Pectoralis Major Transfer: Technique Variations

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Abstract: Subscapularis tears are commonly seen in orthopedic practice and, of all lesions of the rotator cuff these can cause the worst functional deficit of the shoulder. These tears can become surgically irreparable, especially in chronic traumatic cases. The most commonly used surgical procedure to restore horizontal stability is the pectoralis major transfer. Surgical variations for this procedure in the literature include total or partial muscle transfer, transfer above or underneath the conjoint tendon, and the muscle portion to be transferred (clavicular or sternal). The objective of this study was to review the orthopedic literature, to evaluate the most widely utilized surgical technique variations and their results.

Keywords: Rotator Cuff, Pectoralis Muscles, Tendon Transfer, Shoulder Impingement Syndrome.

1. INTRODUCTION

The pectoralis major muscle performs adduction, flexion and medial rotation functions of the shoulder. It is triangular shaped and arises from the anterior surface of the medial third of the clavicle, the sternum (anterior surface), from the 2nd to 7th costalcartilages, and from the aponeurosis of the external oblique muscle. Thepectoralis major inserts laterally into the humerus and above the tendon of the biceps brachii. The two primary muscular bellies, the clavicular and sternal portions, are separated by an intermuscular septum, which is more distinct laterally, proximal to the musculotendinous junction [1, 2, 3]. Its tendon measures, on average, 80.8mm in length and 6.1mm in width, and is divided into 2 layers: the anterior lamina which forms the end part of the clavicular head, and the posterior lamina which arises from the sternum head. There is also a variant (third layer): a more medial, abdominal lamina, which forms from the aponeurosis of the external oblique muscle. The anterior and posterior portions end in one tendon, which rotates 180° on its longitudinal axis, before insertion into the humerus, while the sternal portion inserts poster superiorly into the clavicular fibers. Some cadaver studies have reported these musculotendinous layers cannot be differentiated in their region of insertion into the humerus [1,4].

The pectoralis major is supplied by three branches of the subclavian artery: thoracoacromial (main), superior thoracic and lateral thoracic. The thora-coacromial artery runs medially to the muscle division, whereas the lateral thoracic artery traverses the muscle septum, approximately 8.5cm medial to the humeral insertion. The superior thoracic artery travels anteromedially to the upper edge of the pectoralis major to the chest wall [1, 2]. Its innervations have different origins for each muscle belly: the lateral portion (C5, C6) arises from the lateral fasciculus of the brachial plexus, runs medially to the pectoralis minor and enters the clavicular portion above the intermuscular septum; the innervation of the medial portion starts at the terminal branch of the medial fasciculus (C8, T1), and in most cases continues across the pectoralis minor (running lateral to this in variants), prior to entering the lower surface of its muscle belly. The middle pectoral nerve runs laterally to the thoracic artery and is at risk of injury during the division of the two muscle portions [1].

The subscapularis is the strongest muscle of the rotator cuff and helps stabilize the glenohumeral joint. Its insufficiency, due to tendon rupture, muscle lesion or neurological injury, leads to horizontal imbalance of the forces acting on the humeral head, with severe functional deficit and pain [5]. This imbalancecan also cause humeral head ascension, anterior subluxation and glenohumeral instability [1, 6, 7]. In cases of isolated and irreparable lesion (or associated with lesion of the supraspinal muscle) in active young patients, pectoralis major transfer muscle, associated with tenotomy and tenodesis of the long head of the biceps brachii can be a good surgical option [1, 8].

The pectoralis major transfer technique was first described in 1997 by Wirth and Rockwood for irreparable injuries of the subscapularis. Subsequently, Resch *et al*. described the transfer of the upper two-thirds of the pectoralis major tendon underneath the conjoint tendon. The technique was later modified to pectoralis major transfer underneath the conjoint tendon [7]. In a technique to avoid musculocutaneous nerve damage and improve the muscle force vector,

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Warner *et al*. performed the transfer of only the sternal portion of the pectoralis major underneath the clavicular portion and above the conjoint tendon [10, 2].

