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Scapulothoracic disorders

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ABSTRACT

Scapulothoracic articulation disorders may cause significant malfunction of the shoulder girdle. Scapular winging, dyskinesia, crepitus and bursitis are different pathological entities associated with the scapulothoracic joint. Their pathogenesis is a combination of anatomic, posture, traumatic and neuromuscular alterations. In this monography, the causes, diagnosis and treatment of the scapulothoracic disorders will be discussed.

KEY WORDS: scapula; winging; dyskinesia; crepitus; bursitis

Introduction

The scapulothoracic articulation is essential in the kinesiology of the shoulder girdle. Few papers are referred to scapulothoracic disorders compared to glenohumeral and acromiclavicular joints of the shoulder girdle. Disorders associated with scapulothoracic joint are often poorly understood or difficult to diagnose. They are rather common in heavy manual workers as well as in water sport and overhead sport athletes, as the continuous and intense movement of upper limbs and trunk makes the area of the scapula the most functionally active site. The pathogenesis of scapulothoracic disorders involves anatomic and neuromuscular alterations that affect the biomechanics of the shoulder.

A. Surgical anatomy

Scapula is a thin bone which is the site of attachment of 17 muscles of trunk and upper limb and plays a key role in the coordinated movement of the upper limb (**Fig. 1**).

The muscles attached to scapula can be divided into three groups (**Table I**): (a) The scapulothoracic muscles adjust the scapulothoracic movement and include the major and minor rhomboids, the levator scapula, the anterior serratus, the trapezius, the omohyoid and the pectoralis minor. Conditions of these muscles present with winged scapula or scapulothoracic dyskinesia. (b) The scapulohumeral muscles provide functional strength to the humerus and include the deltoid, the long and short heads of biceps

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TABLE 1. *Muscles attached to scapula*

SCAPULOTHORACIC	SCAPULOHUMERAL	ROTATOR CUFF
1. Levator scapula	1. Long head of biceps brachii	1. Supraspinatus
2. Omohyoid	2. Short head of biceps brachii	2. Infraspinatus
3. Rhomboid major	3. Deltoid	3. Subscapularis
4. Rhomboid minor	4. Coracobrachialis	4. Teres minor
5. Serratus anterior	5. Teres major	
6. Trapezius	6. Long head of triceps brachii	
7. Pectoralis minor		

brachii, the coracobrachialis, the long head of the triceps brachii and the teres major. (c) The rotator cuff muscles control the movement of glenohumeral articulation and consist of the supraspinatus, infraspinatus, subscapularis and teres minor. Disorders of these muscles are common and compose a special subject of study not included in this issue.

B. Biomechanics

The interplay of 4 articulations (Sternoclavicular Joint, Acromioclavicular Joint, Scapulothoracic Joint and Glenohumeral Joint) of the shoulder complex, results in an coordinated movement pattern of the arm elevation. The involved movements at each joint are continuous, although occurring at various rates and at different phases of arm elevation. The movement of the scapula can be described by rotations in relation to the thorax. The scapula moves around a dorso-ventral axis, resulting in a rotation in the frontal plane. In this movement the glenoid cavity is turned cranially (upward rotation) or caudally (downward rotation). In the sagittal plane, around a latero-lateral axis the scapula rotates posteriorly (posterior tilting) or anteriorly (anterior tilting). External and internal rotation occurs around a cephalo-caudal (longitudinal) axis. The external rotation brings the glenoid cavity more into the frontal plane, whereas the internal rotation turns the glenoid cavity more to the sagittal plane.

At rest, the scapula is rotated 30^o anteriorly in frontal plane. The inferior angle of the medial border of the scapula is also deviated 3^o away from

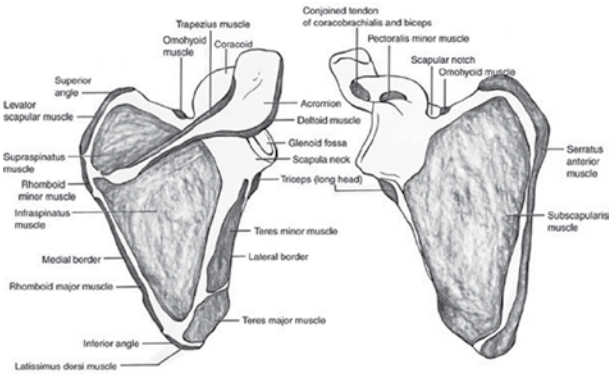

Fig. 1. *Muscular attachments to scapula*

the midline. When observing the lateral side of the scapula, there is an anterior inclination of 20^o in the sagittal plane (**Fig. 2**).

Almost every upper limb movement includes elements of scapulothoracic and glenohumeral motion. In the first 30^o of humeral abduction, most of the movement is provided by the glenohumeral joint. The rest 60^o are equally distributed to glenohumeral and scapulothoracic joints. Overall, the glenohumeral to scapulothoracic ratio during abduction of the shoulder up to 90^o is 2:1.

