

Results of pectoralis major transfer with fascia lata autograft augmentation for scapula winging

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Fifteen patients (9 male and 6 female) with a mean age of 32.8 years (range, 17-44 years) were examined at a mean follow-up of 64 months (range, 33-118 months) after undergoing pectoralis major transfer with a fascia lata autograft for scapular winging. Ten patients were treated as part of a worker's compensation claim. Twelve reported that they would undergo the procedure again. The mean Rowe score was 66 (range, 41-92), the mean Constant-Murley score was 74 (range, 32-95), the mean Simple Shoulder Test score was 8 of 12 positive responses, and the mean American Shoulder and Elbow Surgeons score was 63 (range, 10-87). Pain decreased in 11 patients, whereas function improved in 10 patients. According to the Rowe scoring system, the results were excellent in 2 patients, good in 5, fair in 4, and poor in 4. Better results occur in patients attaining at least 60° of external rotation postoperatively. Although complete relief of pain and full function were not always achieved, most patients returned to their preoperative level of activity with minor adaptations. (*J Shoulder Elbow Surg* 2002;11:345-50.)

INTRODUCTION

Scapular winging is a common abnormality of the shoulder complex and can cause debilitating pain. Although winging can be caused by weakness of the trapezius or rhomboid muscles, serratus anterior dysfunction is the most commonly cited cause of scapular winging in the literature.

Originating from the lateral aspects of the upper 8 ribs, the serratus anterior inserts into the anteromedial border and the inferior angle of the scapula. The serratus anterior functions during arm elevation to

stabilize the scapula to the chest wall. It is the most powerful protractor of the whole upper limb. With weakness of the muscle, arm elevation causes the inferior angle of the scapula to rotate medially and the medial border of the scapula to migrate posteriorly off the chest wall.

Although scapular winging can be asymptomatic, pain occurs when compensating periscapular muscles become fatigued. Patients also report weakness with overhead activities because of the loss of scapular stabilization.

The long thoracic nerve is formed from the anterior rami of C5 to C7, and its injury causes serratus anterior weakness or paralysis. The roots of C5 and C6 run through the middle scalene muscle, then merge with fibers from C7, before traveling along the lateral aspect of the thorax. The superficial location of the long thoracic nerve makes it susceptible to blunt trauma, stretching injuries, brachial plexus neuritis, Parsonage-Turner syndrome, and iatrogenic injuries.

Typically, serratus anterior palsy resolves over the course of 8 to 12 months.^{8,9,11,12,14-17,22} Initial treatment centers on gentle range-of-motion exercises to avoid a stiff shoulder. Electromyographic studies can be obtained at 3-month intervals to document recovery of the nerve. If, after a year, there is no sign of recovery on physical examination and electromyography, many surgical options may be offered.^{4,5,9,11,13,19,23} We report the results of 15 patients in whom nonoperative management failed and who underwent transfer of the sternal head of the pectoralis major to the inferior angle of the scapula for serratus anterior weakness.

MATERIALS AND METHODS

From November 1988 to January 1996, 21 patients with severe, disabling, chronic scapular winging had a pectoralis major transfer with tensor fascia lata autograft placed into the inferior portion of the scapula. The same surgeon (M.P.) performed all operations. All of the patients were initially evaluated and treated at other facilities for painful shoulder conditions other than scapular winging. Because of persistent pain and loss of function, they were referred to us for treatment. Of the 21 patients, 1 had died of an unrelated illness and 5 were unavailable for repeat physical examinations but had documented evidence of intact tendon transfer. Thus, 15 patients (9 male and 6

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Table Patient data and outcomes

