Techniques for lower trapezius tendon transfer for the management of irreparable posterosuperior rotator cuff tears

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ABSTRACT

Irreparable posterosuperior rotator cuff tears are a challenging treatment problem. Several tendon transfers have been described for the treatment of irreparable tears. Recently the lower trapezius (LT) tendon transfer has grown in popularity. This procedure has shown promise in biomechanical studies, improving the external rotation moment arm at the side. This transfer may be done in several ways, including an open approach with an acromial osteotomy, mini-open, and arthroscopic-assisted. The purpose of this paper is to review the current evidence and rationale for the use of the LT transfer and to describe the available techniques.

1. Introduction

Irreparable rotator cuff tears in the young and active patient can be a challenging problem. Lack of adequate active forward elevation, external rotation, and weakness can be functionally debilitating problems for patients, resulting in difficulty with activities of daily living, work demands, and recreational activities. Although traditionally described for treatment of permanent nerve injuries, tendon transfers have been adapted for use in the setting of irreparable rotator cuff tears.^{1–4}

The most common tendon transfer for the reconstruction of posterosuperior rotator cuff tear is the latissimus dorsi (LD) tendon transfer.^{5–7} This transfer has yielded good to excellent pain relief in most patients; however, improvement in function has been variable.⁸ Because the LD is a natural internal rotator and creates a vertical force vector when transferred, the normal force couples around the glenohumeral joint are not restored.⁹ Even in patients with good postoperative clinical results, limited electromyographic activity of the LD muscle during shoulder abduction has been reported.⁶

Lower trapezius (LT) tendon transfer is another option for transfer to improve external rotation strength. The line of pull and vector of the LT muscle mirrors the line of pull of the insufficient or absent infraspinatus as compared to the LD tendon.¹⁰ Transfer of the lower trapezius tendon lengthened with Achilles tendon allograft was first described by

Elhassan et al., in 2009 to improve external rotation in an adult patient with traumatic brachial plexus injury.² Shortly after, Bertelli et al. described the direct transfer of the lower trapezius to the infraspinatus tendon in 7 children with obstetric brachial plexus injury.¹ Since then, its use has been popularized in patients with massive irreparable cuff tears.⁴ In this article we will review the anatomy and biomechanics of the lower trapezius muscle and describe different techniques of performing the LT tendon transfer. Indications, contraindications, and factors associated with a poor outcome after LT transfer are found in Table 1.

2. Anatomy and function

The trapezius muscle has a large origin from the posterior skull base to the T12 vertebrae and covers the cervical, thoracic and shoulder regions. It consists of three segments; upper, middle and lower trapezius fibers. The lower trapezius muscle fibers originate from T4 to T12 (range T2–T12) and converge laterally and insert on the medial scapular spine at the dorsal trapezius tubercle.¹¹ The tendinous portion of the LT is triangular in shape and measures 49 mm ± 9 mm in length with a footprint 30 mm ± 7 mm in width. It is innervated by the accessory nerve (motor) and from the C3 and C4 (sensory). The distance from the nerve to the footprint increases as the nerve moves distally. The closest distance from the medial footprint to the nerve (the closest distance is at

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the superior portion of the lower trapezius) is, on average, 58 mm, and distances as close as 23 mm have been reported in a cadaveric study.¹¹

3. Biomechanics

Studying voluntary contractions of the trapezius muscle on normal individuals has shown the ability to selectively activate the lower trapezius muscle from the upper subdivision in all subjects. This demonstrates the ability to independently control the lower trapezius by voluntary command.¹² Omid et al. reported the biomechanical effects of the LT transfer in rotator cuff-deficient shoulder models. They demonstrated that compared to the LD, LT tendon transfer better restored shoulder kinematics and glenohumeral force couples in the adducted position. Importantly, despite the improved biomechanics with a LT transfer, the kinematics and the level of the joint reaction forces never normalize in either a LD or a LT transfer.¹⁰

In a biomechanical study by Elhassan et al., the authors evaluated the external rotation moment arm (ERMA) of LT and LD transfers with the arm at the side and at 90° abduction. The authors reported significantly larger ERMA in the LT transfer compared to the LD transfer with the arm at the side, however, in 90° abduction the LD transfer had a significantly higher ERMA than the LT transfer. The ERMA of the LT was comparable to the previously reported amounts for the infraspinatus and teres minor with the arm at the side. The ERMA was greatest for the LT transfer when the tendon was attached to the infraspinatus insertion of the greater tuberosity as compared to the proximal diaphysis.¹³

4. Surgical technique

4.1. Tendon harvest

Once a clear understanding of the normal anatomy is established, identifying the muscle fibers of the LT muscle and its tendon insertion on the dorsum of the medial scapular spine is straightforward. Because the muscle is superficial and the tendon is very thin, there is a risk of damage to the muscle/tendon during exposure and harvest. In almost all patients, there is a fat layer of variable thickness that overlies this tendon and careful excision of this layer can render the dissection much easier. The nerve is closest to the tendon insertion at the superior border of the LT insertion and is most at risk as dissection is carried medially. There is a triangular bare area beneath the insertion site on the dorsum of the scapula which can be used as a guide for finding the tendinous insertion site.¹¹

