



EXHIBIT SELECTION

Scapular Winging: A Great Masquerader of Shoulder Disorders

AAOS Exhibit Selection

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Background: The incidence of scapular winging is unclear, but it may be more common than previously thought. It can be difficult to diagnose because the presenting complaint and physical examination may direct the practitioner toward more common shoulder and neck conditions. Ongoing scapular dysfunction may result in inappropriate or failed surgery. Our goals were to (1) describe the common misdiagnoses (instability, labral abnormality, impingement, and cervical spine disease), the clinical scenarios and examination findings leading to diagnostic difficulty, the definitive treatment options available, and the clinical outcomes and complications; and (2) review the important aspects of the patient history, physical examination of the scapula, and associated studies necessary to make the correct diagnosis of scapular winging.

Methods: We reviewed the literature relative to, and our own experience with, the treatment of scapular winging and identified a series of patients with this condition who were initially misdiagnosed with other shoulder or spine abnormalities. In our literature search, only nine clinical studies reported on a series of patients with scapular winging that was initially misdiagnosed or had a delay in diagnosis ($n = 53$ patients). We examined these cases for presenting or preexisting diagnoses and for surgical procedures that had been performed before the diagnosis of scapular winging.

Results: For patients ultimately diagnosed with scapular winging, initial presentations and diagnoses included rotator cuff disorders (20%), glenohumeral instability (8%), peripheral nerve disorders (6%), cervical spine disease (6%), acromioclavicular disorders (6%), thoracic outlet syndrome (4%), and unknown or unspecified (41%). The most common surgical procedures performed before definitive scapular winging treatment were rotator cuff (22%), instability (22%), nerve (14%), acromioclavicular (12%), cervical spine (5%), and thoracic outlet (4%) procedures.

Conclusions: Clinically, scapular winging often mimics more common shoulder abnormalities and can result in unnecessary or unsuccessful surgical procedures. Diagnosis can be readily achieved with simple physical examination and specific provocative maneuvers in conjunction with electromyography and nerve conduction studies. Prompt diagnosis and recognition can avoid substantial shoulder dysfunction.

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The coordinated motion of the scapula results from a delicate balance of several scapulothoracic stabilizing muscles. Dysfunction of one muscle group can interrupt the synchronized motion of the scapula, which can alter glenohumeral mechanics, leading to various pathologic conditions. Scapular winging can masquerade as multiple other disorders. The diagnostic dilemma is recognizing scapular dysfunction in the presentation of more common shoulder disorders and other conditions involving the cervical spine or brachial plexus. Understanding the clinical presentation of scapular winging and selecting appropriate physical examination maneuvers and diagnostic tests facilitate a timely diagnosis and efficient treatment.

Our goals were to (1) describe the common misdiagnoses, the clinical scenarios and examination findings leading to diagnostic difficulty, the definitive treatment options available, and the clinical outcomes and complications; and (2) review the important aspects of the patient history, physical examination of the scapula, and associated studies necessary to correctly diagnose scapular winging.

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Anatomy and Types of Scapular Winging

The scapulothoracic stabilizers include the serratus anterior, trapezius, rhomboid major and minor, and levator scapulae. Additional muscles with attachments to the scapula include the deltoid, supraspinatus, infraspinatus, subscapularis, teres minor, teres major, a small slip of the latissimus dorsi, triceps long head, biceps long head, coracobrachialis, pectoralis minor, and omohyoid.

Primary scapular winging arises from the paralysis of the serratus anterior, trapezius, rhomboid major and minor, and/or levator scapulae¹⁻³. Serratus anterior palsy, attributed to injury of

the long thoracic nerve, is the most diagnosed form of scapular winging⁴⁻⁹. The serratus anterior, a flattened muscle that originates from the upper eight or nine ribs, inserts anteriorly onto the medial border of the scapula^{2,7}. The primary purpose of the serratus anterior is to stabilize the scapula against the chest wall and to laterally and upwardly rotate the inferior angle of the scapula during overhead activities⁷. Patients with serratus anterior palsy display medial winging, i.e., superior translation of the scapula with medial rotation of the inferior angle^{7,10} (Figs. 1-A and 1-B).

The trapezius proximally originates from the occipital bone and C7-T12 spinous processes and distally inserts onto the scapular spine, lateral aspect of the clavicle, and acromion¹¹. It is innervated by the C3, C4, and spinal accessory (cranial XI) nerves; its normal function is to retract, elevate, and rotate the scapula¹¹. Injuries to this muscle are usually iatrogenic, secondary to neck dissection or lymph node biopsy, and result in lateral winging, which is associated with shoulder “droop” (inferior translation of the scapula) at rest and the lateral movement of the inferior angle of the scapula with movement of the upper extremities^{2,12,13} (Figs. 2-A and 2-B).

The rhomboid minor and rhomboid major muscles together retract and elevate the scapula while medially retracting its inferior angle¹¹. The rhomboid minor originates from the ligamentum nuchae and the spinous processes of the C7-T1 vertebrae; it inserts onto the superior medial border of the scapula^{11,14}. The larger rhomboid major originates from the spinous processes of the T2-T5 vertebrae and inserts onto the medial border of the scapula^{11,14}. Rhomboid major and minor palsy arises from injury to the dorsal scapular nerve (C5), most commonly as a result of entrapment beneath hypertrophic middle scalene muscles¹⁵. Similar to trapezius palsy, rhomboid palsy results in lateral winging and shoulder “droop”².