During abduction, in the scapular level, the point of rotation of the scapula moves so that for the first 0^o - 30^o the scapula rotates around its actual center. From 30^o to 60^o rotates around the glenoid fossa, leading to medial and superior displacement of the inferior angle of the scapula (**Fig. 3**). Moreover, during arm abduction, the coracoid process and the ac-

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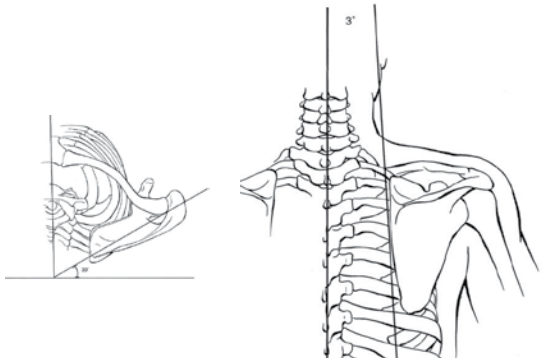

Fig. 2: *Stereoscopic position of scapula*

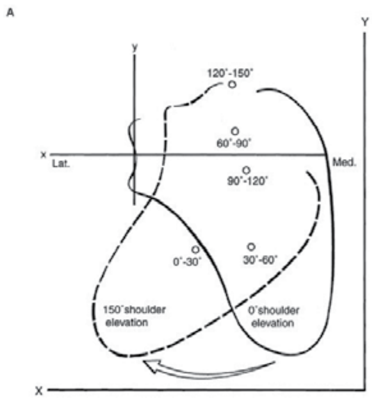

Fig. 3: *Movements of scapula*

romion move superiorly, reducing the sub-acromial impingement (**Fig. 4**).

C. Muscle function around the scapula

Activation of the upper fibers of trapezius, which insert at the lateral part of the scapular spine, the acromion and the lateral end of the clavicle, moves the scapula superiorly. This action is opposed by the gravity and the latissimus dorsi muscle, which acts as the main stabilizer of the scapula. Its action is reinforced by the inferior fibers of the anterior serratus, the pectoralis minor and the lower trapezius.

The upward rotation of the scapula begins with the activation of middle trapezius, which stabilizes the scapula by its attachment to the medial part of the scapular spine. At the 45^{o} of scapular protraction the serratus anterior draws the inferior angle of the scapula outwards. The upper trapezius draws the lateral angle of the scapula superiorly, while the lower trapezius which inserts to the medial part of the scapular spine, draws the scapula downwards, leading to upward rotation (**Fig. 5**).

The downward rotators of the scapula are mainly the rhomboids and the levator scapula, which draw superiorly the medial border of the scapula, while the pectoralis minor, the lower part of pectoralis major and the latissimus dorsi stabilize the lateral border of the scapula (**Fig. 6**).

The anterior movement of the scapula is performed by the serratus anterior, pectoralis major and minor, as they move the scapula anteriorly and

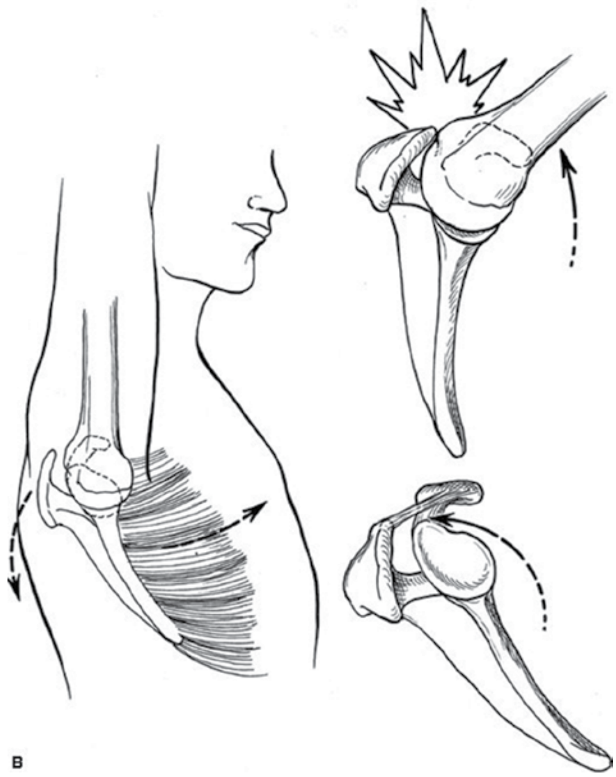

Fig. 4: *Scapular-humeral synergy*

outward. The posterior movement of the scapula is performed by the middle trapezius and rhomboids (**Fig. 7**).

D. Bursae of the scapula

The bursae of the scapula ensure the smooth scapulothoracic movement. There have been described

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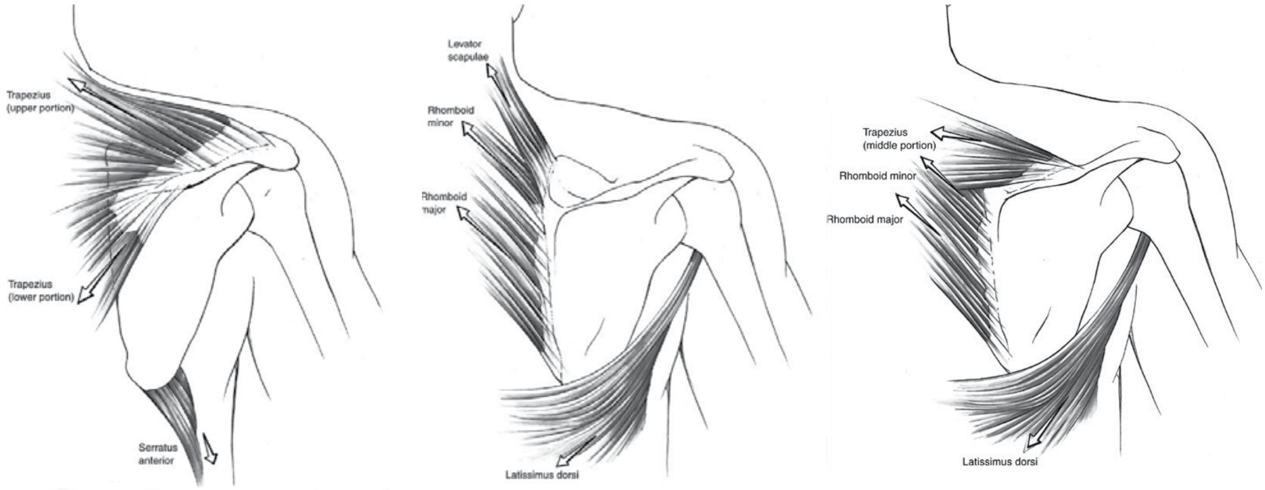

