Review Article

Tendon Transfers for Irreparable Rotator Cuff Tears

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Abstract

Tendon transfer is one treatment option for patients with massive irreparable rotator cuff tears. Although surgical indications are not clearly defined, the traditional thought is that the ideal candidate is young and lacks significant glenohumeral arthritis. The proposed benefits of tendon transfers are pain relief and potential increase in strength. The biomechanical rationale for the procedure is to restore the glenohumeral joint force couple and possibly to restore normal shoulder kinematics. The selection of donor tendon depends on the location of the rotator cuff deficiency. Transfers of latissimus dorsi and pectoralis major tendons have been shown to consistently improve pain; however, functional benefits are unpredictable. Trapezius tendon transfer may be an alternative in patients with massive posterosuperior rotator cuff tears, although longer-term follow-up is required.

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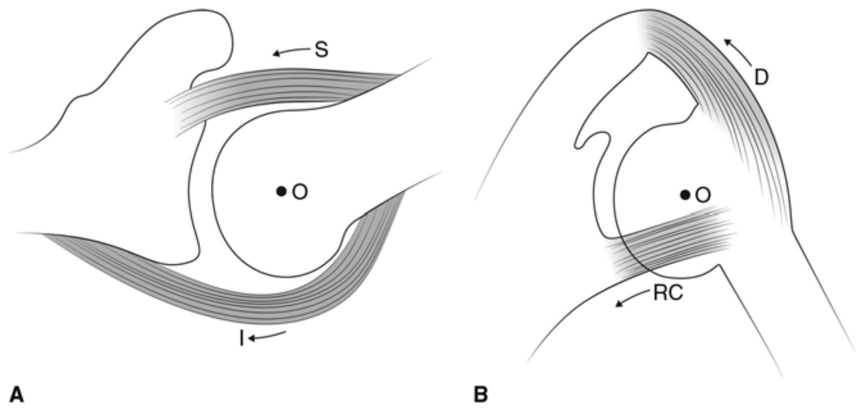
Rotator cuff disease is among the most prevalent musculoskeletal disorders. In 2006, it was estimated that 17 million persons in the United States were at risk for resulting disability.[1] Repair of a torn rotator cuff tendon is one of the most common surgeries performed by orthopaedic surgeons. Up to 94% of patients fail to heal, however.[2] Healing is most likely dependent on host biologic factors, such as age. Given the rapidly increasing number of elderly patients, the prevalence of failed rotator cuff surgery will inevitably rise. Currently, few reliable options exist to manage irreparable rotator cuff tears (RCTs).

The rotator cuff muscles converge at the tendinous insertions to surround the proximal humerus. These muscles are the subscapularis anteriorly, the supraspinatus superiorly, and the infraspinatus and teres minor posteriorly. The function of the rotator cuff is to provide concavity compression of the humeral head into the glenoid[3] (Figure 1). This stabilizing compressive force allows the periscapular muscles to move the shoulder around the glenoid. Rotator cuff dysfunction can lead to abnormal kinematics if the anterior-posterior or superior-inferior force couples are disrupted, leading to anterior or superior instability, respectively.

Prevalence and Classification

RCTs occur more commonly with advanced age. Studies have shown asymptomatic tears in up to 54% of patients aged >60 years.[4] Little is known regarding the natural history of the torn rotator cuff; some studies have suggested that tears do not heal spontaneously and that they tend to grow larger over time.[1,5] Fatty degeneration has been shown to correlate with chronicity of RCTs, and this

Figure 1



Illustrations of the force couples involved in normal shoulder function. **A,** The subscapularis (S) and infraspinatus (I) make up the coronal plane force couple. **B,** The deltoid (D) and the rotator cuff (RC) make up the transverse plane force couple. O = center of rotation

Table 1

Goutallier Staging System of Fatty Infiltration in Rotator Cuff Tear[7]

Stage	Level of Fatty Infiltration
0	Normal muscle with no fatty streak
1	Some fatty streaks in the muscle
2	Fatty infiltration is important, but more muscle exists than fat
3	Equal amounts of fat and muscle
4	More fat than muscle

finding is a negative prognostic factor.[6] Some RCTs can progress to the point of becoming irreparable.[7] The true incidence of irreparable RCTs is unknown.