Our literature review revealed variations in the pectoralis major muscle transfer technique, used for irreparable injuries of the subscapularis: total or partial muscle transfer, underneath or above the conjoint tendon, and different muscle portions transferred (sternal or clavicular). The objective of this study was to review the orthopedic literature to evaluate the most widely utilized surgical technique variations and their respective results.

2. MATERIALS AND METHODS

A review was carried out of the orthopedic literature published between 2000 and 2015 held on the following databases: the Regional Library of Medicine (BIREME), Medline, PubMed, Cochrane Library and Google Scholar. Combinations of the following search terms were employed: pectoralis major transfer, subscapular injury. Studies addressing the following topics were selected: pectoralis major transfer and subscapularis injury, in English or Portuguese.

3. RESULTS

Valenti *et al*. conducted a prospective study comparing transfer of the clavicular or sternal portion of the pectoralis major underneath the conjoint tendon in 15 patients with irreparable tears of the subscapularis, of this patient group, 8 were submitted to transfer of the clavicular portion and 7 of the sternal portion. After a mean follow-up of 24 months, the authors found no statistical differences between the two surgical techniques, and concluded that both were effective for improving shoulder pain and function [11].

Resch *et al*. carried out pectoralis major transfer in 12 patients with a mean age of 65 years, and observed improvements in shoulder pain and function on the Constant-Murley scales. The authors recommended transfer of 50% of the pectoralis major for patients with isolated ruptures of the subscapularis, and 2/3 for associated injuries of the subscapularis and supraspinal muscles. The clavicular portion of the pectoralis major was transferred because the sternal portion, according to the authors, compromised vascular supply of the muscle. The authors explained that the clavicular portion had segmental branching of the thoracoacromial artery, responsible for maintaining blood supply in the transfers. They also opted for transposition of the pectoralis major underneath the conjoint tendon owing to two main biomechanical advantages: Interposition of soft tissue between the coracoid process and humeral head (with reduction in bone attrition and consequent pain relief) and improvement in the horizontal stability of the shoulder, since the transferred tendon is placed in an anatomically more favorable position, acting as a force vector more closely resembling that of the subscapular muscle [7].

Vidil *et al*. treated 5 patients with a mean age of 54 years (45-71 years) that had irreparable subscapularis tears. Four of these patients had undergone acromioplasty, two of which had been submitted to concomitant repair of rotator cuff tears. One patient had humeral arthroplasty with associated injury of the subscapularis. The transfer was performed using the clavicular portion of the pectoralis major, inserted into the lesser tubercle with transosseous sutures. Average follow-up time was 19 months for clinical and radiological assessment. The authors concluded that this method can promote improvement in pain and anterior stability. They also stated that improvement in anterior subluxation of the humeral head can help prevent secondary degeneration of the glenohumeral joint [12].

Jost *et al*. performed 30 pectoralis major transfers in rotator cuff tears, comprising 12 isolated subscapularis tears, 13 subscapularis tears associated with supraspinal tears, and 5 subscapularis, supraspinatus and infraspinatus tears. The operations were performed by transferring the whole pectoralis major tendon, above the conjoint tendon with fixation by anchors medially to the greater tubercle. The authors noted that superior subluxation of the humeral head was not restored but the post-operative clinical outcome was satisfactory, leading to improvement in pain, likely attributed to improved horizontal equilibrium of the joint. Outcomes in patients with subscapularis tears alone or associated with supraspinatus tears were better than for tears associated with the infraspinatus muscle [13].

Jennings *et al*. carried out an anatomical study of 22 cadavers involving dissection of the pectoralis major insertion, assessing the possibility of identifying their sternal and clavicular portions. The authors concluded that, in all cases, it was possible to identify and split the two muscle portions, where transfer of the sternal portion produced a more similar force vector to that of the subscapularis muscle. The authors concluded that splitting the two muscle portions was a safe and effective surgical procedure [14].

In their casuistic, Hackl *et al*. made no distinction between the two portions of the pectoralis major, using 50% to 2/3 of the muscle tendon for transfers in the treatment of irreparable subscapularis tears. The surgical technique used was conjoint tendon transfer, performing humeral fixation with transosseous sutures in the lesser tubercle and 30 degree external rotation to reduce tension at the time of suturing. Applying the Constant scale, the authors observed that scores improved from 35 points pre-operatively to 68 points post-operatively. They also found that, after clinical improvement, internal rotation force of the shoulder was not restored [6].