Fig. 5-7: *Muscular forces applied to the scapula*

2 main and 4 accessory bursae in this area (**Table 2**, **Fig. 8**). The first main bursa is located between the serratus anterior muscle and the thoracic wall. The second is located between the subscapularis and the serratus anterior muscles.

Bursitis of the scapulothoracic joint is clinically manifested in two locations: At the superior medial angle and the inferior angle of the scapula. At the inferior angle of the scapula, the inflamed bursa is located between the serratus anterior and the thoracic wall. Many names have been attributed to this bursa so far, like *infraserratus bursa, bursa mucosa serrata* etc. Initially, Codman believed that the bursa of the superior medial angle is located between the three first ribs and the scapula[1]. Finally, Von Grueber was the one who identified the bursa between the serratus anterior and the subscapularis muscle and named it *bursa mucosa angulae superioris scapulae*[2].

An accessory bursa is found in the triangular surface of the inner part of the scapular spine and below the trapezius. Codman believed that this bursa was responsible for the scapulothoracic crepitus and named it *trapezoid bursa*. Many authors believe that the accessory bursae developed in order to counteract the abnormal biomechanics of the scapulothoracic joint and this is the reason that are not steadily found at the same region or at the same tissue plane.

D. Scapulothoracic disorders

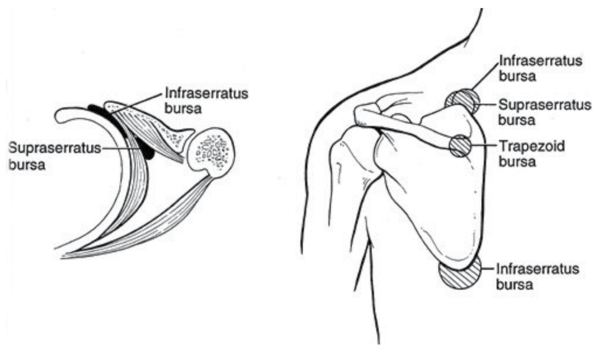

Fig. 8: *Bursae of scapula*

1. WINGED SCAPULA

Winged scapula is the most common disorder of the scapulothoracic articulation and various factors are implicated in its pathogenesis. It is classified to primary, secondary and voluntary (**Table 3**). **Primary** winging refers mainly to anatomic disorders that directly affect the joint. The **secondary** form is usually related to pathology of the glenohumeral joint. Finally, the **voluntary** form is rather rare and is attributed to psychological causes.

I. PRIMARY WINGED SCAPULA

A. Neurological disorders

1) Major and minor rhomboids palsy

This is a rare cause of winged scapula. These muscles are innervated by the dorsal scapular nerve (C5 root). This nerve passes deeply or through the le-

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TABLE 2. *Bursae of the scapula*

CLASSIFICATION		ANATOMIC SITE	INTERSPACE
Major/Anatomic		Below SA	SA-Thoracic wall
		Above SA	SA-Subscapularis
Minor/Ectopic	Superior Medial angle	Below SA	SA- Thoracic wall
		Above SA	SA-Subscapularis
	Inferior angle	Below SA	SA-Thoracic wall
	Scapular spine	Trapezius	Inner part of spine-T

SA: Serratus Anterior, T: Trapezius

vator scapula muscle and then reaches the rhomboids. Winging of the scapula can be the result of C5 pathology or damage to the dorsal scapular nerve.

Patients with weakening of the rhomboids are presented with pain along the medial border of the scapula. The winging of the scapula is not very obvious at rest. It is possible, though, to resemble with the winged scapula caused by the trapezius weakening with depression of the scapula, outward displacement and outward rotation of the inferior angle. Furthermore, atrophy along the medial border of the scapula may exist. During arm abduction, the inferior angle of the scapula is drawn downwards and outwards due to the action of anterior serratus. The winging becomes even more evident when the arm is slowly adducted starting from the position of anterior flexion, so that the inferior angle of the scapula is drawn outwards and dorsally while hands are lying on the hips. Electromyography and other tests of neurological conduction can be very helpful in the differential diagnosis and the distinction from other neurological disorders.

Treatment is based on the strengthening of the trapezius. If symptoms persist and conservative measures fail, patients can benefit by the ***Dickson procedure*** [3]. In this procedure, two cylindrical grafts of the fascia lata connect the lower part of the medial border of the scapula with the paraspinal muscles and the inferior angle of the scapula with fibers of the latissimus dorsi. This technique stabilizes the scapula and partially inhibits the high thoracic scoliosis that can emerge due to the paralysis of the rhomboids and the levator of scapula. However, there is a possibility that the grafts will eventually become loose and elongated.