4.1.1. Indirect approach

The indirect (medial) approach is performed in the lateral decubitus position (Fig. 1). Since the scapula moves freely on the chest wall, then the location of the lower trapezius tendon and distance between the medial border and the nerve can be influenced by the position of the arm/scapula. For this reason, we recommend placing the arm in a dynamic arm holder that allows traction on the arm, and this position should be maintained during the muscle harvesting. A vertical incision is made 2 cm medial and parallel to the medial border of the scapula, extending approximately 5 cm from the scapular spine. The overlying fat layer is incised first. Second, the muscle is identified and dissected toward its insertion on the medial spine of the scapula. Finally, the tendon

Fig. 1. Indirect (medial) incision for lower trapezius tendon harvest.

is peeled off its insertion as lateral as possible in order to maximize tendon length. The harvested tendon is prepared by passing #2 non-absorbable sutures in a Krackow fashion.

To mobilize the muscle, dissection is bluntly performed between the lower and middle trapezius. The spinal accessory nerve is located on the undersurface of the muscle, so dissection between the superficial muscle fibers is safe. If more excursion is needed we recommend exploring and protecting the spinal accessory nerve during the muscle dissection.² The nerve can be easily identified approximately 2 cm medial to the medial border of the scapular body.¹¹ However, in most cases when the transfer is performed for massive rotator cuff tear, exploring the nerve is not necessary.

4.1.2. Direct approach

The direct (horizontal) approach is at the tendinous insertion of the LT as opposed to the medial approach which is an indirect approach that first identifies the muscle belly and traces it to the insertion. The direct approach can be performed in the beach chair or lateral decubitus position (Fig. 2). The position of the arm during surgery should be

Table 1
Exposure techniques for tendon harvest.

		Position	Advantages	Disadvantages
Graft harvest	Medial incision	Lateral decubitus	Larger exposure	Only possible in lateral decubitus
	Horizontal incision	Beach chair/lateral decubitus	Smaller tissue bridge for graft passage	Limited exposure
Graft attachment	Acromial osteotomy	Beach chair/lateral decubitus	Good exposure	Risk of deltoid attachment failure
	Mini-open	Beach chair/lateral decubitus	Acromion untouched	Limited exposure
	Arthroscopic-assisted	Beach chair/lateral decubitus	Deltoid attachment untouched	Larger learning curve

respected as was mentioned above. A 4 cm skin incision is made parallel to the scapular spine, centered on its medial side. After identifying the LT tendon, its attachment on the spine of the scapula is released. The tendon is prepared by passing Krackow sutures, then the muscle is released further medial and separated from the middle trapezius as described above. Given the lateral nature of this approach, there is no need to explore the accessory nerve.

5. Graft preparation

In patients with brachial plexus injury who have intact rotator cuff tendons but paralyzed muscles, direct trapezius tendon transfer to the infraspinatus tendon can be performed in most cases. However, in patients with massive irreparable rotator cuff tear with deficient posterior-superior rotator cuff tendons, the LT tendon does not have the necessary length or excursion to reach the greater tuberosity, and an Achilles tendon allograft is typically utilized. If allograft is not available, semitendinosus autograft is also an option although the tendon is less robust. The need for graft is a limitation of the LT transfer. Graft healing problems and graft creep are potential complications.¹⁰ The allograft is attached to the LT tendon by heavy, non-absorbable, braided sutures in a locking-stitch fashion. Based on the graft attachment technique, attachment of the allograft to the tuberosity is done before or after its attachment to the LT tendon.

6. Graft attachment

Elhassan et al. in the first report of LT transfer for irreparable cuff tear used an acromion osteotomy for exposure of the proximal humerus.⁴ Later, to preserve the deltoid insertion and to avoid complications such as acromial nonunion, mini-open and arthroscopic-assisted techniques have been utilized.¹⁴

Fig. 2. Direct (horizontal) incision for lower trapezius tendon harvest

6.1. Acromion osteotomy

Acromion osteotomy allows for complete exposure of the greater tuberosity. The incision is performed just medial to the palpable lateral margin of the acromion. With electrocautery, the soft tissue medial to the origin of the middle deltoid is debrided to the bone. Using an osteotome or saw, an osteotomy of the lateral acromion is performed in a way that leaves a 5–7 mm section of bone attached to the origin of the middle deltoid. Then, the detached bone is mobilized laterally. Remnant suture material or loose anchors are removed. The greater tuberosity is then prepared using a rasp or high-speed burr. Two double-loaded suture anchors are then placed at the infraspinatus footprint. The Achilles graft is then incorporated and tied to the LT tendon medially using multiple heavy nonabsorbable sutures in a figure-of-eight fashion. The graft is then passed in a subdeltoid fashion from medial to lateral (Fig. 3). The arm is placed in 50° abduction and 60° external rotation, at which point the graft is tensioned and tied using suture anchors on the tuberosity. The excess graft is excised. Two additional suture anchors are placed laterally, and the suture limbs are incorporated into the anchors for a double-row repair (Fig. 4).