The term irreparable RCT is commonly and often incorrectly used interchangeably with the term massive RCT. Not all massive cuff tears are irreparable, and care must be taken to use accurate terminology when describing both types of lesion. Massive RCTs are classified based on their size, but several definitions have been proposed. Cofield et al[8] were the first to define a massive tear as one measuring >5 cm in diameter. More recently, Gerber et al[9] defined a massive tear by the number of tendons involved (ie, two or more). Once a massive RCT is identified, it can be further classified as posterosuperior (involving the supraspinatus, infraspinatus, and possibly teres minor) or anterosuperior (involving the subscapularis and supraspinatus). These two tear patterns differ in epidemiology, mechanism, prognosis, and management.[10]

The definition of an irreparable RCT is less clear. Irreparable RCTs are typically large and retracted, with degenerated and nonfunctional muscle bellies. Goutallier et al[7] classified muscle quality by the amount of fatty infiltration in the rotator cuff muscle as identified on CT. Although it is unknown precisely what amount of fatty infiltration is possible before a tear is deemed to be irreparable, most authorities believe that irreversible changes are Goutallier grades 3 or 4[7] (Table 1). The Goutallier classification was later validated with MRI and is now the most commonly used modality to assess muscle quality.[11]

Acromiohumeral distance is another radiographic parameter that may be used to determine whether an RCT is repairable, with some studies suggesting that an acromiohumeral distance of <7 mm is associated with decreased likelihood of reparability.[12] In addition, it is important to distinguish between static and dynamic humeral head migration. Static migration is considered to be a worse prognostic factor than dynamic migration, and static migration is considered irreversible.

Biomechanics of Intact and Rotator Cuff–deficient Shoulders

The muscles that make up the rotator cuff provide dynamic stability to the shoulder. Electromyography (EMG) has demonstrated that activity in the rotator cuff precedes activity in the deltoid and pectoralis major, which suggests that the rotator cuff actively stabilizes the glenohumeral joint in preparation for movement by the periscapular muscles.[13] The anterior and posterior rotator cuff muscles provide concavity compression, that is, a balancing force across the glenoid. Burkhart[3] first provided a biomechanical description of this force-couple concept after performing fluoroscopic evaluation of patients with massive RCTs. He reported that normal shoulder function is possible with a massive unrepaired RCT only when a balance exists between two important force couples—one in the coronal plane (ie, rotator cuff) and the other in the transverse plane (ie, deltoid)[3] (Figure 1).

Early rotator cuff disease commonly affects the anterior insertion of the supraspinatus tendon. It was recently demonstrated, however, that degenerative RCTs initiate approximately 15 mm posterior to the biceps tendon.[14] With tear progression, the anterior and posterior force couple may be disrupted, leading to altered kinematics and fatty degeneration. Involvement of the anterior fibers of the supraspinatus, which presumably corresponds to the anterior force couple, has been shown to correlate to fatty degeneration of the rotator cuff.[15] Fatty degeneration is irreversible even with repair and leads to reduced function of the rotator cuff musculature.[6]

It is not known at which stage an RCT adversely affects glenohumeral kinematics. A recent biomechanical study suggested that involvement of the infraspinatus tendon is necessary to cause significant changes in humeral head kinematics.[16] It also revealed that with massive cuff tears, the pectoralis major and latissimus dorsi play important roles in humeral head stabilization. Another biomechanical study noted that in persons with massive RCTs, the integrity of the remaining rotator cuff muscles (ie, subscapularis, teres minor) play a much larger role.[17] Furthermore, sometimes these muscles must bear a supraphysiologic load.

Clinical Evaluation, Physical Examination, and Imaging

Irreparable RCTs are associated with an unpredictable degree of pain and dysfunction. A shoulder may function well in the setting of a massive painless RCT. Alternatively, a small painful tear may cause significant disability and loss of function.

Physical examination begins with inspection of the shoulder. Atrophy of the supraspinatus and infraspinatus fossae can signify chronic involvement and a diminished likelihood of irreparable tissue. The rotator cuff can be assessed by testing the specific muscles that comprise it.