TABLE 3. *Classification of winged scapula*

I. PRIMARY
A. Neurological causes
1. Long thoracic nerve: Anterior serratus palsy
2. Accessory nerve: Trapezius palsy
3. Dorsal scapular nerve: Rhomboids palsy
B. Osseous causes
1. Osteochondroma
2. Poor fracture healing
C. Soft tissues
1. Flexion deformities
2. Muscular detachments
3. Muscular agenesis
4. Scapulothoracic bursitis
II. SECONDARY
1. Disorders of glenohumeral joint
2. Disorders of the subacromial space
III. VOLUNTARY
1. Psychological causes

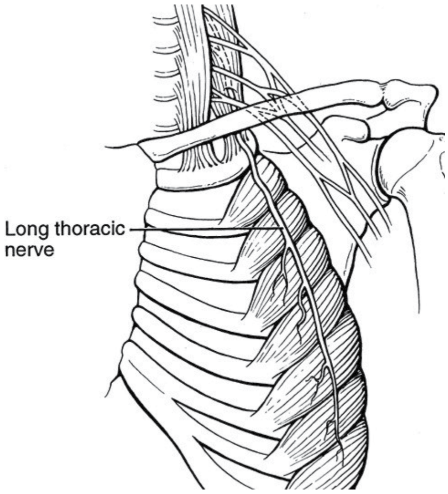

Fig. 9: *Course of long thoracic nerve.*

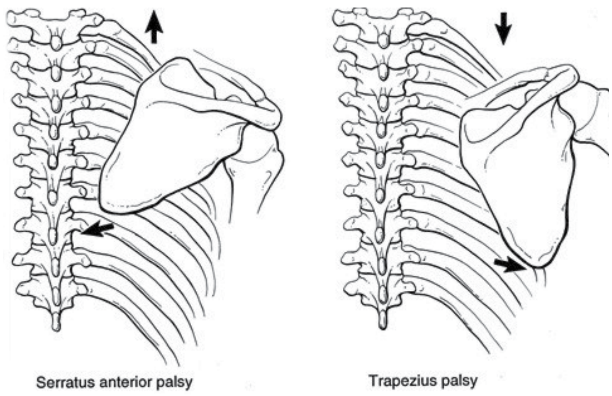

Fig. 10: *Serratus anterior (left) and trapezius (right) palsy*

2) Serratus anterior palsy

Palsy of the serratus anterior can cause a painful winged scapula. The long thoracic nerve that innervates the serratus anterior is formed by the C5,6,7 roots, passes below the brachial plexus and the clavicle and above the first rib. It then runs superficially along the lateral thoracic wall, where it is more susceptible to trauma (**Fig. 9**). Blunt trauma or protraction of the nerve is rather common in athletes, especially those involved with tennis, golf, hockey on ice, soccer, basketball, bowling, javelin throw, wrestlers etc. Repeated minor injuries in workers that use their shoulder extensively have been reported as causes of nerve paralysis. Penetrating trauma can rarely cause nerve damage. Nevertheless, surgical procedures like radical mastectomy, first rib resection and transaxillary sympathectomy have been associated with long thoracic nerve damage. The nerve can also get paralyzed due to non-traumatic causes, like the faulty positioning of the surgical patient under general anesthesia, viral causes, inoculation, brachial plexus or long thoracic neuritis. Moreover, sleeping with the arm placed under the head so that supports it in order to facilitate reading of a book has been shown to cause nerve dysfunction. Lastly, C7 radiculitis can also be a cause of serratus anterior weakening and winged scapula.

Patients with serratus anterior palsy usually complain about pain, as the rest of the scapular muscles are trying to compensate for the winging of the scapula. Extreme pain should lead us to consider the possibility of brachial plexus neuritis or mononeuritis of the long thoracic nerve (*Parsonage-Turner syndrome*) [4]. The scapula is located in a more superior position, displaced inwards with the inferior angle facing inwards (**Fig. 10**). The patient presents with difficulty abducting the arm over 120^o, where the winged scapula is more obvious. Pain is even worse in arm abduction when the head of the humerus tilts to the ipsilateral shoulder.

Electromyography is considered gold standard for the confirmation of the diagnosis. It should be repeated every 1-3 months to monitor the healing of the long thoracic nerve, since most cases with paresis are resolved spontaneously within the first 1 to 2 years.

Conservative treatment starts immediately after the diagnosis and includes exercises for the maintenance of the range of movement of the glenohumeral joint. There are many types of braces that keep the scapula attached to the thoracic wall, but their role is controversial.

Penetrating trauma should be treated with early nerve repair. On the other hand, late surgical repair with neurolysis and neuronal grafts does not always give satisfactory results. In patients with symptomatic winged scapula for over a year, surgical repair can alleviate the pain and repair the functional-

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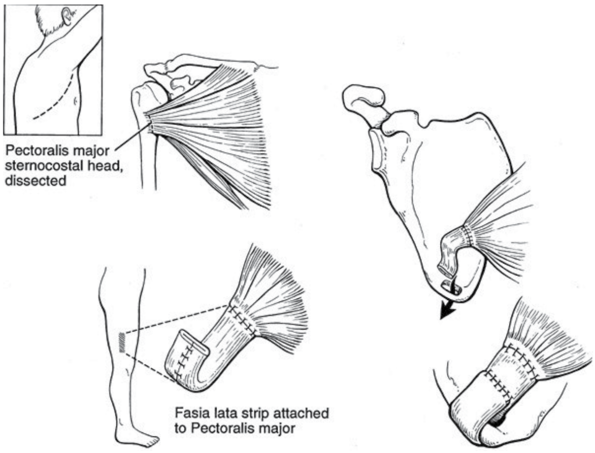

Fig. 11: Dissection of the sternocostal head of the pectoralis major and enhancement with fascia lata autograft for the treatment of the serratus anterior palsy