Patient	Sex	Age at surgery (y)	Prior surgeries	Worker's compensation	Follow-up (mo)	Subjective winging	Objective winging*
1	F	44	—	Yes	57	Mild	1.5 cm with 20 lb
2	F	21	Open reconstruction	Yes	38	Mild	1.5 cm with 10 lb
3	M	38	(1) Distal clavicle resection, (2) Anterior capsular shift, (3) Biceps tenodesis, (4) Posterior capsular shift, (5) Revision capsular shift, (6) Arthroscopic debridement	Yes	53	Mild	1.7 cm with 15 lb
4	F	33	—	No	98	Mild	1.3 cm with 8 lb
5	M	37	—	Yes	84	Moderate	2.1 cm with 25 lb
6	M	40	Arthroscopic acromioplasty	Yes	77	Negligible	0.6 cm with 25 lb
7	F	38	—	Yes	74	Negligible	None with 25 lb
8	F	37	—	No	33	Moderate	2.5 cm with 5 lb
9	M	44	Manipulation	Yes	36	Mild	1.1 cm with 5 lb
10	M	30	Arthroscopic acromioplasty	Yes	60	Negligible	0.4 cm with 15 lb
11	M	18	—	No	79	Mild	2.0 cm with 10 lb
12	M	17	Capsular shift	No	48	Mild	2.0 cm with 25 lb
13	F	25	(1) Partial excision of scapula, (2) Capsular shift	No	50	Negligible	None with 8 lb
14	M	27	—	Yes	118	Negligible	None with 25 lb
15	M	44	Distal clavicle resection	Yes	63	Negligible	None with 10 lb

*Winging measured while patient held as much weight as possible in abduction. A ruler measured the distance from the posterior thorax to the tip of the inferior scapula.

†Without caveat.

female) were available for follow-up at a mean of 64 months (range, 33-118 months) after undergoing pectoralis major transfer with tensor fascia lata autograft (Table). Ages ranged from 17 to 44 years (mean, 32.8 years). Winging was caused by trauma in 12 patients (fall from a height in 3, wall collapsing on 2, a large metal roll injuring the arm in 1, ceiling tile falling on 1, catching a falling industrial pipe in 1, a football injury in 1, restraining a prisoner in 1, garbage slinging in 1, and a motor-vehicle accident in 1). Winging was idiopathic in 2 cases and iatrogenic in 1 after radiation therapy. This latter patient had adhesive capsulitis of the shoulder develop and was referred to undergo physical therapy. An aggressive stretching session caused injury to the long thoracic nerve, resulting in winging. Eleven of the patients had jobs involving heavy labor (3 carpenters, 2 electricians, 1 self-described heavy laborer, 1 sheriff's deputy, 1 transport supervisor, 1 radiology technician, 1 garbage slinger, and 1 landscaper) and 4 had sedentary jobs (2 in sales, 1 physician reimbursement specialist, and 1 physician). Ten patients were treated as part of a worker's compensation claim. Eight had 14 procedures before undergoing the pectoralis transfer. These procedures included 6 capsular shifts, 3 arthroscopic acromioplasties, 2 distal clavicle resections, 1 inferior scapula excision, 1 manipulation of the shoulder under anesthesia, 1 biceps tenodesis, and 1 arthroscopic debridement. All patients had prominent scapular winging, weakness of arm abduction, and fatigue with overhead activities. Long thoracic nerve lesions were documented by electromyography in 11 patients. The pectoralis transfer was performed a mean of 25 months (range, 3-72 months) after presentation

to the senior surgeon (M.P.). A complete discussion of the surgical protocol has been published previously.¹⁹

At follow-up, all 15 patients were given a subjective questionnaire to complete before the examination. A single independent investigator (M.S.), who was not involved in the surgeries, conducted a comprehensive examination that combined the Rowe,²⁰ Constant-Murley,³ Simple Shoulder Test, American Shoulder and Elbow Surgeons,¹ and Short Form-36 (SF-36)²⁵ rating scales. Strength was assessed by asking the patient to maintain as much weight as possible at 90° of abduction. A grading system was developed by the authors to measure the amount of winging while the patient performed strength testing. A ruler was used to calculate the distance from the tip of the inferior scapula to the posterior thorax. A measurement of 1 cm or less was defined as negligible, from 1 to 2 cm as mild winging, from 2 to 3 cm as moderate winging, and greater than 3 cm as severe winging. Outcomes were defined by means of Rowe²⁰ shoulder evaluation and Constant-Murley³ clinical assessment. The SF-36 was also used to provide a measure of the patient's general health.²⁴ Statistical analysis was performed with the paired 2-sample *t* test.

