



REVIEW ARTICLE

Pectoralis major tendon transfer for irreparable subscapularis tears



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Background: Subscapularis insufficiency is a debilitating condition with few treatment options. Historically, pectoralis major tendon transfer has been suggested when the subscapularis tendon or muscle is deemed irreparable; however, the results of this salvage procedure have been mixed.

Methods: A comprehensive review of the peer-reviewed literature addressing pectoralis major tendon transfers was performed. The clinical presentation, relevant anatomy, biomechanical rationale, surgical indications, technical considerations, reported outcomes, and significant complications are reviewed in this report. Where possible, attempts at direct comparison of outcomes among surgical techniques and surgical indications have been made.

Results and Conclusions: Despite the heterogeneous reporting of clinical results, it is clear that surgical indications affect outcomes. Specifically, isolated subscapularis insufficiency shows the best prognosis with pectoralis major tendon transfer. Patients with anterosuperior instability after large rotator cuff tears or shoulder arthroplasty have the least predictable pain relief and worse functional outcomes.

Level of evidence: Review Article.

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Tendon transfers remain a viable treatment for patients with certain patterns of rotator cuff insufficiency. Most commonly, tendon transfers are indicated in younger patients with irreparable cuff tears, shoulder pain, and dysfunction. Whereas most tears involve the posterosuperior cuff, tears of the subscapularis tendon can also present with pain and limited function. Given the relative infrequency of these tears compared with posterosuperior

tears, many patients have a delay in diagnosis.^{23,29,33} Once torn, the subscapularis may retract, leading to rapid fatty degeneration of the muscle. Both shortening and adhesions may render the muscle irreparable. Several authors have noted that primary repair of chronic tears produces unsatisfactory results.^{23,29,33}

It is hypothesized that the subscapularis tendon is critical to balancing muscular forces around the glenohumeral joint.^{3,4} Because it is the sole rotator cuff musculotendinous unit anterior to the glenohumeral joint, insufficiency due to a tendon tear, muscle injury, or neurologic insult leaves the humeral head unbalanced, producing functional disabilities.^{3,4} This often manifests as either static or dynamic proximal humeral migration with decreased acromiohumeral

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distance.⁶ In some instances, recurrent anterior subluxation and instability are also prominent features of anterior rotator cuff deficiency.^{10,13} Reductions in the coracohumeral interval have been shown to be associated with degenerative changes in the subscapularis, occurring more commonly in patients with a reduced acromiohumeral distance.²⁶

For patients with irreparable subscapularis tears or in whom attempted repair has failed (with persistent shoulder pain and dysfunction), salvage procedures are offered.^{9,23} Depending on the patient's age, activity level, and concomitant glenohumeral joint disease, arthroplasty has also been used in these settings, with and without pectoralis major transfer. Hemiarthroplasty has been attempted with varying levels of success and restoration of function^{12,16,32}; however, anatomic total shoulder arthroplasty is contraindicated in the setting of rotator cuff dysfunction because of concern for eccentric glenoid wear, early loosening, and poor functional results.² More recently, reverse total shoulder arthroplasty has gained popularity for selected older and lower-demand patients.⁵

Although arthroplasty may be appropriate in older patients, the management of high-demand, active, or young patients with an irreparable subscapularis tear continues to represent a significant therapeutic challenge. Several authors have advocated tendon transfers in this setting, assuming that the patient has a well-preserved glenohumeral joint.^{7,15,30,31} Non-arthroplasty reconstruction options include arthroscopic debridement with biceps tenotomy or tenodesis⁸ and tendon transfer, commonly involving the pectoralis major.^{17,23,33} The pectoralis major can be transferred in its entirety, or it can be split.^{13,29} The tendon is then rerouted beneath the conjoined tendon or transferred superficially. In this way, a transfer is used to rebalance the forces on the humeral head through an inferiorly directed force vector. If rerouted deep to the conjoined tendon, the pectoralis transfer is thought to also reduce subcoracoid impingement through a soft-tissue interposition effect that aids in pain relief. These techniques can be used for subscapularis tears in isolation, for subscapularis tears with anterior supraspinatus tears, or in combination with posterior cuff repair for posterosuperior tears. In addition, they have been used for subscapularis insufficiency after failure of subscapularis repair after open shoulder stabilization or shoulder arthroplasty.^{11,24,25} The latter case, subscapularis insufficiency after arthroplasty, presents a significant therapeutic challenge, often because of recurrent instability.¹ We will review the relevant surgical anatomy, surgical techniques, biomechanical rationale, and clinical outcomes of pectoralis transfers.

Anatomic considerations

Tendinous anatomy

The pectoralis major insertion consists of 2 distinct layers.^{18,20,33} The anterior lamina is the terminal portion of

the clavicular head, whereas the posterior lamina originates from the sternal head. A variable third layer, the abdominal lamina, is derived from the aponeurosis of the external oblique muscle medially. The sternal and clavicular lamellae fuse into a single tendon that then rotates nearly 180° about its longitudinal axis before insertion on the anterior humerus. This rotation results in the inferior (sternal) fibers attaching superior and posterior to the clavicular fibers on the humerus when the arm is in an adducted position. Jennings et al¹⁸ found the anterior lamina (clavicular head) to be 1.5 cm long and 2.9 cm wide at the musculotendinous junction and 4.7 cm wide at the humeral insertion. The posterior lamina (sternal head) had dimensions of 3.7 cm, 2.1 cm, and 4.3 cm, respectively. At the humeral insertion, the two tendons overlap approximately 2.7 cm, producing a total footprint between 5.7 and 6.3 cm.^{18,20,33}

Muscular anatomy

The muscle of the pectoralis major arises primarily from the anterior surfaces of the medial clavicle, the length of the sternum, the cartilage of ribs 2 through 7, and the aponeurosis of the external oblique muscle. The clavicular muscle belly constitutes 61% of the total muscle bulk. The two primary muscle bellies, clavicular and sternal, are separated by an intermuscular septum that is more distinct laterally near the musculotendinous junction than within the muscle proper. The three muscle bellies are morphologically indistinct medially at their bony origins, beginning at a point about 10.5 cm medial to the humeral insertion.¹⁸

Neurovascular anatomy

Two branches of the subclavian artery, thoracoacromial and lateral thoracic, provide the primary blood supply to the pectoralis major. The thoracoacromial artery travels medial to the muscular division, whereas the lateral thoracic artery crosses the septum between the two muscle bellies at a mean of 8.5 cm medial to the humeral insertion.

The innervation of the pectoralis major conveniently allows for separation of its two muscle bellies. The lateral pectoral nerve arises from the lateral cord of the brachial plexus, passes medial to the pectoralis minor, and enters the clavicular head superior to the intermuscular septum.¹⁸ In a separate study, the lateral pectoral nerve was found to enter the clavicular head at a mean of 12.5 cm (range, 10–14.9 cm) medial to its humeral insertion.²⁰

The medial pectoral nerve begins as a terminal branch of the medial cord. In most instances, it travels through the substance of the pectoralis minor before entering the undersurface of the pectoralis major. Klepps et al²⁰ reported variable paths for the medial pectoral nerve, noting that it sometimes passed lateral to the pectoralis minor. Jennings et al¹⁸ further confirmed this, reporting that it passed lateral to the pectoralis minor in 4 of 24 cadavers whereas the nerve divided in 2 specimens (8%), with one branch

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