The levator scapulae proximally originates from the transverse processes of the C1-C4 vertebrae and distally inserts onto the

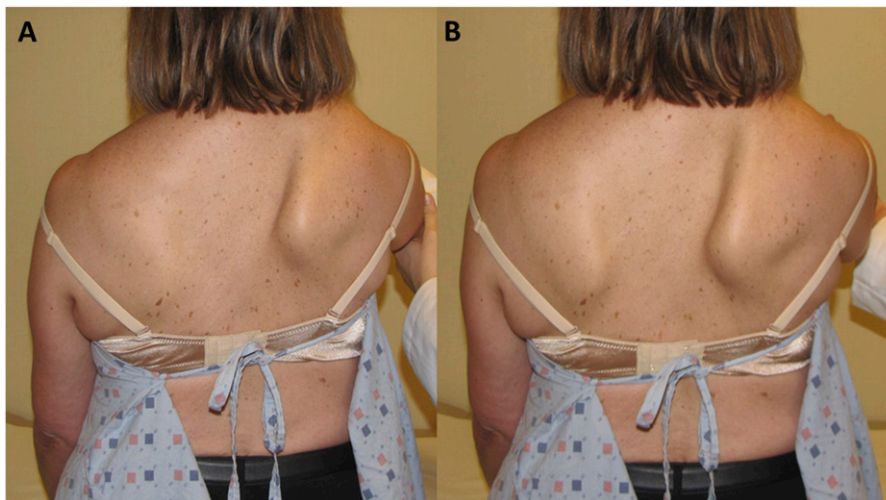


Fig. 1

Figs. 1-A and 1-B Clinical example of a patient with serratus anterior palsy and medial winging. **Fig. 1-A** With forward elevation, superior translation of the scapula with medial winging of the inferior angle is noted in the right shoulder. **Fig. 1-B** This medial winging becomes more prominent with resisted forward elevation.



Fig. 2-A

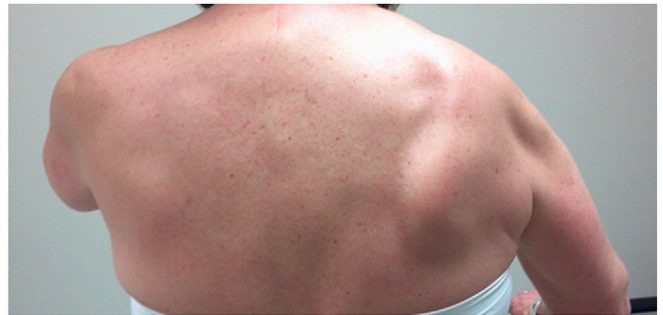


Fig. 2-B

Figs. 2-A and 2-B Clinical example of a patient with trapezius palsy and lateral winging. **Fig. 2-A** The shoulder “droops” down (inferior translation of the scapula) and is positioned more laterally compared with the normal left side. **Fig. 2-B** The lateral winging is more prominent with attempted forward elevation of the shoulder.

upper medial border of the scapula¹¹. This muscle not only elevates the medial border of the scapula while downwardly rotating the lateral angle of the scapula, but also assists the trapezius and rhomboid muscles to retract the scapula medially and upward¹¹. Damage to the dorsal scapular nerve (C5) and the ventral primary rami of C3 and C4 results in weakness with scapular retraction.

Incidence and Prevalence

The true incidence of scapular winging is unknown, possibly because this condition is underdiagnosed. Nevertheless, scapular winging remains a relatively rare disorder. In the earliest literature, Johnson and Kendall¹⁶ commented on 111 published cases and added twenty more cases. Gregg et al.⁷ reported ten cases of isolated serratus anterior palsy in young athletes over a three-year period at a large tertiary care center, noting that at the time of publication (1979), 250 cases existed in the literature⁷.

Over the course of a three-year period, the Harvard Shoulder Service diagnosed fourteen patients with symptomatic scapular winging¹⁰. Interestingly, eight had been previously misdiagnosed with another condition(s), and seventeen surgical procedures had been performed. Only five of the eight misdiagnosed patients had positive electromyography (EMG) findings for long thoracic nerve palsy. This cohort emphasizes the potential for misdiagnosis of scapular winging and supports the notion that its incidence may be higher than previously recognized¹⁰.

Causes

The scapulothoracic stabilizing muscles include the serratus anterior, trapezius, rhomboid major and minor, and levator scapulae. The delicate balance of these muscles produces the coordinated motion of the scapula; dysfunction in just one of these muscle groups can interrupt that motion. Several mechanisms of insult to a nerve(s) have been reported to result in winging, including a traction phenomenon, compression of a nerve, iatrogenic nerve damage, and atraumatic lesions.

Traction injury to a nerve has been reported after motor vehicle accidents, after falls, and in sporting activities^{9,17-20}.

Traction or stretch injuries to the long thoracic nerve have been well described in numerous sports. Positions in overhead sports such as baseball, football, tennis, volleyball, and javelin throwing all stretch the long thoracic nerve. Football tackling with the shoulder depressed and contralateral neck bent away also places the nerve at risk for repetitive stretch injury¹⁹. The long thoracic nerve, with contributions from C5-C7, passes between the anterior and middle scalene muscles and travels along the chest wall to the serratus anterior. Neurapraxia can occur with increases in nerve length of only 10%²¹. Although the exact pathologic insult to the nerve is unknown, repetitive traction to the nerve may result in vascular intimal injury²².

Hester et al.²³ dissected the course of the long thoracic nerve in six cadaveric specimens; in each specimen, they found a tight fascial band of tissue creating a sling over the nerve. The band of tissue arose from the inferior aspect of the brachial plexus, continued above the middle scalene muscle insertion onto the first rib, and produced a digitation extending to the proximal aspect of the serratus anterior muscle. The authors reported a “bow-stringing” of the nerve across the fascial band occurring when the arm was brought into abduction and external rotation and noted additional compression of the nerve when the scapula migrated medially and upward. This abnormal scapular motion is seen with scapular dyskinesia and thus could be a contributing factor in the development of winging²³.

Iatrogenic injury to the long thoracic nerve is not uncommon. Vastamäki and Kauppila²⁴ reported that, of 197 cases of isolated serratus anterior paralysis, thirty-two (16%) had an iatrogenic cause. The locally invasive procedures responsible for the injury included first rib resection, mastectomy with axillary dissection, scalenotomy, surgical treatment of spontaneous pneumothorax, and infraclavicular plexus anesthesia. Additionally, eight cases of paralysis after general anesthesia and one after spinal anesthesia were reported. First rib resection was the most common procedure resulting in the injury²⁴.

