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Pectoralis major tendon transfer for the treatment of scapular winging due to long thoracic nerve palsy

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Background: Painful scapular winging due to chronic long thoracic nerve (LTN) palsy is a relatively rare disorder that can be difficult to treat. Pectoralis major tendon (PMT) transfer has been shown to be effective in relieving pain, improving cosmesis, and restoring function. However, the available body of literature consists of few, small-cohort studies, and more outcomes data are needed.

Materials and methods: Outcomes of 26 consecutive patients with electromyelogram-confirmed LTN palsy who underwent direct (n = 4) or indirect transfer (n = 22) of the PMT for dynamic stabilization of the scapula were reviewed. All patients were followed up clinically for an average of 21.8 months (range, 3-62 months) with evaluations of active forward flexion, active external rotation, American Shoulder and Elbow Surgeons (ASES) score, visual analog scale (VAS) pain score, and observation of scapular winging.

Results: Preoperative to postoperative results included increases in the mean active forward flexion from 112° to 149° ($P < .001$) an in mean active external rotation from 53.8° to 62.8° ($P = .045$), an improvement in the mean ASES score from 28 to 67.0 ($P < .001$), and an improvement in the mean VAS pain score from 7.7 to 3.0 ($P < .001$). Recurrent scapular winging occurred in 5 patients. There was no difference in outcome by length of follow-up.

Conclusions: PMT transfer is an effective treatment for painful scapular winging resulting from LTN palsy. This is the largest reported series of consecutive patients treated with PMT transfer for the correction of scapular winging.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Scapular winging; long thoracic nerve palsy; pectoralis major tendon transfer

Long thoracic nerve (LTN) palsy causing paralysis of the serratus anterior muscle is infrequently encountered.[1,4,5] The serratus anterior muscle functions to stabilize the scapula to the thorax during shoulder elevation,[2-4,8,13,15] and its vector of force provides the scapula with

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protraction and upward rotation.[13,15] Paralysis results in significant dysfunction of the shoulder, including restricted motion, decreased strength and endurance, and local pain with use.[2-6,8,9,12,13,15] Examination of the shoulder will reveal medial winging of the scapula with attempted forward flexion of the shoulder. Most LTN palsies will resolve within 6 to 18 months, and observation, with maintenance of range of motion (ROM), should be the basis of treatment.[2,4,8,9]

If conservative measures fail, transfer of the pectoralis major tendon (PMT) to the inferior angle of the scapula has shown promising results for treatment. Reported techniques have varied from transfer of the sternal head alone (direct method)[4,13] or with an interposed segment of autograft or allograft tendon (indirect method), usually taken from the fascia lata[2,5,6,8,9,12] or hamstrings.[2,3,15] This study describes the outcomes in a large series of consecutive patients with scapular winging who were treated with direct or indirect transfer of the PMT.

Materials and methods

Between January 2007 and November 2009, 26 patients underwent PMT transfer at 3 institutions for treatment of painful scapular winging resulting from LTN palsy that had been unresponsive to conservative management for an average of 58 months (range, 12-120 months) and remained symptomatic. The etiology of LTN palsy was confirmed as secondary to injury in 6 patients and was not known for the remaining 20. Physical therapy for range of motion (ROM) was maintained throughout the nonoperative period.

Patients were a mean age of 33.1 years (range, 16-53 years) at the time of surgery. Of the 26 patients (10 men, 16 women), 7 were smokers, 5 were involved in a worker's compensation claim, 5 had occupations involving at least light manual labor before injury, and 10 patients had undergone 20 previous shoulder operations. Although the relation of most of these procedures to the underlying LTN palsy could not be confirmed, the procedures in 4 patients were directly related to a suspected painful nerve lesion, comprising 2 brachial plexus neurolyses, 1 LTN decompression, and 1 scalene release.

The average follow-up at the time of the study was 21.8 months (range, 3-62 months). A subgroup analysis was performed to decipher any differences between the 17 patients with more than 12 months of follow-up and 9 patients with less than 12 months follow-up. Patient demographics and related information are reported in Table I.

All patients were treated by one of three surgeons (R.N., J.W., R.G.) who had been fellowship-trained in surgery of the shoulder. Inclusion criteria consisted of a diagnosis of LTN palsy confirmed by electromyography (EMG), painful winging of the scapula, and failure of conservative management for a minimum of 12 months. The study excluded patients with a diagnosis not confirmed by EMG.