The supraspinatus is assessed with thumb-down abduction in the scapular plane. The infraspinatus is assessed by measuring external rotation strength with the arm in adduction. The teres minor is assessed by evaluating external rotation strength with the arm in 90° of abduction. Numerous tests have been proposed to evaluate the integrity of the subscapularis, including the more commonly used abdominal compression, lift-off, and bear hug tests.[18-20] Lag signs have been shown to correlate with RCT size and are poor prognostic factors.[21] The hornblower sign indicates significant disruption of the rotator cuff with irreversible involvement of the teres minor.[22]

Imaging should always begin with four plain radiographic views. A true AP view of the shoulder (ie, Grashey view) is useful to determine glenohumeral joint pathology and to assess proximal humerus migration. This image should be obtained with the arm in slight abduction to accentuate loss of the force couple. With slight abduction, the deltoid provides a superiorly directed force which, in the absence of the force couple provided by the rotator cuff, results in proximal humerus migration. An AP radiograph of the shoulder reveals acromioclavicular pathology. Shoulder axillary lateral views must be obtained to assess the position of the humeral head on the glenoid in the sagittal plane. This view is helpful in determining subtle anterior subluxation signifying subscapularis dysfunction. A scapular Y view is useful to assess the body of the scapula and the position of the humeral head in relation to the glenoid, and it provides a good view of the supraspinatus outlet.

The muscle bellies are assessed on T1-weighted sagittal oblique MRI, and cuts must be sufficiently medial to allow proper assessment of the bellies. The degree of fatty degeneration should be noted, as well, to determine the reparability and function of the tissue. If MRI is contraindicated, CT arthrography is an acceptable alternative.[7] Most recently, ultrasonography has demonstrated moderate (72%) to excellent (100%) accuracy in detecting fatty degeneration; however, this modality is very operator dependent.[23]

Management of Irreparable RCTs

Many patients with irreparable RCTs respond favorably to nonsurgical treatment. Physical therapy is the mainstay of treatment, focusing on deltoid reconditioning,[24] strengthening of any remaining cuff tissue, and periscapular strengthening.[17] Nonsteroidal anti-inflammatory drugs and subacromial corticosteroid injections can be helpful, as well.

When nonsurgical measures fail to improve the patient's pain, surgical options should be considered. No reliable treatment exists for irreparable RCTs. Numerous surgeries have been proposed, however, including rotator cuff débridement,[25] partial rotator cuff repair,[26] biceps tenotomy/tenodesis,[27] tendon transfers, and arthroplasty.[28] One study showed good results with reverse total shoulder arthroplasty in nonarthritic patients with massive posterosuperior RCTs.[28] However, this is not a viable option in younger, more active patients. In this patient population, tendon transfers may be a more reasonable option.

Biomechanics of Tendon Transfers

The goal of tendon transfer is to restore the force couples in the shoulder. With latissimus dorsi transfer, the goal is to exert an external rotation force that allows for a more balanced state in the glenohumeral joint. In effect, the latissimus dorsi replaces the function of the posterior force couple. The goal of pectoralis major transfer is to exert an internal rotation centering force, thereby replacing the function of the subscapularis. This is intended to function as the anterior force couple. In theory, restoration of the anterior and posterior force couples will allow the glenohumeral joint to pivot around a stable fulcrum when the periscapular muscles are active. The critical function of the rotator cuff can never be fully replaced, however, and this balance in the force couple is rarely attained.

The likely reason that the periscapular muscles cannot fully restore the normal function of the rotator cuff muscles is the anatomic position of the periscapular muscles and the resulting force vectors in relation to the anatomic positions of the native rotator cuff muscles. For example, in both subcoracoid and supracoracoid transfers the pectoralis major transfer is always anterior to the normal position of the subscapularis. Additionally, the latissimus dorsi transfer is always posterior and inferior to the infraspinatus and teres minor muscle bellies. This results in the generation of a nonphysiologic vector across the glenohumeral joint, leading to abnormal kinematics.

In the rotator cuff–deficient shoulder, other muscles take on new roles in an attempt to compensate for the lost force couples. The teres major is pathologically active in patients with massive RCTs. EMG has demonstrated that in rotator cuff–deficient shoulders, the teres major compensates for superior translation by firing asynchronously during abduction and forward flexion. Activation of the teres major results in adduction of the shoulder. Contraction of the teres major thus results in diminished abduction and forward elevation of the glenohumeral joint, which may be a subconscious attempt to decrease the pain from subacromial impingement, which is worse in extreme abduction and forward elevation.[29]

Options for Tendon Transfers

Numerous tendon transfers have been described, including transfer of the long head of the triceps, the deltoid, the trapezius, the subscapularis, the latissimus dorsi, the pectoralis major, and the teres major. Most of these are of historical interest, however. Currently, the most commonly used transfers for irreparable RCTs include the latissimus dorsi transfer and the pectoralis major transfer. The trapezius transfer has been the subject of renewed interest.