Elhassan *et al*. compared transfer of the sternal portion of the pectoralis major above the conjoint tendon in three groups of patients with irreparable subscapularis tears: Group 1, comprising 11 patients previously submitted to open surgery for treatment of anterior glenohumeral instability; Group 2, with 8 patients previously submitted to total or partial arthroplasty of the shoulder for fracture, osteoarthrosis or a vascular necrosis; and Group 3 with 11 patients previously submitted to attempted arthroscopic repair of severe rotator cuff tears. The authors observed poor results only in Group 2 (post-arthroplasty), probably due to associated prosthetic subluxation. Groups 1 and 3 showed improvements in pain and on subjective assessments by each patient, with statistically significant improvement relative to pre-operative assessment [15].

In a bibliographic review, Nelson *et al*. concluded that failures in pectoralis major transfer surgery were generally attributed to anterosuperior instability, associated with severe rotator cuff tears or prior arthroplasty. These patients had less pain relief and unsatisfactory functional outcomes, mirroring the results found by Elhassan *et al*. [1, 15].

In a study of 10 cadavers, Gibon *et al*. carried out arthroscopic transfer of the pectoralis major for irreparable tears of the subscapularis using the arthroscopic technique. The surgical technique entailed making a small incision of around 4.7cm to detach the pectoralis major tendon from the humerus. The arthroscopic procedure then ensued with introduction of the optic *via* the posterior hole. An anteroinferior hole was then made at the rotator interval for dissection of the coracoid process, and another anterosuperior hole, before the long head of the biceps, to remove the remaining subscapularis tendon from the greater tubercle. The next surgical step was transposition of the pectoralis major tendon underneath the conjoint tendon and subsequent fixation with 2 metal anchors into the lesser tubercle. The author suggested that this technique can be feasible, and although challenging and requiring preliminary analysis in cadavers, may prove promising, conferring all the advantages of shoulder arthroscopy [16].

Shin *et al*. carried out a systematic review of 8 articles on pectoralis major transfer for irreparable subscapularis tears. In five of the articles, the Resch techniques was reported, in which 50% to 2/3 of the pectoralis major tendon was used in transfer of the clavicular portion underneath the conjoint tendon. In two studies, the pectoralis major was transferred superficially to the conjoint tendon. One of the studies failed to report the technique used. Muscle transfer underneath the conjoint tendon attained a higher weighted average Constant score (63.0±4.0) compared to transfer above the conjoint tendon (57.3±7.0) ($p<0.001$). The authors concluded that, despite the small statistical difference, a clinical difference between the groups was unlikely. Likewise, no statistically significant difference for musculocutaneous nerve damage was found between the methods. The authors also reported improvements in function, force and pain after pectoralis major transfer in patients with irreparable subscapularis tears, irrespective of the method used [17, 7].

Lederer *et al*. assessed pectoralis major transfer underneath the conjoint tendon, with and without bone graft taken from the humeral insertion. The authors compared the two groups using the Constant score and magnetic resonance imaging. They detected no statistical differences between the two techniques, with both procedures showing good and excellent outcomes [18].

Gavriilidis *et al*. performed transfer of the clavicular portion of the pectoralis major underneath the conjoint tendon in 15 patients with anterosuperior rotator cuff tears, involving the subscapularis and supraspinatus muscles. Sutures were applied in the lesser tubercle and anterior region of the greater tubercle. Mean follow-up was 37 months and the Constant and Murley scales were applied for assessment. The authors concluded that the technique produced good results, with improvement in pain and partial restoration of the range of motion of the shoulder. They also concluded that this surgical technique can also be used in anterosuperior rotator cuff tears [8].