Another study indicated that cervical lymph node biopsy was the most common operation associated with spinal accessory

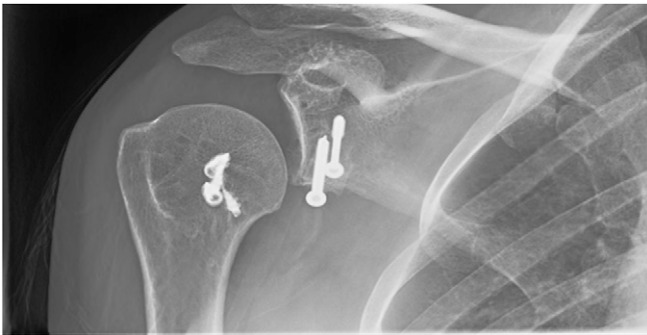


Fig. 3-A



Fig. 3-B



Fig. 3-C

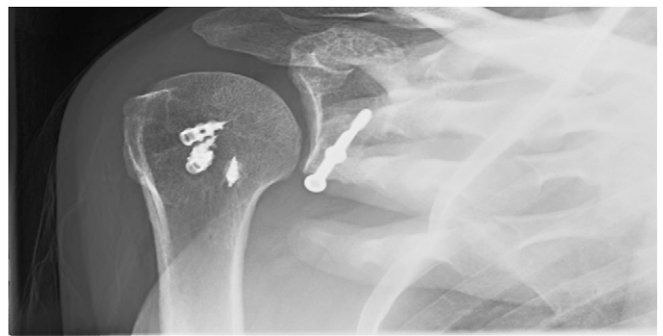


Fig. 3-D

Figs. 3-A through 3-I Clinical and radiographic example of serratus anterior palsy (preoperatively, preoperatively with manual scapulothoracic compression, and after pectoralis major tendon transfer). The preoperative anteroposterior radiograph (**Fig. 3-A**), posterior clinical photograph (**Fig. 3-B**), and lateral clinical photograph (**Fig. 3-C**) show scapular winging, poor glenohumeral alignment, and decreased range of motion. The preoperative anteroposterior radiograph (**Fig. 3-D**), posterior clinical photograph (**Fig. 3-E**), and lateral clinical photograph (**Fig. 3-F**) with scapulothoracic compression show a recentered humeral head, improved range of motion, and stability. The anteroposterior radiograph (**Fig. 3-G**), anterior clinical photograph (**Fig. 3-H**), and lateral clinical photograph (**Fig. 3-I**) after pectoralis major tendon transfer show a recentered humeral head, improved range of motion, and stability.