Latissimus Dorsi Transfers

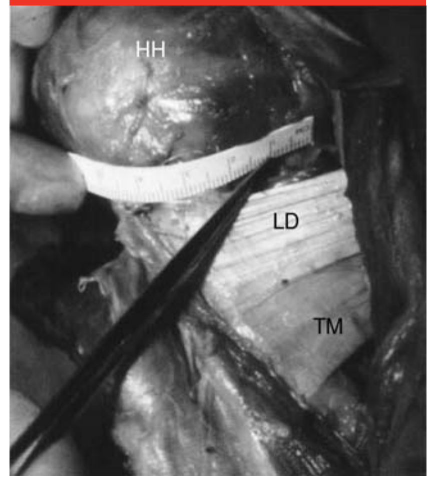
Relevant Surgical Anatomy

The latissimus dorsi muscle extends, internally rotates, and adducts the humerus. The thoracodorsal artery serves as the main blood supply to the latissimus dorsi muscle, and this muscle is innervated by the thoracodorsal nerve (C6, C7), which arises from the posterior cord of the brachial plexus. The neurovascular pedicle enters the muscle on the anteroinferior surface approximately 2 cm medial to the muscular border.[30] The latissimus is well situated for transfer because it has the largest potential excursion of all the muscles in the shoulder (33.9 cm).[31] The latissimus dorsi tendon always inserts anterior to the teres major insertion, approximately 7 mm lateral.[32] In most cadaver specimens, the latissimus dorsi tendon overlaps the superior 39% of the teres major tendon[32] (Figure 2).

The axillary nerve always lies superior to the latissimus dorsi tendon. The distance between the axillary nerve and tendon is greatest in external rotation and shortest in internal rotation (range, 2.3 to 3.9 cm).[32] The transferred latissimus dorsi tendon always passes medial to the axillary nerve. The radial nerve is always medial to the coracobrachialis and anterior to the latissimus dorsi tendon. In one study, the distance between the radial nerve and latissimus dorsi tendon was greatest in external rotation and shortest in internal rotation.[32]

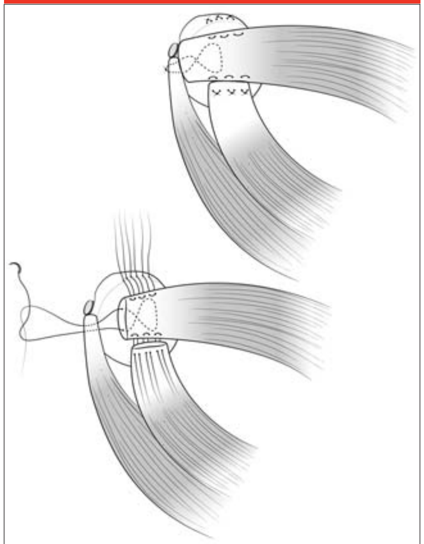
Latissimus dorsi tendon transfer is performed with either a two-incision[33] or a single-incision technique.[34] The tendon is usually sharply detached from the bone, brought over the top of the humeral head, then repaired to the supraspi-

Figure 2



Anterior photograph of a right cadaver shoulder. The humeral head (HH) is seen at the top of the image. In most specimens, the latissimus dorsi tendon (LD) overlaps the superior 39% of the teres major tendon (TM), as seen here.[32] In others, the LD overlaps the entire TM. (Reproduced with permission from Cleeman E, Hazrati Y, Auerbach JD, Shubin Stein K, Hausman M, Flatow EL: Latissimus dorsi tendon transfer for massive rotator cuff tears: A cadaveric study. *J Shoulder Elbow Surg* 2003;12[6]:539-543.)

Figure 3



Illustrations of the final steps in latissimus dorsi tendon transfer from a superior view. *Bottom,* The tendon is brought over the top of the greater tuberosity and repaired transosseously, the anterior edge of the tendon transfer is repaired to the superior border of the subscapularis, and any remnant cuff tissue is repaired to the medial edge of the tendon transfer. *Top,* Final appearance of the transfer.