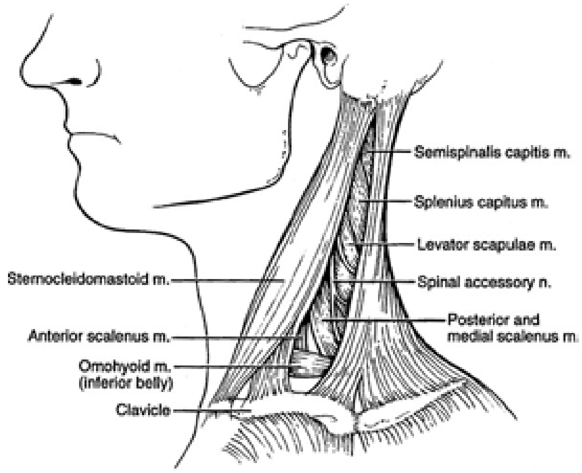

Fig. 12: *Course of the accessory nerve*

ity of the scapula. Historically, these procedures are classified into three categories: (a) arthrodesis of the scapulothoracic joint, (b) use of fascial support and (c) muscle-tendon transfers. For the muscle-tendon transfer, graft sources are usually the pectoralis major, the sternocostal and clavicular heads of pectoralis major, the rhomboids and combinations of the above muscles.

The arthrodesis procedures for the scapulothoracic joint can relieve the pain, but can also lead to loss of scapular mobility. Other complications of arthrodesis are pseudoarthrosis and pneumothorax. The indications of this method are limited to cases where other techniques have failed, simultaneous paralysis of many muscles of the shoulder and in workers that perform heavy tasks and apply too much pressure on the shoulder. Fascial grafts have the drawback of loosening and failure of their supportive ability. Consequently, muscle-tendon transfers have earned interest in the treatment of the winged scapula due to anterior serratus paralysis. Transfer of various muscles has been used, with that of sternocostal head of pectoralis major to be the most popular (**Fig. 11**). The patient is placed at the lateral decubitus position and the incision runs through the axilla, from the pectoralis major up to the inferior angle of the scapula. Alternatively, two different incisions can be made and the pectoralis major is reversed subcutaneously. The sternocostal head of the pectoralis major is released from its insertion biceps groove at the humerus. Then, an autologous graft from the ipsilateral fascia lata (18x15 cm) is prepared. The 18 cm tube-shaped autograft is then side-to-side sutured at the free end of the tendon of the pectoralis major. An aperture is made at the inferior end of the medial border of the scapula and the graft is passed through it sutured under mild tension. Postoperatively, the arm is suspended with a triangular bandage and passive mobilization begins. Active mobilization starts after the first 6 weeks and strengthening exercises after 12 weeks. Early complications of this technique include pneumothorax, while fracture of the inferior angle of the scapula and graft failure has been reported as late complications. Arthrodesis of the scapulothoracic joint can be performed in case of severe complications.

3) Trapezius muscle palsy

The accessory nerve innervates the majority of the trapezius muscle. Its course is superficial, found in the subcutaneous tissue of the posterior cervical triangle, making it susceptible to trauma (**Fig. 12**). The causes of the accessory nerve trauma include blunt trauma, traction, sharp trauma (during lymph node biopsy) and the radical cervical lymph node excision.

Patients suffering from trapezius palsy usually

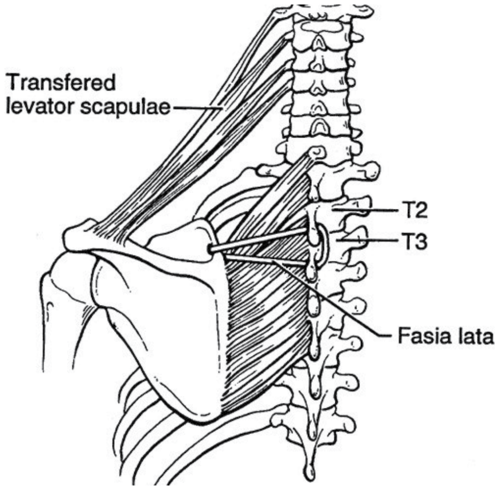

Fig. 13: *Dewar-Harris procedure*

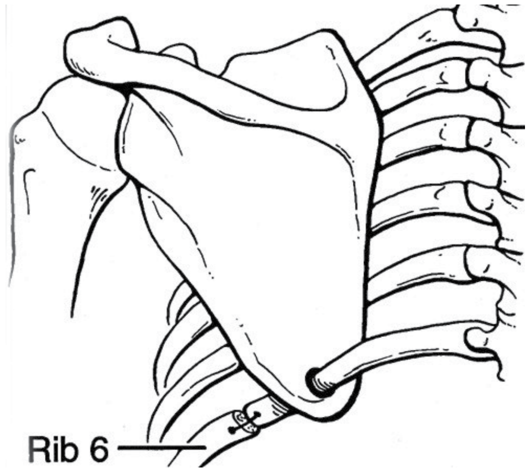

Fig. 14: *Spira procedure*

present with pain due to the counterbalancing action of the levator of the scapula and the rhomboids. Other causes of pain in these patients are the progression to frozen shoulder, the subacromial friction and cervical radiculitis due to protraction of the brachial plexus as a result of the shoulder drop.

Clinical evaluation reveals inability to shrunk the shoulder, as well as inability of abduction and forward flexion of the ipsilateral arm. The scapula is found in a lower level than normal, displaced outwards with the inferior angle headed outwards (**Fig. 10**). Electromyography is used to confirm the diagnosis.