Fig. 3-E

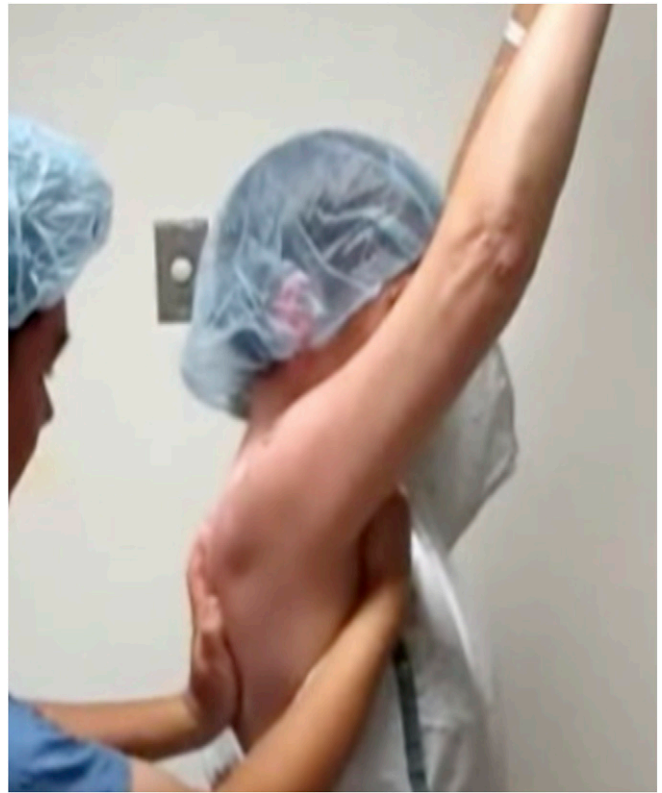


Fig. 3-F



Fig. 3-G

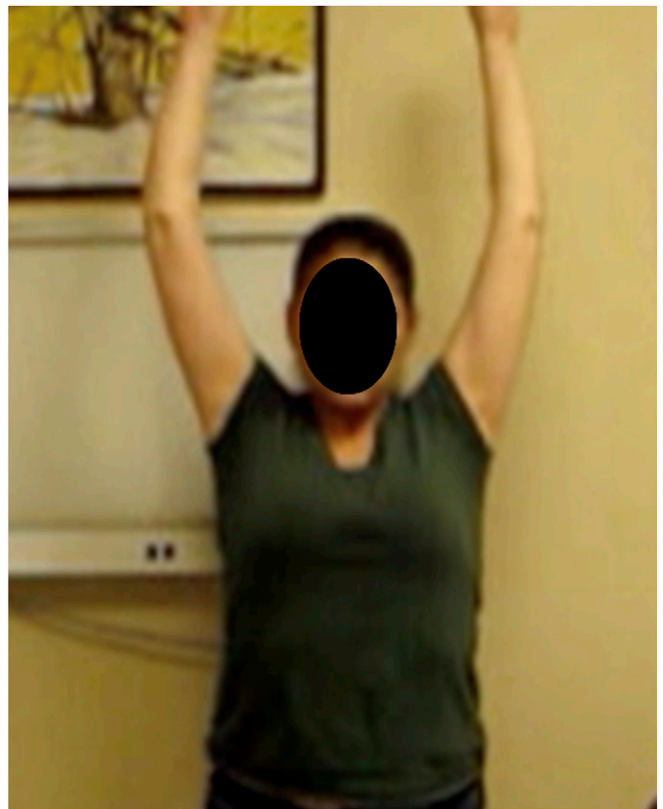


Fig. 3-H

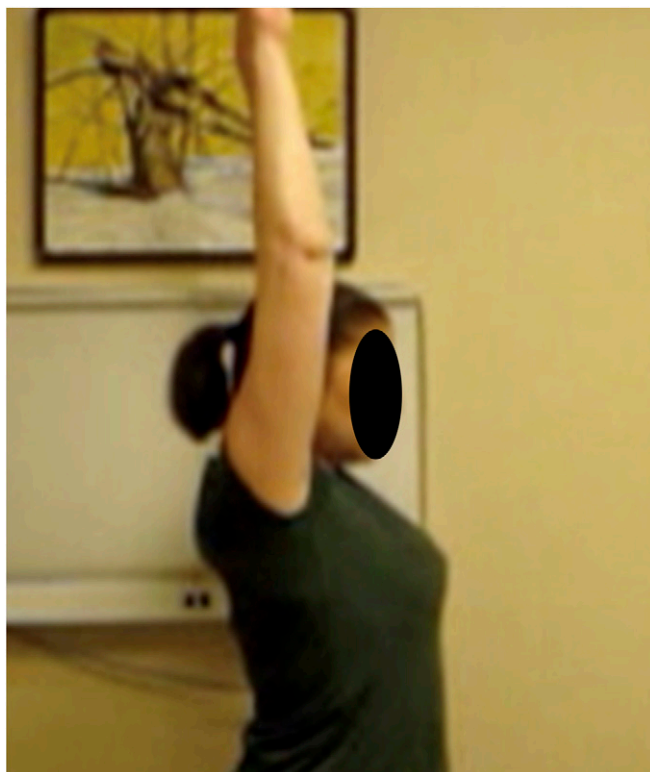


Fig. 3-1

nerve injury²⁵. Such injury can result in trapezius palsy. The superficial course of the spinal accessory nerve in the region of the posterior cervical triangle makes it vulnerable to injury²⁰. Camp and Birch²⁶ reported on 111 patients who were treated for spinal accessory nerve lesions between 1984 and 2007; in 80.2% (eighty-nine patients), the cause was iatrogenic, most commonly during lymph node procedures (sixty-two patients), excision of brachial cysts (six), or other procedures involving neck dissection (twenty-one).

Various atraumatic causes of scapular winging have been described. A winged scapula has been the presenting symptom in patients with Arnold-Chiari I malformation²⁷ and Guillain-Barré syndrome²⁸ and has been acquired in patients with systemic lupus erythematosus²⁹, a polio virus infection¹⁷, and Lyme disease³⁰. Genetic conditions, such as facioscapulohumeral dystrophy, can also result in scapular winging from generalized shoulder girdle weakness³¹.

Clinical Presentation

Patients with scapular winging often present with posterior shoulder pain, which may radiate down the arm or up the ipsilateral paraspinal cervical region^{2,32-34}. This pain can be spontaneous or associated with trauma (repetitive or sudden)^{7,33}. Other symptoms include limited forward elevation and/or abduction; weakness (particularly fatigue in flexion); and clicking, catching, or popping of the upper extremity with motion^{2,7,16,32,34,35}.

Because of the vague nature of these symptoms, a detailed history—including hand dominance; occupation; mechanism

of injury (in traumatic cases); medical history (particularly previous injuries and treatments); and the surgical and/or nonsurgical intervention history of the shoulder, neck, thorax, and breast—is critical for discerning the type of scapular winging^{2,9,33}.

In most cases, a thorough musculoskeletal examination is sufficient for making a diagnosis of scapular winging^{2,32,35}. Patients should be examined in a gown that allows visualization of the entire posterior aspect of the thorax. Clinicians should compare both sides and note the relative positions of the scapulae, evaluate scapular motion with forward elevation, look for scapular dyskinesia and/or asymmetry, and assess for any muscular atrophy^{2,32}. If winging is suspected, clinicians should assess for weakness in forward flexion, extension (hands-on-hips test), and shoulder shrugs. Key provocative tests and maneuvers include the wall push-up (resisted forward elevation) and the scapular compression test (relief of pain and increased forward elevation with manual compression of the scapula to the chest wall)^{10,36} (Figs. 3-A through 3-I).

A patient with serratus anterior palsy often shows medial scapular winging at rest and may report arm weakness and periscapular pain^{2,7,10}. Although pain may radiate down the arm, it is typically localized to the rhomboid and levator scapulae muscles because of overcompensation, which results from a loss of function of the serratus anterior^{6,9,10,19}. Because of the inhibited contribution of the serratus anterior in scapular protraction, winging in such patients is accentuated when they are asked to attempt a wall push-up and/or active forward elevation^{7,9,10} (Fig. 1-B). Most patients with severe serratus anterior palsy cannot abduct the affected arm past 110° to 120° except when scapular compression is applied^{7,10}.

Hallmarks of trapezius palsy include trapezius wasting or weakness, an asymmetrical neckline, and shoulder “drooping.”³⁷ Patients often present with periscapular muscle pain, stiffness, and arm weakness, particularly with overhead activity^{2,35,37}. Winging can, but may not, be apparent in forward flexion because of serratus anterior compensation³⁵. Winging is minimal at rest but tends to be exacerbated with resisted arm abduction, with the inferior scapular border rotating toward the midline and the body shifting more laterally³⁵ (Figs. 2-A and 2-B). Prominent winging with resisted active external rotation is a strong indicator of trapezius palsy³⁸.