RESULTS

According to the criteria of the Rowe assessment, 2 of the 15 patients had excellent results, 5 had good results, 4 had fair results, and 4 had poor results (Table). The mean Rowe score was 66 (range, 41-92), the mean Constant-Murley score was 74 (range,

Adverse outcomes	Rowe	Constant-Murley	Outcome (Rowe)	Job before injury	Present job	Would repeat surgery
Thigh muscle herniation	92	95	Excellent	Sheriff's deputy	Voluntary retirement	Yes
	76	76	Good	Sales	Same	Yes
	51	51	Fair	Carpenter	Same	Yes
Adhesive capsulitis	90	74	Excellent	X-ray technician	Magnetic resonance imaging technician	Yes
	82	95	Good	Carpenter	Same	Yes
	63	84	Fair	Carpenter	Finishing carpenter	Yes
	83	81	Good	Transport supervisor	Same	Yes
	49	60	Poor	Physician	Same	Yes†
	45	32	Poor	Sales with heavy lifting	Sales without lifting	No
	82	73	Good	Laborer	Same	Yes
	58	73	Fair	Garbage slinger	Same	No
	48	80	Poor	Electrician	Same	Yes†
	41	65	Poor	Physician reimbursement specialist	Same	Yes
Continued pain	74	93	Good	Tree trimmer	Laborer	Yes
	57	Data missing	Fair	Electrician	Retired	No

32-95), the mean Simple Shoulder Test score was 8 of 12 positive responses (range, 1-12 positive responses), and the mean American Shoulder and Elbow Society score was 63 (range, 10-87). Of the 15 patients, 12 stated that they would undergo the surgery again if they had a similar injury in their contralateral shoulder.

Health assessment status was determined by the SF-36. The patients scored lowest in the domains of physical role and bodily pain. The mean raw scores for these were 57.1 (SD, 38.5) and 57.4 (SD, 31.0), respectively. The highest results were in the areas of emotional role (mean, 82.2; SD, 35.3), physical function (mean, 76.6; SD, 20.6), social function (mean, 75.0; SD, 9.45), and mental health (mean, 73.6; SD, 25.3). General health and vitality assessments scored 68.3 (SD, 20.2) and 58.7 (SD, 18.6), respectively.

On follow-up evaluation, although no patient was completely pain-free with all activities, pain decreased in 11 of the 15 patients. Only 1 patient complained of pain at rest and needed narcotics. Four patients stated that they had slight pain during activity, and four stated they had significantly increased pain with activity. Six patients described their current pain as moderate to severe with activity only. Every patient reported significant subjective improvement in their winging. None of the 15 patients had failure or stretching of their graft. Six patients had negligible winging upon strength testing, 7 had mild winging, and 2 had moderate winging (Table).

Of the 15 patients, 13 returned to their former jobs or similar ones. One patient changed her job from an x-ray technologist to a magnetic resonance imaging technologist because the latter job did not require as much lifting. One carpenter became a finishing carpenter, also to avoid heavy lifting. In addition, one salesperson switched to a different job in sales to avoid heavy lifting. Two patients retired. One voluntarily retired but stated that she could have continued as a sheriff's deputy. The other patient retired because of continued disability in his shoulder.

Four patients required additional surgeries after their pectoralis major transfer. Of these 4 procedures, 2 were subacromial decompressions and 1 was a distal clavicle excision. The fourth was a revision posterior capsular shift in a worker's compensation patient, who ended up having a good result and declared that she would have the pectoralis major transfer surgery again. Because these patients were evaluated after their subsequent procedures, it is difficult to ascertain how much the pectoralis major tendon transfer helped as opposed to the subsequent surgery. Even so, 3 of the 4 patients stated that they would repeat the tendon transfer procedure. The one who would not repeat the surgery had a revision acromioplasty after the pectoralis major transfer and ultimately had a fair result. He was not able to continue his job as an electrician and retired.