Ruiz-Iban *et al*. found scant biomechanical evidence for superiority of pectoralis major transfer underneath

the conjoint tendon over transfer above the conjoint tendon. The authors noted that this technique may not be safe for some patients because of insufficient space between the conjoint tendon and musculocutaneous nerve. The authors further suggested that transfer of the sternal portion of the pectoralis major may be more indicated because the orientation of the muscle fibers is more anatomical and similar to that of the subscapularis. Moreover, in terms of the optimal site for tendon insertion into the humerus, the best approach (proving more anatomical) was medial to the bicipital groove [19].

4. DISCUSSION

Subscapular is injuries cause horizontal imbalance of the forces acting on the humeral head, resulting in functional deficit and pain in the shoulder [1, 5, 7]. In cases of irreparable tears in young active patients, pectoralis major transfer is the most widely used technique, according to the literature reviewed, and produces good results [1, 2, 6-20].

Regarding the ideal portion of the pectoralis major muscle to be used in the transfer (sternal or clavicular portions), studies advocating the use of both techniques were found, each with inherent advantages and disadvantages. The authors advocating the use of the sternal portion largely point to the benefits of the orientation of the muscle fibers, which are similar to that of the subscapularis, and thus have a more anatomical force vector [14, 15, 19]. Transfer of the clavicular portion is also recommended, mainly owing to the safety in maintaining vascularization of the muscle belly [7,8,12].

With regard to the amount of the pectoralis major which should be transferred, there is disagreement in the literature, varying according to the technique elected: underneath or above the conjoint tendon. In the case of transfer above the conjoint tendon, there is a tendency to use a larger amount of muscle, whereas a lower quantity is used in the underneath option in order to prevent compression of the musculocutaneous nerve. Transfer underneath the conjoint tendon provides the benefit of more anatomical restoration of the muscle force vector, but has the drawback of greater risk of nerve damage. Most of the studies reviewed showed preference for the technique involving transfer underneath the conjoint tendon owing to the biomechanical gains although no statistical advantage of one technique over the other was evident [6-10, 15, 17-20].

CONCLUSIONS

There was a consensus in the literature consulted with respect to the benefits of pectoralis major transfer surgery for management of irreparable tears to the subscapularis, but no agreement on the different techniques available: total or partial muscle transfer, transfer above or underneath the conjoint tendon, or which muscle portion should be transferred (clavicular or sternal).

CONFLICTS OF INTEREST

The authors of this study declare there was no conflict of interest.

REFERENCES

[1] Nelson GN, Namdari S, Galatz L and Keener JD. Pectoralis major tendon transfer for irreparable subscapularis tears. J Shoulder Elbow Surg 2014; 23(6): 909-18. https://doi.org/10.1016/j.jse.2013.12.035

[2] Omid R and Lee B. Tendon transfers for irreparable rotator cuff tears. J Am Acad Orthop Surg 2013; 21(8): 492-501. https://doi.org/10.5435/JAAOS-21-08-492

[3] Ejnisman B, Carrera EF, Abdalla RJ, Cohen M, Andreoli CV, *et al*. Ruptura do músculo peitoral maior em atletas. Rev Bras Ortop 2002; 37(11-12): 482-488.

[4] Figueiredo EATB, Cohen C, Monteiro GC, Pochini AC, Andreoli CV, Cohen M, *et al*. Footprint do tendon do pectoral major: study anatomic. Rev Bras Ortop 2013; 48(6): 519-23. https://doi.org/10.1016/j.rbo.2013.02.001

[5] Godinho GG, França FO, Freita JMA, Santos FML, Santos RBM, *et al*. Resultados do reparo artroscópico das roturas isoladas do tendão do músculo subescapular. Rev Bras Ortop 2012; 47(3): 330-336 https://doi.org/10.1590/S0102-36162012000300009

[6] Hackl W, Wambacher M, Kralinger F and Smekal V. [Pectoralis major transfer in the treatment of chronic subscapularis insufficiency]. Oper Orthop Traumatol 2007; 19(5-6): 433-41. https://doi.org/10.1007/s00064-007-1026-5

[7] Resch H, Povacz P, Ritter E and Matschi W. Transfer of the pectoralis major muscle for the treatment of irreparable rupture of the subscapularis tendon. J Bone Joint Surg Am 2000; 82(3): 372-82. https://doi.org/10.2106/00004623-200003000-00008