The location of the rhomboids and the subtlety of the winging associated with rhomboid dysfunction make this type of winging a diagnostic challenge². Patients may report medial scapular and arm pain, experience neck and back discomfort, and describe having a feeling of “traction” within the shoulder^{2,35,39-41}. At rest, patients may show minimal deformity and subtle winging^{35,42}. When patients are asked to lower the affected arms from full flexion, the inferior border of the scapula is shifted laterally and dorsally^{1,35}. Patients with rhomboid palsy sometimes have difficulty pushing the elbows backward while the hands are resting on the hips, as well as difficulty bringing the scapulae together^{1,14,43}. However, an ability to do either of these tasks should not rule out a diagnosis of rhomboid palsy because the trapezius muscles may overcompensate⁴².

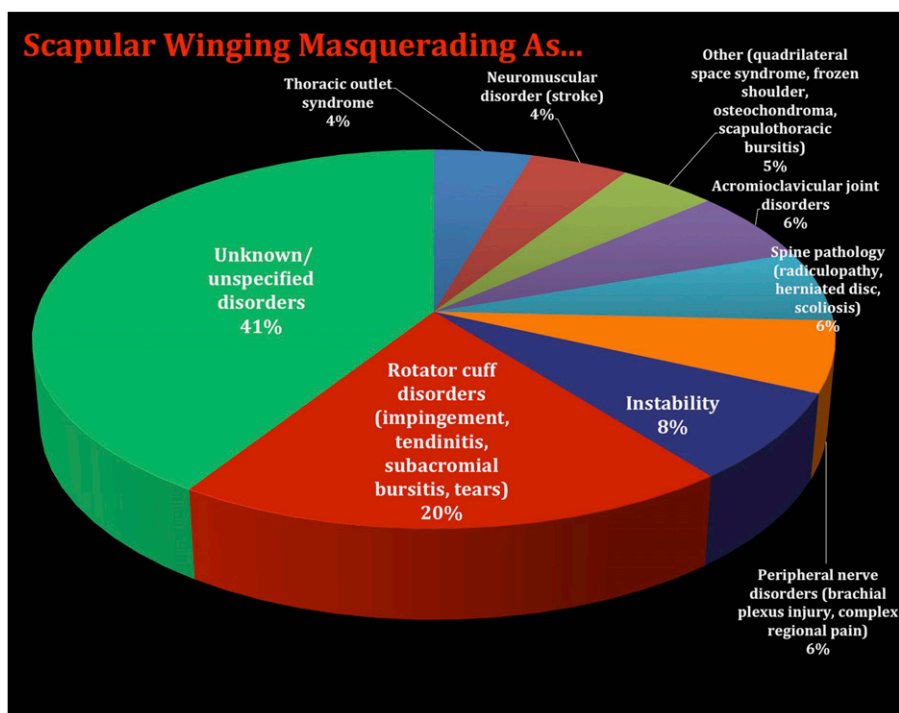


Fig. 4-A

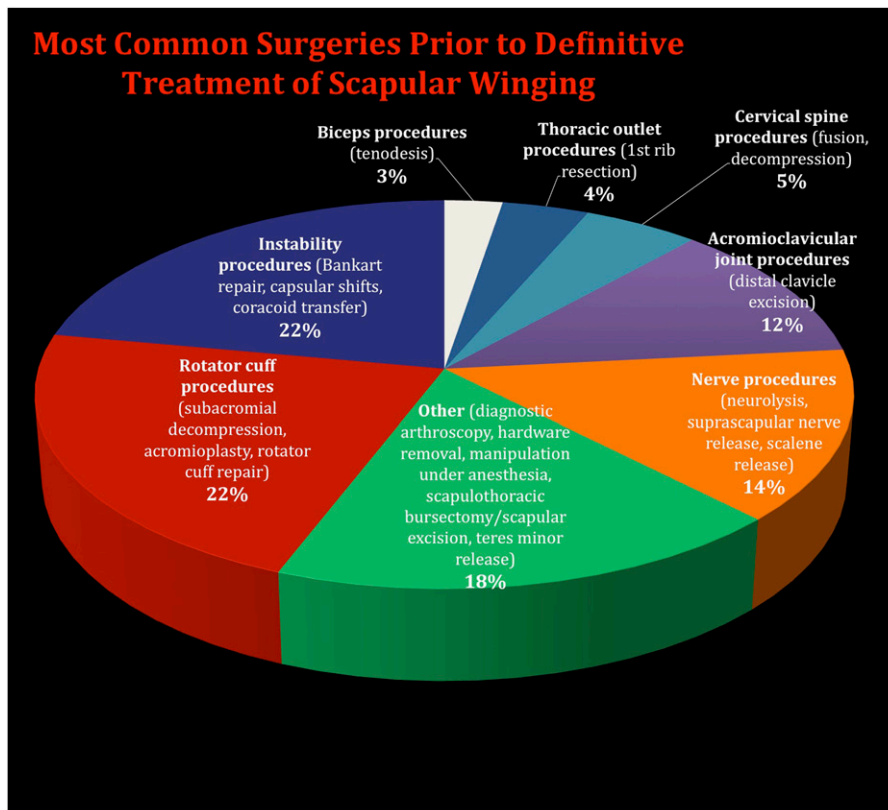


Fig. 4-B

Figs. 4-A and 4-B Graphic representation of the most common conditions that were mimicked by scapular winging (**Fig. 4-A**) and the most common procedures performed before definitive treatment of scapular winging (**Fig. 4-B**), according to data extracted from the studies listed in Table I.