Six patients reported having no instability complaints in their operated shoulder. Five patients expe-

rienced some apprehension with normal use of their arm. Of these 5, there were 2 good results, 1 fair, and 2 poor. Four patients reported that their shoulder has either subluxated or dislocated since the surgery. Of these 4, 2 had fair results and 2 poor. All 4 of these patients had reported instability in their shoulder preoperatively. All 3 patients with fair strength had poor outcomes. Seven patients had less than 60° of external rotation with the arm at the side on follow-up examination. These 7 patients with poor external rotation had either a poor or fair result according to Rowe's scoring system. One patient with a nearly normal range of motion had a fair outcome as a result of his report of functional limitations with overhead activities and difficulty with body care, necessitating an aide at times. There was no correlation between outcome and external rotation with the arm abducted 90°.

All operative limbs had decreased range of motion compared with the opposite arm. Forward elevation in the affected arm averaged 156° (range, 95°-180°) compared with 179° (range, 170°-180°) in the contralateral shoulder ($P = .021$). External rotation with the arm at the side measured 57° (range, 10°-90°) in the operated shoulder at follow-up and 72° (range, 45°-90°) in the nonoperated shoulder ($P = .017$). External rotation in 90° of abduction was 71° (range, 20°-105°) and 85° (range, 55°-105°) for the operated and nonoperated shoulders, respectively ($P = .028$). Internal rotation was also statistically different between the 2 sides, averaging to T9 (range, T6-L4) in the operated shoulder and T6 (range, T4-T7) in the nonoperated shoulder ($P = .007$).

Of the 10 patients who had filed worker's compensation claims, 6 had good or excellent results. Of the 5 who did not file for worker's compensation, only 1 had a good or excellent result. The mean Constant-Murley score of patients with worker's compensation claims was 76 compared with 70.4 for patients not filing for worker's compensation. The numbers in these groups are too small to make statistically relevant conclusions.

There were 4 adverse outcomes in this group of 15 patients. Two patients had persistent adhesive capsulitis postoperatively, one of whom had adhesive capsulitis preoperatively from radiation therapy for breast cancer. Both of these patients have returned to either the same job or a similar type of employment. One patient complained of muscle bulging on the lateral aspect of her thigh. It does not bother her enough to warrant surgical repair. She otherwise had an excellent outcome. It should be noted that most patients had bulging of the muscle, as the edges of the cut fascia were not closed and cannot be closed. All patients were told about this outcome preoperatively. One patient has persistent pain necessitating the use of Vicodin

(Knoll Pharmaceutical Company, Mount Olive, NJ) and can no longer work as an electrician.

DISCUSSION

The literature is replete with options for the surgical treatment of scapular winging. Scapulothoracic fusion stabilizes the scapula to the chest wall but limits the shoulder's range of motion excessively. It is still indicated, however, as a salvage procedure when all else fails.^{10,13} Fascial sling suspensions may ultimately fail because of stretching of the sling and recurrent winging.¹⁸ Muscle transfers have become the most popular alternative, as they provide a dynamic stabilizer to the scapula. The pectoralis major, pectoralis minor, teres major, and rhomboid muscles have all been used to address the problem of serratus anterior weakness.

The sternal head of the pectoralis major is a good choice for transfer because it has excellent excursion and power similar to the serratus anterior.⁶ The pectoralis minor is a weak muscle with a short excursion, and its transfer would likely act only as a tenodesis effect.¹¹ In 1904 Tubby²³ described a case in which the pectoralis major was sutured directly to the serratus anterior. Despite the fact that the repair eventually stretched out, this report paved the way for further tendon transfers. Dickson⁴ may have been the first to use fascia lata as a graft stabilizer. Other authors have described using rolled fascia lata as a connection between the pectoralis and scapula.^{5,11}

Connor et al² emphasized the importance of relying on the fascia lata as reinforcement and not as a connection between the pectoralis and scapula. In their technique, enough of the sternal head of the pectoralis major is harvested to allow direct contact between the pectoralis and scapula. Using this technique, they reported satisfactory results in 10 of 11 cases.