Treatment of patients with winged scapula due to accessory nerve palsy depends on the duration and the intensity of the symptoms. Initial treatment is conservative, with the suspension of the arm in a triangular bandage in order to provide relaxation for the rest of the muscles. Physical therapy aims at the preservation of range of motion of the glenohumeral joint and the avoidance of the progression to frozen shoulder. In cases of blunt trauma-related paralysis, regular follow-up with electromyography every 4-6 weeks is necessary to monitor nerve function. In cases of palsy due to sharp trauma or when no nerve function can be detected, surgical investigation with neurolysis, placement of nerve grafts or combination of the above techniques is the treatment of choice. The results of those methods are rather variable, while they seem to be better when neurolysis is performed within 6 months.

Patients that present with symptoms lasting up to a year are not likely to benefit from conservative treatment. Historically, a great variety of surgical techniques has been reported for the treatment of winged scapula due to trapezius muscle palsy. These techniques can be divided in (a) static stabilization, including arthrodesis of the scapulothoracic joint and (b) dynamic stabilization, including muscle-tendon transfers.

Dewar-Harris technique used to be a very popular method.[5] The medial border of the scapula is stabilized on the spinous processes of T1 and T2 vertebrae with bundles of fascia lata that substitute the middle and lower trapezius. The levator scapula is then transferred to the peripheral end of the scapular spine to substitute the upper trapezius (**Fig. 13**). Postoperatively the arm is placed in spica and at 45^o-50^o abduction for 6-8 weeks.

Partial arthrodesis of Spira is another historically interesting procedure [6]. During Spira procedure, an aperture is created at the inferior angle of the scapula. The sixth rib is dissected, penetrates the scapula through the hole and its ends are reattached (**Fig. 14**). Full arthrodesis procedures of scapulothoracic joint are indicated in cases of generalized inability of the muscles of the shoulder. Since arthrodesis limits the mobility of the scapula and fascial

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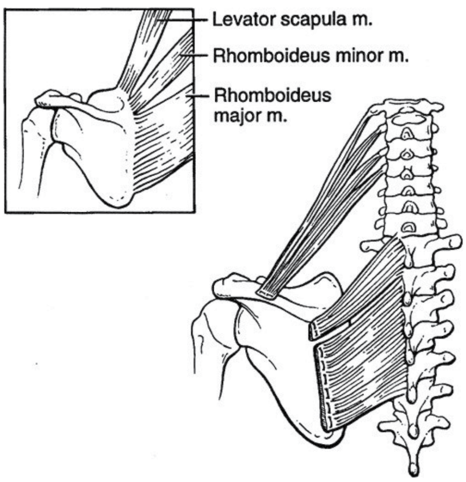

Fig. 15: Eden-Lange procedure

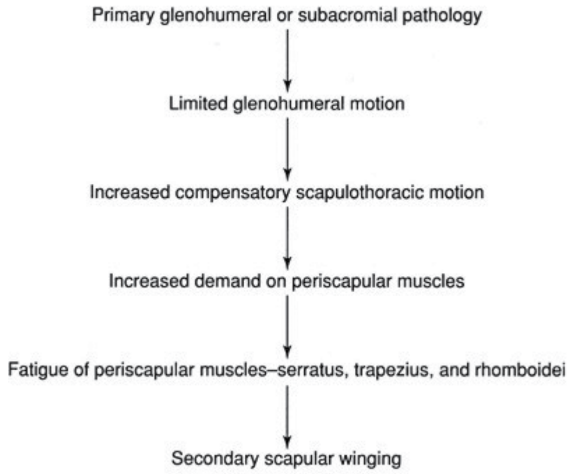

Fig. 16: Secondary winging cataract

grafts usually fail due to loosening after 2-3 years, dynamic stabilization with muscle-tendon transfers is currently the treatment of choice.

In the Eden-Lange technique, the levator scapula and the rhomboids are transferred outwards (**Fig. 15**) [7-9]. The levator of the scapula substitutes the upper trapezius, the rhomboid minor substitutes the middle and the rhomboid major the lower trapezius. The lateral relocation of the insertions of these three muscles optimizes the biomechanical outcome and deceases the winging. This method includes two incisions. The first one is performed along the medial border of the scapula and the second one above the scapular spine. The insertions of the three muscles are detached along with an osseous segment. The rhomboids are then directed peripherally under the infraspinatus and fixated with intraosseous sutures (*via* osseous holes made 5 cm peripherally of the medial border of the scapula). The levator of the scapula is directed subcutaneously towards the second incision and gets fixated to the spine through osseous apertures. Postoperatively, the patient uses an arm abduction brace for 4-6 weeks, followed by physical therapy program with passive and active mobilization. The outcomes of this method are considered excellent, with 91% reporting pain alleviation and 87% significant improvement in the functionality of the shoulder.

B. Osseous malformations

Osteochondroma of the scapula or the ribs is the main osseous causes that can lead to winged scapula. This type of winging is due to structural rather than functional causes and can be accompanied by scapular crepitus. Patients usually present with winging that does not change in respect to upper limb movement. Electromyography is normal and the osteochondroma is revealed when either a tangential X-ray of the scapula or a CT scan are performed. Surgical excision of the osteochondroma is the treatment of choice.

Primary causes of the winged scapula include poor positioning during scapula and clavicular fracture healing. These patients can remain asymptomatic due to intact muscle functioning.

C. Soft tissues disorders

Muscular disorders causing winged scapula include traumatic muscle ruptures and congenital muscle agenesis. Electromyography is normal and MRI reveals the cause of winging. Muscle detachments are treated with direct repair. In cases of congenital muscle agenesis of the trapezius, anterior serratus and rhomboids, patients usually compensate for the functional deficiency without the need of surgery.