Figure 4

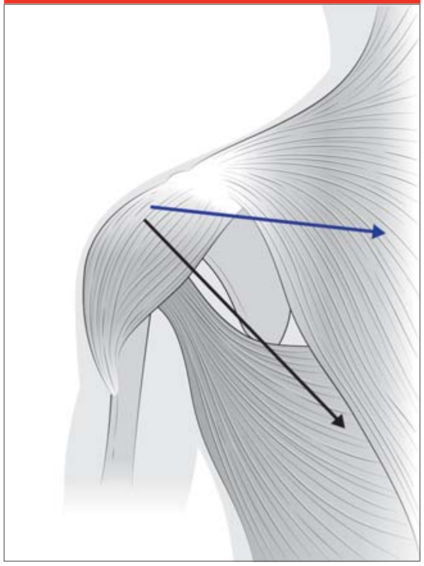


Illustration of the force vectors of the normal rotator cuff (top, blue arrow) and the latissimus dorsi (bottom, black arrow). The pull of the latissimus dorsi is much more vertical than is the physiologic pull of the native rotator cuff.

natus footprint with the use of suture anchors or a transosseous technique. Alternatively, a small osteotomy can be performed in an effort to improve healing of the transfer.[35] Any remnants of the torn rotator cuff are then sutured to the medial edge of the latissimus dorsi tendon (Figure 3). This is not always possible, however, due to significant scarring in the setting of chronic RCT.

Indications and Outcomes

Latissimus dorsi tendon transfers were first described in patients with brachial plexopathies that caused lack of external rotation. This concept of using muscle transfer to improve shoulder external rotation was applied by Gerber et al[33] in the management of irreparable posterosuperior RCTs. They defined massive irreparable RCTs as those in which, with the arm in 60° of abduction, the tendon cannot be anchored to the bony trough despite aggressive releases. The mechanism by which the tendon transfer exerts its effect is controversial. Improvement in external rotation occurs by either active contracture or a tenodesis effect.[36] Some EMG studies have suggested limited activity during external rotation,[36] whereas others have shown the transfer to be active on EMG.[37] The line of pull of the latissimus dorsi transfer is more vertical than that of the native posterior cuff, which may explain the varied results in restoring external rotation (Figure 4). Although it has been suggested that this vertical pull may restore any superior migration of the humeral head, this has not been shown to occur clinically.

Latissimus dorsi tendon transfer provides good pain relief in most patients; however, the functional results are less predictable. Proper patient selection is critical. Factors associated with poor outcome include subscapularis dysfunction, deltoid dysfunction, osteoarthritis of the glenohumeral or acromioclavicular joint, and loss of teres minor function.[38,39] One study indicated that preoperative psychomotor skills testing may prove to be a new method to predict outcomes following latissimus transfer.[40] Subsequent rupture of the transferred tendon may be a cause of poor outcomes. A modification using an osteotomy to enhance healing demonstrated better outcomes with osteotomy than with tenotomy.[35]

Suboptimal results in the revision setting have been reported in several series.[41] Others, however, have shown little difference between primary and revision transfers.[42] Subscapularis dysfunction appears to be a relative contraindication to latissimus transfer, with several studies indicating unpredictable results.[36,38] Biomechanical evidence also exists to support the diminished outcomes of latissimus transfer in the absence of an intact subscapularis.[43,44]

A recent systematic review noted the limited evidence available for the use of latissimus dorsi tendon transfer in patients with irreparable tears of the posterosuperior rotator cuff. Most studies to date are retrospective reviews that lack control groups,[41] and the studies vary with regard to their inclusion criteria, exclusion criteria, outcome measures, and surgical technique. Despite these shortcomings, some general comments can be inferred from the literature. Latissimus dorsi tendon transfer can provide significant pain relief, but the functional results are more variable. Although good functional outcomes have been reported in most series, it is difficult to conclude in which patients the surgery works best. What is clear from the literature is that patients should not expect restoration of normal function or complete elimination of pain following latissimus transfer.