Four patients were treated with direct transfer of the entire PMT by 1 surgeon (R.G.), who has made it standard practice to perform direct transfer of the PMT for all scapular winging that requires surgical intervention. The other 22 patients were treated with indirect transfer of the sternal head with interposed hamstring autograft by the other 2 surgeons, who routinely perform indirect transfers of the PMT for scapular winging requiring surgical treatment (R.N., n = 9; J.W., n = 13).

Postoperative care consisted of sling immobilization for 6 weeks to allow for healing, followed by passive ROM for 6 weeks, and finally, active ROM for 12 weeks before resumption of normal activities.

Preoperative evaluation of the affected shoulder consisted of American Shoulder and Elbow Surgeons (ASES) score, visual analog scale (VAS) pain score, assessment of active ROM in forward flexion and external rotation, and observation of scapular winging. The postoperative evaluation at most recent follow-up consisted of these same measures.

Table I Demographics

Pt	Age	Sex	Follow-up (mon)	Technique	Prior procedures
1	21	F	10	Direct	Latarjet, open subscapularis repair, brachial plexus neurolysis
2	41	F	16	Direct	Bankart ×2, manipulation under anesthesia, rotator cuff repair
3	27	M	14	Direct	Bankart
4	53	M	19	Direct	Arthroscopy, cervical spine fusion
5	29	F	29	Indirect	
6	37	F	35	Indirect	
7	51	M	45	Indirect	
8	45	M	19	Indirect	
9	43	F	32	Indirect	
10	52	M	35	Indirect	
11	31	M	22	Indirect	
12	36	F	49	Indirect	
13	25	M	62	Indirect	
14	22	F	3	Indirect	
15	40	F	34	Indirect	Rotator cuff repair, capsular release
16	24	F	6	Indirect	SAD
17	21	F	9	Indirect	
18	21	F	12	Indirect	Capsular shift, bursectomy
19	25	M	31	Indirect	
20	25	M	17	Indirect	
21	31	M	28	Indirect	Long thoracic nerve decompression
22	44	F	9	Indirect	Scalene release
23	31	F	10	Indirect	
24	52	F	10	Indirect	SAD, Bankart, brachial plexus neurolysis, cervical decompression/fusion
25	16	F	6	Indirect	
26	17	F	6	Indirect	

F, female; *M,* male; *SAD,* subacromial decompression.

Surgical technique

Direct method

For direct transfer of the PMT, the patient is placed in the lateral decubitus position to allow access to the anterior and posterior chest. A curvilinear incision is made over the anterior chest, extending from the coracoid process to the anterior axillary fold, and the deltopectoral interval is developed. The cephalic vein is retracted laterally with the deltoid, and the insertion of the PMT on the humerus is identified. The entire insertion of the PMT is released, using a bone saw to harvest this with a 3-mm bone wafer. The tendon and muscle are then mobilized medially to allow excursion, and the tendon is tagged with suture.

A dorsal skin incision of approximately 6 cm is then made along the inferolateral angle of the scapula. The teres minor and subscapularis muscles are partially dissected away from the bone subperiosteally to expose what will become the site of attachment. After abrading the ventral surface of the scapula with a burr, 4 drill holes are created to allow passage of nonresorbable suture. A whipstitch is used to secure the 4 nonresorbable sutures to the tendon.

The anterior incision is used to explore from anterior to posterior using blunt dissection, and care is taken to avoid the neurovascular structures located laterally in the axilla. The inferolateral scapula is identified, and the PMT is passed into this area. The medial border of the scapula is then manually reduced by an assistant. The sutures are then passed through the drill holes in the scapula, and the tendon is tensioned through the posterior incision over biceps buttons (Arthrex Inc, Naples, FL, USA). Adequate ROM and the absence of scapular winging are confirmed before wound closure.

Indirect method

Indirect transfer of the sternal head of pectoralis major proceeds in the manner described by Warner and Navarro.[15] The patient is placed in a semilateral position and draped to allow access to the anterior and posterior chest, as well as to the ipsilateral lower extremity. The procedure begins as the semitendinosus and gracilis tendons are harvested under tourniquet. These grafts, approximately 22 to 24 cm in length, are then sewn together along their length with each end tapered to allow passage of the graft through the PMT.