TABLE I Summary of Published Study Data and Findings*

Study	No. of Cases	Age† (yr)	Sex, M:F	Previous Diagnoses	No. of Previous Surgical Procedures	EMG Findings
Streit et al. ⁶¹	26	33 (16-53)	10:16	20 no misdiagnoses, 6 unknown diagnoses (not linked to suspected painful nerve lesion)	20‡ (10 patients)	26 positive
Noerdlinger et al. ⁵⁹	15	33 (17-44)	9:6	15 unknown diagnoses (not linked to suspected painful nerve lesion)	12§ (8 patients)	11 positive
Perlmutter and Leffert ⁵³	16	33 (20-55)	7:9	16 delayed diagnoses	7# (8 patients)	16 positive
Warner and Navarro ¹⁰	8	33 (24-43)	4:4	5 impingement, 2 instability, 2 posterior instability, 2 scapulothoracic bursitis, 1 AC joint injury, 1 frozen shoulder, 1 RSD, 1 rotator cuff tear	19** (5 patients)	3 negative, 5 positive
Connor et al. ⁵⁷	11	34 (20-52)	4:7	5 misdiagnoses (unspecified), 2 trapezius palsy	7†† (7 patients)	11 positive
Bigliani et al. ⁵⁶	22	32 (8-74)	6:16	8 no previous misdiagnoses, 14 misdiagnoses	13‡‡ (7 patients)	12 incomplete or incorrect
Post ⁶⁰	8	31 (18-39)	6:2	8 delayed diagnoses, 3 misdiagnoses, 1 quadrilateral space syndrome	5§§ (3 patients)	1 negative, 7 positive, LTN palsy
Iceton and Harris ⁵⁸	15	31 (17-55)	13:2	10 no previous misdiagnoses, 5 delays in diagnosis by ≥6 mo	NA	NA
Gozna and Harris ³³	14	NA	NA	10 diagnostic delays (4 clinical, 6 attributed to misdiagnosis of rotator cuff tear)	NA	12 positive, 2 missing EMGs

*NA = not available, AC = acromioclavicular, RSD = reflex sympathetic dystrophy (complex regional pain syndrome), EMG = electromyography, LTN = long thoracic nerve, MDI = multidirectional instability, FSH = facioscapulohumeral muscular dystrophy, TTS = time to surgery, FF = forward flexion, ER = external rotation, and ASSES = American Shoulder and Elbow Surgeons score. †The values are given as the mean, with the range in parentheses. ‡Includes three rotator cuff repair, three Bankart (one revision), two brachial plexus neurolysis, two cervical spine fusion and/or decompression, two subacromial decompression, and one each of the following: arthroscopy, bursectomy, capsular release, capsular shift, LTN decompression, manipulation under anesthesia, open Latarjet, and scalene release. §Includes six capsular shift; three arthroscopic acromioplasty; two distal clavicle resection; and one arthroscopic debridement. #Includes three resection of first rib; two resection of first rib with transfer of pectoralis minor; one anterior cervical discectomy with C5-C6 arthrodesis; and one Bankart. **Includes three AC joint resection; three posterior shift/revision; three arthroscopy; three biceps tenodesis; two acromioplasty; and one each of the following: anterior shift, Bristow, closed manipulation, screw removal, and rotator cuff repair. ††Includes two arthroscopic distal clavicle excision; two levator scapulae/rhomboid transfer; and one each of the following: rotator cuff repair, suprascapular nerve release, scapulothoracic bursectomy. ‡‡Includes six nerve repair, neurolysis, or nerve-grafting; three anterior acromioplasty; two thoracic outlet decompression; one AC joint resection; and one glenohumeral arthroscopy. §§Includes one each of the following: acromioplasty with clavicle resection, cervical spine fusion, teres minor release for quadrilateral space syndrome, and first rib resection. ##Mean preoperative vs. postoperative values.

Diagnostic Studies

Conventional shoulder (Grashey, axillary, and scapular Y views), cervical spine, and chest radiographs may be used to evaluate for gross structural abnormalities such as mass lesions and osteochondromas^{5,9,44,45}. Computed tomography and magnetic resonance imaging should be considered for additional evaluation of mass lesions, fracture malunion, osteochondromas of the scapula or ribs, and any other common potential misdiagnoses^{44,46-48}.

Because many common shoulder disorders may mimic scapular winging, EMG testing is the only definitive diagnostic

test for serratus anterior, trapezius, rhomboid, and levator scapulae dysfunction⁴⁹⁻⁵¹. EMG testing should include evaluation of the long thoracic nerve, spinal accessory nerve, trapezius, rhomboids, and serratus anterior¹⁰. Although EMG testing is helpful in determining which muscles may be contributing to scapular winging, the extent of nerve recovery cannot be predicted from the initial degree of nerve denervation^{6,50}. Therefore, clinicians should consider conducting serial EMG tests to evaluate the extent of nerve recovery^{2,51}. Additionally, not all patients with symptomatic winging show EMG nerve dysfunction, particularly in the case of serratus anterior palsy¹⁰.

TABLE I (continued)

Correct Diagnosis	TTS† (mo)	Surgery	Results	Follow-up† (mo)
LTN palsy	58 (12-120)	26 pectoralis major transfers (4 direct, 22 indirect)	FF##: 112° vs. 149°. ER##: 54° vs. 63°. ASES##: 8 vs. 67. 5 recurrent scapular winging	22 (3-62)
Winging (unspecified)	25 (3-72)	15 pectoralis major transfers with fascia lata autograft augmentation	Rowe assessment: mean, 66; 2 excellent, 5 good, 4 fair, 4 poor. ASES: mean, 63	64 (33-118)
16 serratus anterior dysfunction	NA (16-32)	8 pectoralis major transfers with fascia lata graft strips, 8 pectoralis major transfer/rectangular fascia lata grafts	Modified Constant and Murley: 8 excellent, 5 good, 1 fair, 2 failure	51 (25-108)
8 serratus anterior dysfunction	40 (12-86)	8 modified pectoralis major transfers	7 complete resolution of painful winging, 1 lost to follow-up. FF##: 97° (range, 80°-120°) vs. 150° (range, 120°-165°)	For 7/8 patients: 32 (24-40)
9 serratus anterior paralysis, 2 serratus anterior and trapezius paralysis	27 (12-60)	11 modified pectoralis major transfers	10 improved function, pain reduction, elimination of winging. FF##: 110° (80°-140°); 175° (150°-180°). Pain##: 8 vs. 3. 1 unsatisfactory outcome	41 (12-84)
22 trapezius paralysis secondary to spinal accessory nerve injury	34 (11-78)	22 Eden-Lange procedures	ASES: 13 excellent, 6 satisfactory, 3 unsatisfactory	90 (24-168)
4 LTN palsy, 4 LTN palsy with MDI	21 (12-35)	8 pectoralis major transfers	Subjective evaluation: 6 excellent, 1 excellent with transient hematoma, 1 excellent but with serosanguineous fluid aspirated from donor thigh	27 (12-57)
1 brachial plexus neuropathy, 1 FSH, 1 iatrogenic LTN division, 12 unspecified winging	25 (7-48)	15 pectoralis major transfers	Subjective evaluation: 9 successful, 2 fair, 4 failure/ reoperation	NA (12-192)
14 serratus anterior dysfunction	NA (6-60)	11 nonop. treatment, 3 pectoralis major reattachments via fascia lata graft	1 excellent, 1 excellent after a revision surgery, 1 persistent winging	NA