Winged scapula can also present in 50% of patients suffering from scapular bursitis. Bursitis is usually accompanied with pain and crepitus. Con-

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servative or surgical management of bursitis leads to the effective treatment of the winging and the associated symptoms.

II. SECONDARY WINGED SCAPULA

Secondary winging of the scapula is due to disorders of the glenohumeral articulation that cause abnormal scapulothoracic dynamics (**Fig. 16**). Detailed evaluation of the patient is imperative. The patient should be able to perform passive, active and resisted flexion of the ipsilateral arm and scapula motion should be monitored. Electromyography is normal.

Flexion deformities and muscle contractions around the glenohumeral joint cause secondary winged scapula. Patients with damage in the upper brachial plexus develop this kind of contractions due to the disordered equilibrium of the muscles of the shoulder, with the humerus in abduction and internal rotation. When the humerus is forcibly adducted and externally rotated, the lateral angle of the scapula projects away from the thoracic wall, producing the "*scapular Putti sign*"[10]. Furthermore, the fibrosis of the deltoid causes pronounced winging during adduction while disappears during abduction. Fibrosis of the deltoid can be congenital or due to intramuscular injections.

Winged scapula can be manifested as a reflex muscle spasm after painful conditions of the glenohumeral joint and the subacromial space (**Table 4**). Patients with painful shoulder tend to limit the movement of the scapulothoracic joint. This forces the muscles around the scapula to work harder, as the scapulothoracic motion has to increase in order to compensate for the decreased motion of the glenohumeral joint. When fatigue of these muscles occurs, winging ensues (**Fig. 16**). Management of the primary causes will improve scapular winging. Physical therapy is also needed.

III. VOLUNTARY WINGED SCAPULA

These are rare cases and the physician should seek for a phycological background.

2. SCAPULAR DYSKINESIA

Certain shoulder disorders like glenohumeral instability and subacromial impingement can cause secondary alterations in the dynamics of the scapulothoracic joints causing scapulothoracic dyskinesia. The opposite can also occur, when scapulothoracic dyskinesia leads to disorders of the glenohumeral joint (**Table 5**).

The use of various electromyographic methods revealed a particular and repetitive type of scapulothoracic asymmetry. The synchronized movement of the athletes engaging in throwing sports, depends on the coordination of the scapulothoracic movement. Any pathology in the stabilizing muscles leads to inadequate attempt and increased risk of trauma. The position of the scapula at the time of throwing determines the length-traction relationship of the muscles and enables the creation of the maximal muscle forces and the best possible performance of the athlete. Scapula movement determines the position of the glenohumeral joint in space and optimizes the relevant position of the glenoid fossa towards the head of the humerus to maintainstability of the glenohumeral joint. It also raises the acromion to avoid subacromial impingement and last-

TABLE 4. *Causes of secondary winged scapula related to painful disorders of the shoulder*

Rupture of the rotator cuff muscles
Pseudarthrosis of acromial fractures
Poor healing of clavicular and glenoid fractures
Avascular necrosis of the humeral head
Acromegalic arthropathy of the shoulder
Disorders of the acromioclavicular joint
Shoulder instability

TABLE 5. *Relation of scapulothoracic asymmetry with shoulder pathology*

Shoulder pathology	Static asymmetry	Dynamic asymmetry
Glenohumeral instability	32 %	64 %
Subacromial impingement	57 %	100 %

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TABLE 6. *Causes of scapulothoracic crepitus*

Connective tissue	
Muscle	Atrophy Fibrosis Anatomic abnormalities
Bone	Rib osteochondroma Scapular osteochondroma Rib fracture Hooked superomedial angle of the scapula Lushka's tubercle Reactive bone spurs from muscle avulsion
Other soft tissues	Bursitis Tuberculosis Syphilis
Disorders of the scapulothoracic congruence	
Spine scoliosis Thoracic spine kyphosis	

ly, the muscles around the scapula are important in order to ensure strength against the eccentric load at the various stages of throwing.

Kibler was the first to describe the lateral slide test for the assessment of the scapulothoracic dyskinesia.[11-13] This test is designed to evaluate the patient's ability to stabilize the medial border of the scapula during different positioning and loading. Arms are placed in three different positions: (a) at resting position, (b) hands on hips with fingers anterior and thumbs posterior and (c) arms at 90° with internal rotation. In asymptomatic patients, asymmetry is less than 1 cm. In symptomatic patients with pain and limited range of motion, there is significant asymmetry more than 1 cm in positions (a) and (b).

Clinically, the outward position of the scapula leads to greater anteversion of the glenoid fossa, leading to an increase in the anterior interspace of the glenohumeral joint, and therefore to instability and cartilage lesions. Moreover, disorders of shoulder motion lead to elevation of the acromion and subsequent subacromial crepitus.

Management of the scapulothoracic dyskinesia consists of strengthening exercises of the scapular muscles, while strengthening of the rotator cuff muscles should be avoided until the functionality of the scapula has been restored.

3. SCAPULOTHORACIC CREPITUS

Over time, many names have been attributed to the symptomatic scapulothoracic crepitus, like *snapping scapula, washboard syndrome, scapulothoracic syndrome, rolling scapula, grating scapula, scapulocostal syndrome*, while many causes have been identified (**Table 6**). Although Codman [1] was the one who said that he was able to make his scapula produce a noise loud enough to be heard in the whole room without feeling any pain, Boinet was the first to describe this disorder at 1867. It wasn't until 37 years later, when Mauclaire classified the scapulothoracic crepitus in three groups: (a) *froissement*, is described as a normal mild friction sound, (b) *frottement*, is a more intense sound of coarse friction which is usually pathologic and (c) *craquement* is the intense and loud noise of scapular popping, which is always abnormal [14]. These scapular sounds arise from two sources: either from the tissue between the scapula and the thoracic wall, or from congruence disorders of the scapulothoracic joint. Milch states that the *frottement* is associated with soft tissue pathology or bursitis, while the *craquement* indicates osseous causes [14].