Attention then turns to the anterior chest, where a 4-cm curvilinear incision is made, beginning just laterally and inferiorly to the coracoid process and medial to the anterior axillary crease. Next, the deltopectoral interval is developed, and the insertion of the pectoralis major on the humerus is identified. The interval between the clavicular and sternal heads of pectoralis major is defined and developed using blunt dissection with the aid of a Penrose drain, and the sternal head alone is harvested sharply from its insertion on the humerus.

After the muscle is mobilized and its medial attachments are freed to allow maximal excursion, the autograft is woven through the end of the PMT and the 2 limbs of the graft are sewn to together and to the PMT. To facilitate tendon transfer, the shoulder is then flexed forward to bring the inferior pole of the scapula anteriorly, and a 3- to 4-cm incision is made over the posterior chest over the palpable edge of the scapula.

The latissimus muscle is split, the muscular attachments to the dorsal and ventral surfaces of the scapula are elevated subperiosteally, and an 8- to 10-mm hole through the inferior angle of the scapula is created using a burr or a drill. Next, a soft-tissue tunnel is created through the posterior incision to allow careful passage of the tendon autograft from anterior to posterior. While an assistant manually reduces the scapula to the chest wall, the graft is passed through the hole created in the scapula, doubled back on itself, and sutured in a U-shape, thereby doubling its thickness in this area. Adequate ROM and the absence of scapular winging are confirmed before wound closure.

Statistical analysis

Means and standard deviations were calculated for all variables. Group means were evaluated statistically with a paired t test to examine for a difference between preoperative and postoperative ASES scores, VAS pain scores, active forward flexion, and active external rotation. Subgroup analysis with independent samples t test was done to determine whether there were differences between groups by length of follow-up (<12 months vs >12 months). A value of $P < .05$ was determined to be statistically significant.

Results

Mean preoperative to postoperative results included increases in active forward flexion from 112.1° to 148.7° ($P < .001$) and in active external rotation from 53.8° to 62.8° ($P = .045$), and improvement in the ASES score from 28.0 to 67.0 ($P < .001$) and in the VAS pain score from 7.7 to 3.0 ($P < .001$). Recurrent scapular winging occurred in 5 patients treated with indirect transfer. For these 5 patients, the mean active forward flexion was 128.0°, the mean ASES score was 39.2, and the mean VAS pain score was 5.6. Not enough data were available to calculate mean active external rotation for this subgroup.

There were 5 postoperative complications in 5 patients, all of whom underwent indirect transfer: 3 patients described a small area of numbness in the anterior leg, over the site of graft harvest; medial arm neuritis after indirect PMT transfer occurred in 1 patient, thought to be due to stretching of the intercostobrachial nerve during retraction; and in 1 patient a hematoma developed after indirect PMT transfer that resolved without evacuation. Results are reported in Table II.

Although only 4 patients were treated with the direct method of transfer, making outcomes comparison with the indirect method of little value, the outcomes for this subgroup were mean improvements in the ASES score of 21.2 to 71.3 and in the VAS pain score of 6.3 to 1.8, mean active forward flexion increased from 80° to 141.3°, and mean active external rotation decreased slightly from 40° to 37.5°.

To determine whether our patients with shorter follow-up exhibited any significant differences in preoperative or postoperative function and ROM, a subgroup analysis was performed to compare 2 groups: 9 patients with less than 12

Table II Outcomes

Variable	Average ± SD	Range	*P*
ASES score			
Pre-op	28.1 ± 13.8	10–54	<.001
Post-op	67.1 ± 19.0	12–98	
VAS pain score			
Pre-op	7.7 ± 1.6	3–10	<.001
Post-op	3.0 ± 2.6	0–9	
AFF,°			
Pre-op	112.1 ± 35.5	30–170	<.001
Post-op	148.7 ± 23.6	90–180	
AER,°			
Pre-op	53.8 ± 11.3	15–90	
Post-op	62.8 ± 18.8	30–90	<.001
Winging, %	19.2		

AER, active external rotation; *AFF,* active forward flexion; *ASES,* American Shoulder and Elbow Surgeons; *SD,* standard deviation; *VAS,* visual analog scale.