Postoperative protocols vary. However, it is widely believed that 4 to 6 weeks of immobilization in a rigid orthosis with the arm in slight abduction and near full external rotation is required. Gentle passive range of motion in abduction and external rotation can begin immediately, but internal rotation and adduction are prohibited during the first 6 weeks. Active range of motion is introduced at 6 weeks, at which time the brace may be removed. Biofeedback programs are begun between 12 and 16 weeks postoperatively, and gains can be expected up to 1 year postoperatively.

Pectoralis Major Transfers

Relevant Surgical Anatomy

The pectoralis major muscle serves to flex, internally rotate, and adduct the humerus. The main blood supply is provided by the pectoral branch of the thoracoacromial artery. Additional sources of blood include the lateral thoracic and supreme thoracic arteries. Innervation arises from the medial pectoral (C7, C8, T1) and lateral pectoral (C5, C6) nerves. The pectoralis major is well situated for transfer because it has the second largest potential excursion, at 18.8 cm.[31] The pectoralis major tendon always inserts lateral to the intertubercular groove lateral to the biceps tendon. The pectoralis major has a broad tendinous undersurface, with a mean width of 5.7 cm at its attachment site lateral to the bicipital groove[41] (Figure 5).

The distance from the pectoralis major tendon insertion to the pectoral nerves is between 11.9 cm (medial pectoral nerve) and 12.5 cm (lateral pectoral nerve).[41] The medial pectoral nerve is always located inferior to the lateral pectoral nerve. The lateral pectoral nerve consistently passes medial to the pectoralis minor before entering the pectoralis major, so dissection is safe provided it is lateral to the pectoralis minor. The mean distance between the proximal branch of the musculocutaneous nerve and the coracoid process was 4.7 cm (range, 4 to 9.5 cm) in 70% of specimens.[45]

Pectoralis major transfers are performed through the deltopectoral approach. Techniques vary with regard to the amount and portion of the tendon used as well as the position of the graft in relation to the coracoid process.

Indications and Outcomes

Pectoralis major transfers have been described for use in irreparable anterosuperior RCTs, specifically, disruption of the subscapularis. Several techniques have been described, and none has been shown to be superior.

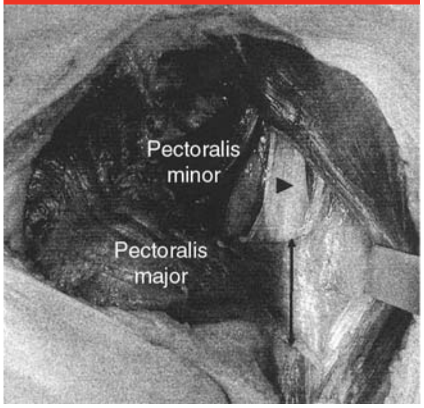
Pectoralis transfers were first described in 1997 by Wirth and Rockwood for irreparable tears of the subscapularis.[46] Later, Resch et al[46] described transferring the superior two thirds of the pectoralis major tendon underneath the conjoined tendon to reproduce the normal anatomy of the subscapularis. This technique was later modified to involve transfer of the entire pectoralis major tendon underneath the conjoined tendon[47] (Figure 6).

Warner[10] described a modification to help avoid injury to the musculocutaneous nerve. His technique involved transfer of the inferior, sternal portion of the pectoralis major beneath the clavicular head of the muscle and superficial to the conjoined tendon (Figure 7). He also described combining teres major and pectoralis major transfers to provide a stabilizing force better than that of the pectoralis transfer alone.

Klepps et al[47] emphasized the necessity of dissecting the musculocutaneous nerve from the overlying conjoined tendon and passing the pectoralis tendon beneath the conjoined tendon but superficial to the nerve. The decision whether to transfer only the superior one half or the entire tendon is based on the degree of subscapularis atrophy and patient age. Elderly patients and all patients with significant atrophy generally undergo transfer of the entire tendon.[47]