Post¹⁹ described the importance of properly preparing the fascia lata graft. He stated that when the graft is wound into a tight spiral and secured with a nonabsorbable suture, the risk of graft stretching is lessened and failures can be reduced significantly. In his original series, 8 patients had excellent results, although the assessment scale defining the outcome was not stated. The present study, which included these original 8 patients, uses accepted scoring systems whose standardization and validation allow for comparison to other studies.

This series may provide some valuable insight into the postoperative treatment of these patients. We have noted that all patients with limited external rotation (below 60°) postoperatively had significantly lower Constant-Murley scores than those with good postoperative external rotation. This would imply that a postoperative rehabilitation protocol emphasizing

the importance of regaining external rotation should be instituted soon after surgery. Post¹⁹ described maintaining the arm in internal rotation for 6 weeks in an immobilizer to protect the repair. Such a protocol may increase the risk of internal rotation contractures and adhesive capsulitis.

Interestingly, when external rotation in the 90° abducted position was reviewed, there was no difference between the groups. The group with excellent results had a mean external rotation in abduction of 77°, the group with good results 71°, the group with fair results 78°, and the group with poor results 78°. This implies that the postoperative immobilization in a sling for 6 weeks affected the rotator cuff interval and superior glenohumeral ligament selectively over the anterior-inferior glenohumeral ligament.

Currently, we believe that transfer of the pectoralis major is the most effective surgery for the treatment of serratus anterior palsy. We have made 2 modifications to improve our results. As done by Warner and Navarro,²⁶ we use a hamstring autograft to augment the pectoralis major tendon through smaller incisions. We expect that this modification will reduce the occurrence of fascial herniations and scar formation. We also use a much more aggressive postoperative protocol with regard to range of motion with emphasis on regaining external rotation with the arm at the side. Active assisted and gentle passive external rotation can be used with little concern about rupturing the transferred tendon out of the scapula. We use a protocol that includes early pendulum exercises and passive elevation with gentle external rotation achieving 45° of passive external rotation in the first 6 weeks. After suitable tendon-bone healing has occurred, by 6 to 8 weeks, the external rotation can be increased to 60°. Again, 6 out of 7 patients with at least 60° of external rotation at the side had good to excellent results.

Another variable is shoulder stability. All 4 patients reporting that their shoulder subluxated or dislocated in the postoperative period had unfavorable results. The explanation for residual shoulder instability after a tendon transfer for scapular winging is speculative at best. There are no data documenting the effect on glenohumeral stability after pectoralis major transfer for a deficient serratus anterior. A probable explanation is that these patients had persistent scapulothoracic dyskinesia postoperatively. With elevation of the arm in certain positions, the scapula is not effectively stabilized against the thorax, and thus, secondary glenohumeral instability may develop. These patients with persistent scapular dyskinesia may sense an unwanted translation with arm elevation that causes symptoms of instability including apprehension and pain. All 4 of these patients in this study had complaints of instability preoperatively documented in their charts as multidirectional instability. It is un-

certain whether their postoperative instability was a failure of the surgery to correct the scapulothoracic kinematics or a case of pre-existing capsular laxity necessitating capsular reefing.

The SF-36 is a questionnaire that measures 8 health concepts and provides a way to compare the health status of patients with different shoulder conditions. The health status results, as indicated by the SF-36 assessment, are comparable to those reported in the literature.^{7,21} When compared with the results of the SF-36 in patients recovering from rotator cuff surgery, all of the scores in the present study were at least as good, if not better.

Although limited by its retrospective and uncontrolled nature, this report presents a relatively large series of patients who underwent pectoralis major transfer for serratus anterior weakness with long-term follow-up. The results in this study parallel many of those in the literature. Direct comparison with other studies is limited, however, because no standard by which to assess shoulder function has been used. This study used the commonly accepted shoulder scoring systems and is a suitable reference for future studies in an effort to improve treatment of this challenging problem. However, this report does introduce into the literature an attempt to grade scapular winging in the patient. Future studies need to document the amount of winging preoperatively and postoperatively to determine whether there has been any objective improvement in the scapular instability.

We, therefore, conclude that pectoralis major transfer with a fascia lata graft can be an effective option for serratus anterior scapular winging. The importance of obtaining nearly full external rotation seems to be somewhat correlated with final outcome.

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