Table III Subgroup analysis with independent samples *t*-test*

Variable	Follow-up	No	Mean ± SD	*P*
Age	<12 mo	9	27.56 ± 12.521	.635
	>12 mo	17	36.00 ± 10.338	
Pre-op				
ASES	<12 mo	1	23.00 ± …	…
	>12 mo	12	28.47 ± 14.275	
VAS	<12 mo	9	8.33 ± 1.000	.229
	>12 mo	17	7.29 ± 1.795	
AFF,°	<12 mo	9	121.67 ± 38.730	.702
	>12 mo	17	107.06 ± 33.730	
AER,°	<12 mo	6	53.33 ± 25.232	.079
	>12 mo	13	54.23 ± 11.519	
Post-op				
ASES	<12 mo	9	50.78 ± 20.596	.619
	>12 mo	17	64.65 ± 23.550	
VAS	<12 mo	9	4.11 ± 2.571	.624
	>12 mo	17	2.47 ± 2.478	
AFF,°	<12 mo	9	149.44 ± 14.884	.091
	>12 mo	17	148.24 ± 27.497	
AER,°	<12 mo	4	45.00 ± 12.247	.180
	>12 mo	14	65.00 ± 18.292	

AER, active external rotation; *AFF,* active forward flexion; *ASES,* American Shoulder and Elbow Surgeons; *SD,* standard deviation; *VAS,* visual analog scale.

* Results show that there was no significant difference between patients with <12 months of follow-up and those with >12 months of follow-up.

months of follow-up and 17 with more than 12 months of follow-up. No significant differences identified between these 2 groups. Subgroup analysis according to length of follow-up is reported in Table III.

Discussion

The long course of the LTN leaves it especially vulnerable to blunt trauma and stretching injury, as well Parsonage-Turner syndrome (brachial plexus neuritis).[4,8,9,12] The shoulder weakness and painful scapular winging associated with this condition usually resolve spontaneously. When no improvement is seen with conservative management, dynamic stabilization with PMT transfer is an effective treatment. Since first being described by Tubby[14] in 1904, variations on the indirect method of transfer have been the mainstay of treatment, with excellent results.[2-4,6,8-10,12,13,15] A cadaveric study by Povacz and Resch[11] in 2000 showed that the excursion of the PMT was sufficient for direct transfer without an interposed tendon graft, making direct bone-to-bone healing possible and avoiding the morbidity of graft harvest associated with indirect transfer. Today, both methods are used, depending on surgeon preference.

The results of our study demonstrate that transfer of the PMT is an effective treatment for painful scapular winging and shoulder weakness as a result of EMG-confirmed LTN palsy. This is in agreement with previous studies of indirect PMT transfer by Connor et al,[2] Galano et al,[4] Iceton et al,[6] Noerdlinger et al,[8] Perlmutter and Leffert,[9] Steinmann and Wood,[12] Tauber et al,[13] and Warner and Navarro[15] (Table IV). The mean active forward flexion of 148.7° attained by our patients was within the range of 144° to 175° reported in previous studies of direct and indirect methods of transfer. Our ASES and VAS results were also similar to those reported by these authors (Table IV), indicating that PMT transfer is effective in restoring function and relieving pain caused by weakness of the serratus anterior muscle. We have reported the largest series of patients to date treated with pectoralis major transfer for painful scapular winging.

A known complication of indirect transfer of the PMT is recurrent winging of the scapula as a result of fraying or stretching of the avascular graft tissue.[2,5-7,9,10] Postoperative winging of the scapula recurred in 5 patients (19.2%) in our study who underwent indirect transfer of the PMT. This proportion is in agreement with previously published rates of recurrent winging, which have ranged from 0% to 26%.[2,4,8,9,11-13,15] None of our patients who underwent direct transfer experienced this complication.

Although a cadaveric study has shown the excursion of the sternal head of pectoralis major is adequate for direct repair,[11] tension on the muscle is a concern, and recurrence of scapular winging caused by iatrogenic traction injury to the medial and lateral pectoral nerves at the time of transfer has been reported.[7] This complication did not occur in our study group. The injury is thought to result from excessive tension placed on the pectoralis major muscle during attachment of the PMT to the scapula and is avoided by releasing the muscle from its chest wall attachments before transposing and securing the graft.