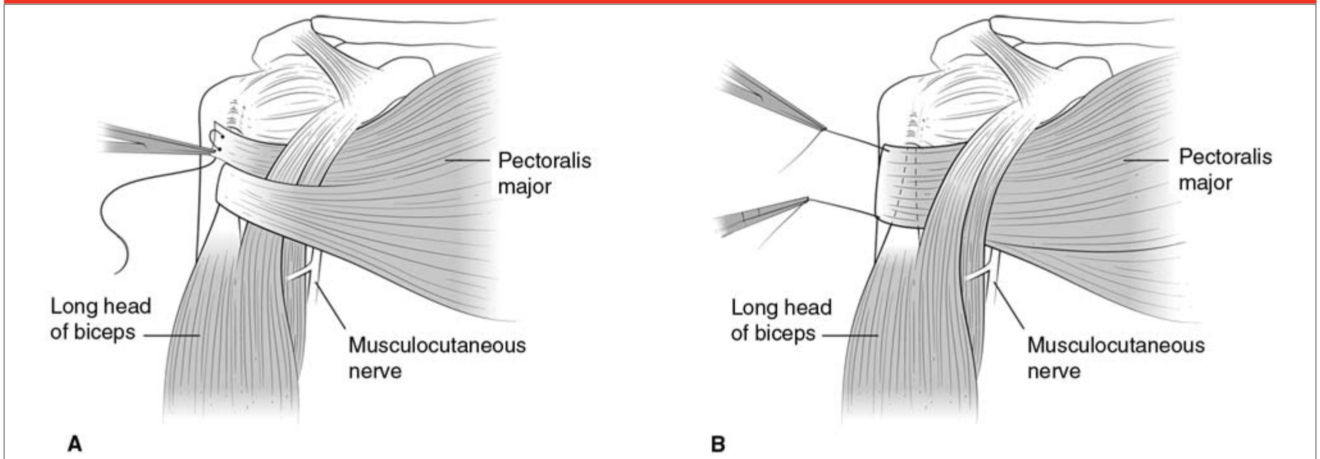
In theory, the subcoracoid pectoralis major transfer better approximates the force vector originally provided by the subscapularis muscle.[46,47] Although no clinical reports comparing the two techniques exist, one biomechanical study showed that subcoracoid transfer of the tendon more closely restores shoulder kinematics to an intact state than

Figure 5



Anterior photograph of a left cadaver shoulder. The pectoralis major has a broad tendinous insertion, with a mean width of 5.7 cm at its attachment site (double arrow) lateral to the bicipital groove. The arrowhead indicates the conjoined tendon. (Reproduced with permission from Klepps SJ, Goldfarb C, Flatow E, Galatz LM, Yamaguchi K: Anatomic evaluation of the subcoracoid pectoralis major transfer in human cadavers. *J Shoulder Elbow Surg* 2001;10[5]:453-459.)

Figure 6



Illustrations of subcoracoid transfer of the pectoralis major tendon. Depending on the space available under the conjoined tendon, the transfer can be either partial (ie, superior one half to two thirds of the length of the tendon) (**A**) or of the entire tendon (**B**). The musculocutaneous nerve lies deep to the tendon transfer, and its location must be confirmed before the transfer to prevent undue tension on the nerve.

Figure 7

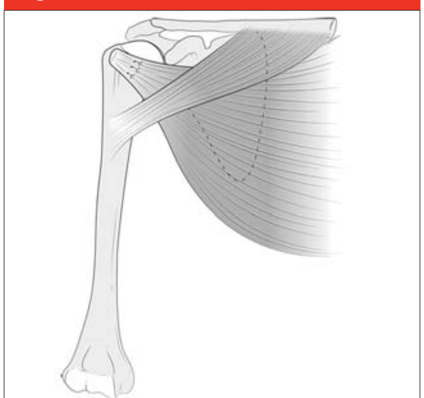


Illustration of a modified pectoralis major transfer to avoid injury to the musculocutaneous nerve. The transfer of the inferior, sternal portion of the pectoralis major is made beneath the clavicular head of the muscle and superficial to the conjoined tendon. In theory, placing the sternal head deep to the clavicular head results in a line of pull closer to that of the native subscapularis. The dashed line indicates the outline of the scapula.

does supracoracoid pectoralis major transfer.[48]

Little supportive evidence exists for pectoralis major tendon transfer in the subscapularis-deficient shoulder. Most published studies are retrospective in nature, and none included a control group for comparison.[46,49-51] The techniques, inclusion criteria, and exclusion criteria are variable, as well. Despite these shortcomings, some generalities exist, including reasonable pain relief and unpredictable functional outcomes following transfer. The revision setting seems to be less than ideal for pectoralis major transfer. One study demonstrated that the underlying pathology affects the outcome.[52] Patients with well-centered humeral heads do much better than patients with anteriorly subluxated humeral heads. Furthermore, the anterior position of the humeral head is not centered after the pectoralis major transfer.[52]

