infraspinatus fascial split extends far enough laterally.
- Graft fixation and arm position:
 - *LD transfer*: Prior to graft fixation, the arm is positioned in 45° of abduction and 45° of external rotation to facilitate a tension-free repair.
 - *LT transfer*: The arm must be positioned in 90° of abduction and maximal external rotation. When the arm is lowered after fixation, adequate tension will be appreciated. Failure to position the arm up and out will result in a loose construct.
- Rehabilitation:
 - *LD transfer*: Since the LD transfer is an “out-of-phase” transfer, a focused rehabilitation program, potentially augmented by techniques such as biofeedback therapy, is critical.

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