Thus, in patients with profound scapular winging but negative EMG findings, clinical suspicion for nerve palsy should remain high^{49,52}.

Scapular Winging as a Masquerader

Scapular winging mimics more common disorders such as Rotator cuff tendinopathy, shoulder instability, cervical radiculopathies, acromioclavicular joint disorders, and nerve disorders. Various, and often multiple, procedures are often performed before the definitive diagnosis of scapular winging (Figs. 4-A and 4-B). Several factors may lead to this misleading and confounding clinical presentation. The scapula can be considered the foundation of the shoulder; poor scapulothoracic rhythm can destabilize this foundation and lead to an acromion that is downward-tilting during attempted arm elevation. This dyskinesia can result in positive impingement signs and an associated rotator cuff tendinopathy (Fig. 5). Additionally, an unstable base can lead to abnormal capsular stresses and, ultimately, instability during glenohumeral motion³⁶.

Patients with scapular abnormality often have poorly localized pain descriptions. Posterior or superior shoulder pain may be attributed to cervical abnormality or acromioclavicular joint disorders when, in fact, this pain can result from unbalanced activity of the trapezius in cases of serratus anterior palsy or from spasms of the rhomboids and levator scapulae in cases of scapular dyskinesia. Scapular winging is also known to result in a drooped or ptotic shoulder position, particularly with trapezius palsy. This altered position can strain the cervical plexus and brachial plexus, leading to symptoms consistent with cervical spine disease. Shoulder ptosis may also narrow the thoracic outlet, causing neurovascular compression.

Recognizing the role of the scapula in normal shoulder mechanics, and how altered scapulothoracic rhythm can lead or contribute to more common types of shoulder abnormality, is important to avoid diagnostic delays and unnecessary procedures. Identifying scapular winging early in its presentation also allows for the best possible long-term outcomes.

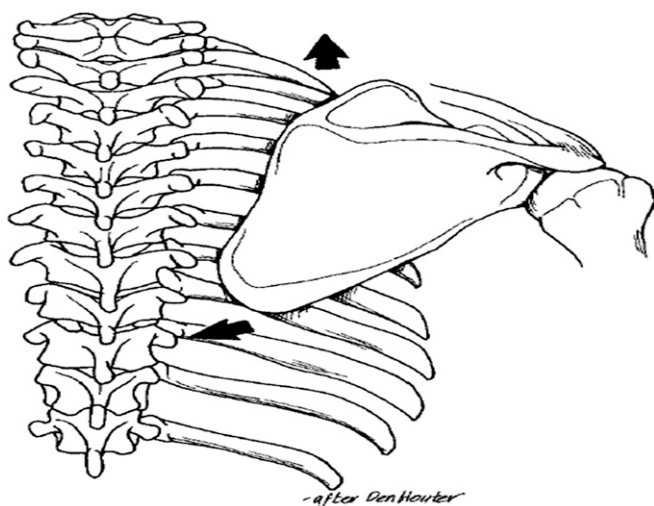


Fig. 5
Scapular motion (arrows) with serratus anterior palsy leads to downward tilting of the acromion and inability of the greater tuberosity to clear the acromion during elevation. Reproduced, with permission from: Kuhn JE, Plancher KD, Hawkins RJ. Scapular winging. *J Am Acad Orthop Surg.* 1995 Nov;3(6):319-25.

Treatment

Serratus Anterior Palsy

Nonoperative treatment remains the mainstay of therapy for serratus anterior palsy^{2,3,5-7,10,16,18,33,53,54}. Physical therapy

focused on range-of-motion exercises and periscapular strengthening is initiated to maintain flexibility and prevent stiffness. Overhead activities and those that result in pain should be avoided. Importantly, the serratus anterior muscle should not be stretched because that may delay functional recovery^{6,16}. A scapular brace may be prescribed to compress the scapula to the thorax and limit use of the serratus anterior muscle^{2,10,55}. However, the brace is not well tolerated, leading to poor compliance and results.

With use of these nonoperative modalities, traumatic serratus anterior palsies typically resolve within six to nine months, whereas nontraumatic palsies may take up to twenty-four months^{9,18}. However, approximately 25% of patients have persistent serratus anterior palsy requiring surgical intervention⁴.

A dynamic muscle transfer of the sternal head of the pectoralis major muscle to the inferior pole of the scapula is the preferred treatment for chronic serratus anterior palsy. Autograft extension utilizing fascia lata or hamstring tendon may be performed to augment the tissue transfer. Success rates range from 74% to 100% (Table I^{10,33,53,56-61}), with resolution of scapular winging deformities, improvements in pain, and restoration of normal scapulothoracic kinematics (Fig. 3-A through 3-I). Postoperative complications included infection, graft stretching, stiffness, and persistent pain.