Postoperative protocols vary, but 4 to 6 weeks of immobilization in a rigid orthosis is required. Many surgeons use a postoperative protocol similar to that following massive anterosuperior rotator cuff repair. Passive motion within safe limits—determined intraoperatively—may begin at 4 to 6 weeks postoperatively. Typically, active motion is postponed until after 6 weeks, and gains may occur for up to 1 year. Function of the pectoralis is very similar to that of the subscapularis, so retraining is not necessary. Thus, biofeedback programs are not routinely implemented.

Trapezius Transfers

Currently, latissimus dorsi tendon transfer is most commonly used with some success in posterosuperior rotator cuff–deficient shoulders; however, functional results and outcomes remain variable. The exact function of the latissimus transfer has come into question in light of conflicting EMG data. In patients with brachial plexopathy, lower trapezius transfer has been used to improve external rotation;[53-55] however, use of this transfer in the rotator cuff–deficient shoulder has not been reported in the literature. Anatomically, the trapezius transfer may be better situated to have a more direct line of pull to improve external rotation (Figure 8).

Despite the limited available evidence regarding its use, transfer of

Figure 8

A B

Intraoperative photographs of a patient undergoing trapezius transfer to address loss of the posterosuperior rotator cuff. **A,** An Achilles tendon allograft is used to allow attachment to the greater tuberosity. **B,** The tendon is then routed subcutaneously, superficial to the rotator cuff muscles but deep to the deltoid. With the arm held in maximal external rotation, suture anchors were placed in the footprint of the infraspinatus to repair the Achilles allograft to the tuberosity.

Figure 9

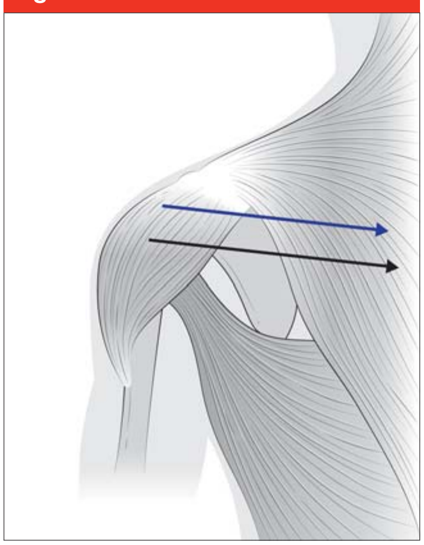


Illustration of the force vectors for the normal rotator cuff (top, blue arrow) and the lower trapezius transfer (bottom, black arrow).

the lower trapezius may be an alternative for patients with irreparable posterosuperior RCTs. The pull of the lower trapezius transfer is much more in line with the physiologic pull of the native rotator cuff. A recent cadaver biomechanical study illustrated that the lower trapezius transfer was more effective than latissimus dorsi transfer in restoring shoulder external rotation with the arm at the side[56] (Figure 9).

In spite of these theoretical advantages, trapezius transfer is limited by the fact that an allograft must be used to improve its excursion. Thus, issues related to healing must be taken into account. Further clinical and biomechanical testing is necessary before this transfer can be recommended.

Summary

Tendon transfer is one possible treatment option in younger patients without significant glenohumeral arthritis. Potential benefits include pain relief and increased strength. The goal of tendon transfer about the shoulder for irreparable RCTs is restoration of the glenohumeral joint force couple and possible restoration of normal shoulder kinematics. The selection of donor tendon depends on the location of the RCT. Currently, latissimus dorsi and pectoralis major transfers are most commonly performed, with variable results. Lower trapezius tendon transfers may provide an alternative to restore external rotation in patients with massive posterosuperior RCTs; however, further biomechanical and clinical studies are needed.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 6, 7, 12, 21, 24, 25, 37, 49, and 52 are level II studies. References 19, 23, 27, 29, 35, 41, and 46 are level III studies. References 1-5, 9, 14, 15, 18, 20, 22, 26, 28, 33, 34, 36, 38-40, 42, 44, 50, 54, and 55 are level IV studies. References 8 and 10 are level V expert opinion.

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