After the LT transfer is complete, the osteotomy is repaired by passing 5 (double) heavy nonabsorbable sutures through 5 transosseous tunnels on each side of the osteotomy and tied over the osteotomy site. A concern in this technique is the union of the osteotomy site due to the importance of the deltoid attachment. In a series of 33 patients, Elhassan reported radiographic union in 25 patients (76%).⁴ However, in the same series, there were no differences in the outcome between those who had confirmed bony healing of the acromion to those who had fibrous union. With acromial nonunion there are concerns for both the short-term functional results and late-term conversion to reverse arthroplasty.

6.2. Mini-open

The mini-open approach avoids the risk of acromial nonunion but limits the exposure of the greater tuberosity. A 4 cm horizontal or vertical incision is made between the anterior and middle heads of the deltoid (Fig. 5). The deltotrachezial fascia is incised. The deltoid is split in line with its fibers and in the raphe between the anterior and middle fibers. If necessary, the deltoid muscle is detached subperiosteally from the acromion as needed for exposure and later repaired. Adhesions in the subacromial and subdeltoid space are released. The tuberosity is

Fig. 3. Passage of the graft.

Fig. 4. Completed graft repair.

Fig. 5. Mini-open incision with deltoid split.

prepared, and the graft is secured to the tuberosity using the technique described above.

6.3. Arthroscopic-assisted

In the arthroscopic-assisted technique, a direct approach is typically used for exposure and harvest of the trapezius tendon. A diagnostic arthroscopy is first performed. Based on preoperative clinical and intraoperative findings, concomitant procedures, such as biceps tenodesis/tenotomy, labral debridement, partial posterosuperior rotator cuff repair, or subscapularis repair can be performed. The tuberosity surface is prepared using an arthroscopic burr. Two 5.5 mm suture anchors are placed into the medial aspect of the greater tuberosity. Under the deltoid

muscle, the infraspinatus fascia is incised and opened at the posterior incision. It is important to create a wide enough opening so that the graft can pass unimpeded. The graft can be passed into the subacromial space in several ways. One option is to use a long grasping instrument inserted retrograde from the lateral portal into the posterior wound in order to grasp the sutures of the Achilles tendon and to deliver the graft into the subacromial space. Another option is to insert a switching stick into the joint from the posterior incision while viewing from an anterolateral portal. A large (8.25 mm or 10 mm cannula) is placed over the switching stick (Fig. 6a). One limb of suture (of opposing colors) from each anchor is retrieved through the cannula. The cannula is then removed, and these sutures are passed through the allograft in a locking-stitch manner from distal to proximal. The two suture limbs are then tied to one another at the medial aspect of the graft. A posterolateral viewing portal is then created, and another cannula is placed into the anterolateral portal. The corresponding limbs of the sutures that were passed through the graft are retrieved out of the anterolateral cannula. By placing traction on these limbs, the graft is shuttled into the subacromial space to its final position on the greater tuberosity. Sutures are then arthroscopically tied. The suture limbs from prior graft preparation can be tied over the top and incorporated into a lateral row using 2 additional knotless suture anchors (Fig. 6b). The arm is then positioned in 45° abduction and 45° external rotation, and the graft is tensioned and sutured to the native trapezius tendon with multiple non-absorbable sutures in a Pulver-Taft weave.

7. Postoperative protocol

After the wounds are irrigated and closed in a layered fashion, a gunslinger brace is applied in 30° abduction and 30–60° external rotation for a period of 8 weeks. No formal physical therapy is started until 6 weeks after surgery. At weeks 6–12, range of motion is initiated,

Fig. 6a. Cannula placement.

Fig. 6b. Arthroscopic view of graft repair to tuberosity.

restricting any cross-body adduction. At 14 weeks, isometric rotator cuff strengthening begins as well as scapular conditioning. Isotonic strengthening begins at 4 months and return to work and recreational activities is allowed at 6 months. Formal therapy may be continued for a period up to 1 year if necessary.

8. Conclusion

The LT transfer can effectively improve external rotation in patients with loss of active external rotation due to severe posterosuperior rotator cuff tears. Improved techniques such as mini-open and arthroscopic assisted approaches using a horizontal incision for tendon harvest can avoid damage to the accessory nerve and problems such as acromial nonunion.

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Mohammad Ghorraishian: Data curation, Writing - original draft,

Writing - review & editing. Michael A. Stone: Writing - original draft, Writing - review & editing, Data curation. Bassem Elhassan: Conceptualization, Methodology, Writing - review & editing. Joseph Abboud: Conceptualization, Methodology, Writing - review & editing. Surena Namdari: Conceptualization, Visualization, Methodology, Supervision, Writing - review & editing, Validation.

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