Alternative surgical procedures, such as a fascial graft or a sling tethered from the scapula to the ribs or spinous

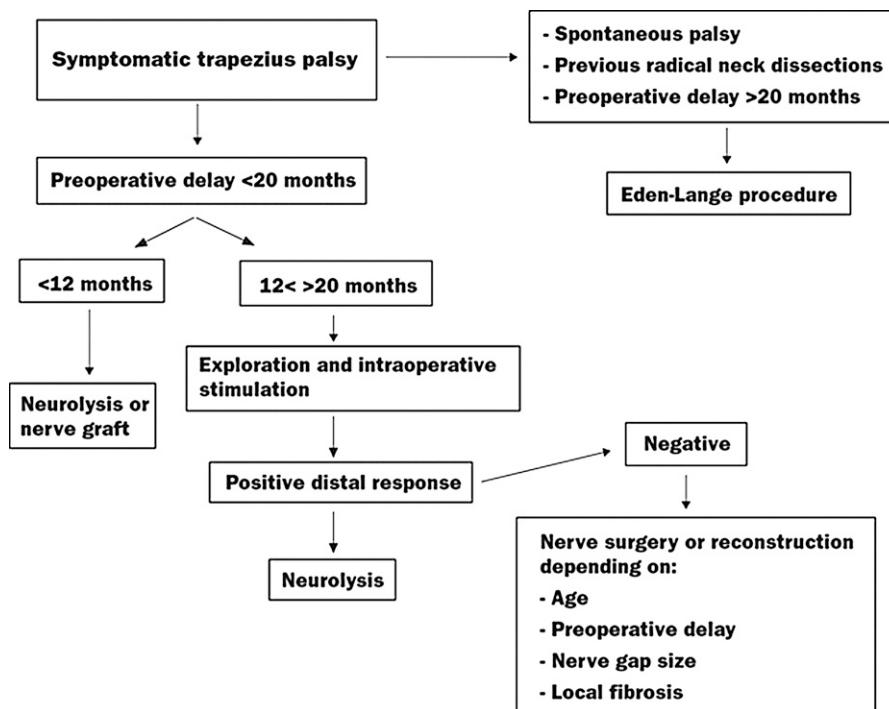


Fig. 6
An algorithm for approaching the treatment of trapezius palsy. Reproduced from: Teboul F, Bizot P, Kakkar R, Sedel L. Surgical management of trapezius palsy. *J Bone Joint Surg Am.* 2004;86(9):1884-90.

process, have been described as providing static stabilization^{9,62,63}. Although effective in the short term, the slings are susceptible to progressive stretching and recurrence of scapular winging. Scapulothoracic arthrodesis can effectively eliminate scapular winging by fusing the scapula to the thoracic ribs. However, it reduces scapulothoracic motion (including elevation, extension, and external rotation) and is associated with increased risk of pulmonary complications and pseudarthrosis⁶⁴⁻⁶⁷. Therefore, it is typically considered a salvage procedure. Furthermore, case reports have shown favorable results following nerve procedures, including long thoracic nerve neurolysis and thoracodorsal and medial pectoral nerve transfers, when they are performed within six months of the initial injury⁶⁸⁻⁷⁰. Additional studies are necessary to fully delineate the role of nerve procedures to treat serratus anterior palsy.

Trapezius Palsy

Nonoperative treatment should be initiated on diagnosis. However, such therapies are not as effective for trapezius palsy as for serratus anterior palsy^{2,20,56,71,72}. Maximal functional gains are typically achieved after one year, with little benefit from additional therapy^{20,48}. Surgery is indicated when nonoperative treatment has been unsuccessful for more than one year.

The Eden-Lange dynamic muscle transfer is the primary procedure used to treat trapezius palsy⁷³. Function of the impaired trapezius muscle is recreated through lateralization of the insertions of the rhomboid major, rhomboid minor, and levator scapulae on the scapula. Success rates range from 71% to 92%, with good pain relief and improved function (Table I)^{10,33,53,56-61}.

For patients with iatrogenic or penetrating trauma to the spinal accessory nerve, surgical exploration and nerve procedures, including grafting, neurolysis, and repair, may be beneficial. Kim et al.⁷⁴ reported grade-3 or better functional recovery in all nineteen patients undergoing neurolysis and in sixty-five of eighty-four patients undergoing end-to-end or interposition graft repair. In addition, Teboul et al.³⁷ showed good or excellent results in sixteen of twenty patients undergoing nerve surgery within twenty months of injury. For an injury to the spinal accessory nerve presenting within twenty months, nerve procedures are recommended; an injury presenting at a later time is typically treated with dynamic muscle transfers³⁷ (Fig. 6). Additional surgical procedures, including fascial grafts and scapulothoracic fusion, may be performed as described above.

Rhomboid Major, Rhomboid Minor, and Levator Scapulae Palsy

Rhomboid and levator scapulae palsies are primarily treated with nonoperative therapy focusing on cervical spine stabilization and strengthening of the trapezius muscle¹. Surgical interventions, including fascial grafts and neurolysis with decompression, have been described: fascial-sling procedures involve using fascia lata grafts to anchor the scapula to the spinal muscles and the latissimus dorsi^{62,75}. In addition, Chen et al.³⁹ showed improvement in fourteen of twenty-two patients undergoing anterior decompression of the soft tissue of the neck. However, nerve procedures are typically considered only when all other nonoperative and surgical treatments have failed².

Conclusions

Scapular winging often mimics more common shoulder abnormalities in its clinical presentation, leading to diagnostic difficulty, unnecessary procedures, and delays in definitive treatment. Diagnosis can be readily achieved with simple physical examination and specific provocative maneuvers in conjunction with EMG and nerve conduction studies. Substantial morbidity can be avoided by the prompt diagnosis and recognition of scapular winging as the cause of, or contributing factor to, the shoulder dysfunction. When nonoperative treatment fails for serratus anterior palsy, dynamic muscular transfers are the treatment of choice, with scapulothoracic fusion reserved for salvage situations or neuromuscular conditions. Trapezius palsy may benefit from early nerve procedures, but dynamic muscular transfers are also an option when nonoperative treatments are exhausted. ■

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