[8] Gavriilidis I, Kircher J, Magosch P, Lichtenberg S and Habermeyer P. Pectoralis major transfer for the treatment of irreparable anterosuperior rotator cuff tears. Int Orthop 2010; 34(5): 689-94. https://doi.org/10.1007/s00264-009-0799-9

[9] Wirth MA and Rockwood CA. Operative Treatment of Irreparable Rupture of the Subscapularis. J Bone Joint Surg Am 1997; 79(5): 722-31. https://doi.org/10.2106/00004623-199705000-00012

[10] Warner JJP. Management of Massive Irreparable Rotator Cuff Tears: The Role of Tendon Transfer. J Bone Joint Surg Am 2000; 82(6): 878. https://doi.org/10.2106/00004623-200006000-00019

[11] Valenti P, Boughebri O, Moraiti C, Dib C, Maqdes A, Amouyel T, *et al*. Transfer of the clavicular or sternocostal portion of the pectoralis major muscle for irreparable tears of the subscapularis. Technique and clinical results. Int Orthop 2015; 39(3): 477-83. https://doi.org/10.1007/s00264-014-2566-9

[12] Vidil A and Augereau B. Transfer of the clavicular portion of the pectoralis major muscle in the treatment of irreparable tears of the subscapularis muscle. Rev Chir Orthop Reparatrice Appar Mot 2000; 86(8): 835-43.

[13] Jost B, Puskas GJ, Lustenberger A and Gerber C. Outcome of pectoralis major transfer for the treatment of irreparable subscapularis tears. The J Bone Joint Surg Am 2003; 85-A(10): 1944-51. https://doi.org/10.2106/00004623-200310000-00012

[14] Jennings GJ, Keereweer S, Buijze GA, De Beer J and DuToit D. Transfer of segmentally split pectoralis major for the treatment of irreparable rupture of the subscapularis tendon. J Shoulder Elbow Surg 2007; 16(6): 837-42. https://doi.org/10.1016/j.jse.2007.03.030

[15] Elhassan B, Ozbaydar M, Massimini D, Diller D, Higgins L, *et al.* Transfer of pectoralis major for the treatment of irreparable tears of subscapularis: does it work?. J Bone Joint Surg Br 2008; 90(8): 1059-65. https://doi.org/10.1302/0301-620X.90B8.20659

[16] Gibon E, El Hajj F and Ouaknine M. Arthroscopic transfer of the pectoralis major for irreparable tear of the subscapularis: a preliminary report. Arthrosc Tech 2014; 3(1): e61-4. https://doi.org/10.1016/j.eats.2013.08.012

[17] Shin JJ, Saccomanno MF, Cole BJ, Romeo AA, Nicholson GP, et al. Pectoralis major transfer for treatment of irreparable subscapularis tear: a systematic review. Knee Surg Sports Traumatol Arthrosc 2016; 24(6): 1951-60. https://doi.org/10.1007/s00167-014-3229-5

[18] Lederer S, Auffarth A, Bogner R, Tauber M, Mayer M, et al. Magnetic resonance imaging-controlled results of the pectoralis major tendon transfer for irreparable anterosuperior rotator cuff tears performed with standard and modified fixation techniques. J Shoulder Elbow Surg 2011; 20(7): 1155-62. https://doi.org/10.1016/j.jse.2011.01.023

[19] Ruiz-Iban MA, Murillo-Gonzalez JA, Diaz-Heredia J, Avila-Lafuente JL and Cuellar R. Pectoralis major transfer for subscapular deficiency: anatomical study of the relationship between the transferred muscle and the musculocutaneous nerve. Knee Surg Sports Traumatol Arthrosc 2013; 21(9): 2177-83. https://doi.org/10.1007/s00167-013-2432-0

[20] Konrad GG, Sudkamp NP, Kreuz PC, Jolly JT, McMahon PJ, *et al.* Pectoralis major tendon transfers above or underneath the conjoint tendon in subscapularis-deficient shoulders. An in vitro biomechanical analysis. J Bone Joint Surg Am 2007; 89(11): 2477-84. https://doi.org/10.2106/JBJS.F.00811

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