Table IV Reported outcomes of pectoralis major tendon transfer

First author	No	AFF,°		ASES		VAS	
		Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
Connor[2]	10	110	175	NR	71	8.2	3
Galano[4]	11	158.2	164.5	53.3	63.8	5	2.9
Noerdlinger[8]	15	NR	156	NR	63	NR	NR
Perlmutter[9]	16	87	158	NR	NR	NR	NR
Steinmann[12]	9	90	144	NR	67.4	NR	NR
Tauber[13]	12	89	171	NR	NR	NR	NR
Warner[15]	8	97	150	NR	NR	NR	NR
This study	26	112.1	148.7	28.1	67.1	7.7	3.0

AFF, active forward flexion; *ASES,* American Shoulder and Elbow Surgeons; *NR,* not reported; *VAS,* visual analog scale.

EMG was used to confirm LTN palsy in each patient before surgical treatment. This investigation is now commonly performed, because PMT transfer is not effective for treating scapular winging caused by scapulothoracic dyskinesia. This condition results from reflex relaxation of the serratus anterior muscle to avoid painful shoulder motion rather than from LTN palsy, and previous studies have demonstrated recurrent instability and winging when patients with scapulothoracic dyskinesia are treated with PMT transfer.[10,15] As detailed by Tauber et al,[13] a useful method to distinguish whether scapular winging is due to true LTN palsy is to apply direct downward force to the upper extremity flexed to 90° in the sagittal plane: if scapular instability is observed with this maneuver, scapulothoracic dyskinesia should be investigated as the cause for winging.

To the best of our knowledge, this is the first report of the results after direct transfer of the entire PMT, which uses both the sternal and clavicular heads to increase the strength of the scapulothoracic articulation. Galano et al[4] and Tauber et al[13] have reported good results using a similar method of direct PMT transfer in which the sternal head alone is transferred directly to the scapula without graft interposition. Although scapular winging was successfully treated in our study, the resulting active forward flexion of 112.1° obtained by our method was not as favorable as the 171° reported by Tauber et al or the 164.5° by Galano et al. This was likely caused by increased tension on the construct because the entire insertion of the PMT was transferred to the inferolateral border of the scapula.

In addition, the cosmetic result in the anterior chest obtained in our patients treated by the direct method was less appealing than that obtained by the indirect method, which again resulted because the clavicular head was transferred with the sternal head of the PMT, leaving a noticeable depression inferior to the clavicle. Tauber et al[13] obtained excellent outcomes with direct transfer of the sternal head alone and noted no dissatisfaction with cosmesis, and Galano et al[4] noted only 1 patient dissatisfied with cosmesis; thus, we do not recommend performing direct transfer of the entire PMT due to the limited shoulder ROM and unfavorable cosmetic result seen in our patients.

Weaknesses of this study include its retrospective nature, the small number of patients undergoing direct transfer, and the short follow-up of 9 patients in our cohort, who were each monitored for less than 12 months. Regarding this last point, however, we included them in our analysis only after performing a between-groups analysis using an independent samples *t* test, which found no significant difference in outcomes between the groups (Table III). Because PMT transfer quickly corrects winging of the scapula, we believe these patients were likely to have achieved near, if not full, motion and symptomatic relief by the time of follow-up. It is possible, however, that we have underestimated recurrent winging in our cohort, because stretching of the graft might cause such a recurrence over time.

A particular strength of our study relates to its multicenter design, which has allowed us to report on the largest series of patients treated with any method of PMT transfer for LTN palsy. Because scapular winging is rare, the existing literature consists of few studies comprising small patient cohorts. By reporting on this large series of patients, conclusions may be strengthened regarding the safety and effectiveness of these procedures.

Conclusion

We have used a multicenter study design to report on the largest series of patients treated by transfer of the PMT for painful scapular winging as a result of EMG-confirmed LTN palsy. As previously reported, this procedure safely and effectively improves cosmesis in the posterior chest, restores shoulder motion, and relieves shoulder pain caused by paralysis of the serratus anterior muscle. Although direct transfer of both heads of the PMT appeared to provide stability and did not result in any recurrent scapular winging in our series, limitation of motion as well as an unfavorable cosmetic

result in the anterior chest make this approach less appealing, in our opinion, than direct transfer using only the sternal head of the PMT.

Disclaimer

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