Muscular causes consist of atrophy, fibrosis and abnormal muscle insertions, while tuberculous and syphilitic lesions represent other soft tissue causes.

Osteochondroma of the ribs or scapula is the most common cause of scapulothoracic crepitus. Other causes include poorly healed rib fractures, abnormalities of superomedial angle of the scapula (hooked angle), Lushka's tubercle and reactive osseous spurs from repetitive chronic muscle avulsion. Any osseous cause that produces scapulothoracic crepitus can lead to bursitis. On the other hand, an inflamed bursa can lead to painful crepitus. Finally, disorders of the scapulothoracic congruence, like scoliosis and thoracic kyphosis, can also be a cause of crepitus.

Diagnosis is made through meticulous history

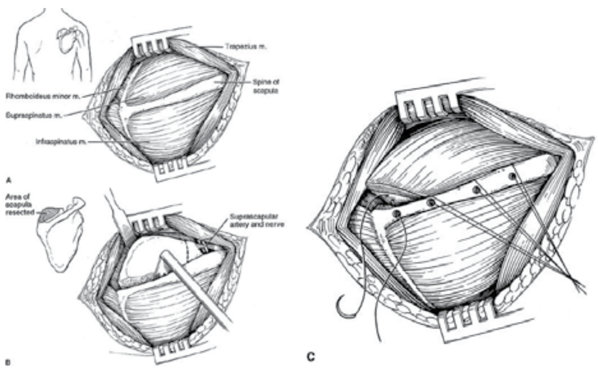

Fig. 17: Superomedial scapular angle resection

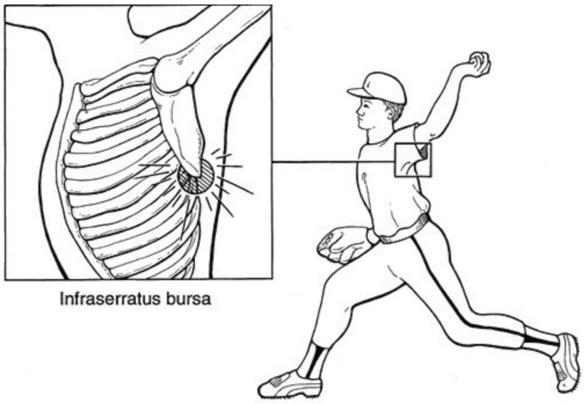

Fig. 18: Scapulothoracic bursitis

and clinical evaluation. Patients are often athletes engaging in throwing sports and workers involved in overhead activities. At inspection, winging implies a space-occupying lesion. Palpation and auscultation during shoulder motion will locate the crepitus. Palpation of a mass, crepitus and eminence at resting position combined with normal scapulothoracic motion are key features in differential diagnosis from winged scapula due to neurological causes. The tangent X-ray and CT scan are also helpful tools in diagnosis.

It is important to note that scapulothoracic crepitus is found in 35% of normal individuals. Furthermore, it is possible that patients with psychiatric background will not respond to treatment. Finally, crepitus is considered an abnormal finding, when associated with pain, winging or other scapulothoracic disorders.

When osseous causes are involved, like osteochondroma, surgical resection is the treatment of choice. In cases of soft tissue pathology, initial management is conservative, with exercises that aim to avoid downward inclination of the scapula (use of figure-of-eight bandage), strengthen exercises of the adjacent muscles and corticosteroid infusion in painful sites.

Surgical techniques include muscle transfers for muscle palsy cases, such as the transfer of rhomboids, trapezius and their re-attachment under the scapula. These procedures are associated with muscle atrophy and failure. Other procedures are the partial resections of the scapula, mainly the medial border or the superior medial angle.

During the superior medial angle resection, the patient is placed at prone position (**Fig. 17**). The incision is made over the medial part of the scapular spine and the overlying soft tissues are dissected. The periosteum of the spine is then elevated to create space between trapezius and scapula. The supraspinatus, rhomboids and levator scapula are subperiostically dissected starting from the spine. The superomedial angle of the scapula is resected with the use of a scapular saw. Care is taken not to injure the suprascapular nerve and the dorsal scapular artery. The muscles and periosteum are then reattached in place and sutured through osseous tunnels. Postoperatively, the arm is suspended in triangular bandage and patients start passive mobilization immediately. Active mobilization starts at 8 weeks following the operation and strengthening exercises at 12 weeks.

Complications of the partial scapular excision are pneumothorax and postoperative hematoma. Recurrence is more common in younger patients, but are rarely symptomatic.

4. SCAPULOTHORACIC BURSITIS

Scapulothoracic bursitis can either accompany scapular crepitus or be a separate entity. Patients often complain of pain related to activities or present with audible or palpable crepitus. They usually de-

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scribe a repetitive activity that makes scapula move against the posterior thoracic wall. A chronic inflammation is then developed that leads to fibrosis and scarring followed by crepitus and pain (**Fig. 18**).

Initial management is conservative with rest, analgesics and NSAIDs. Physical therapy, with strengthening exercises and stretching of the dorsal musculature, improves posture. Heat patches and cortisone injections offer pain. If symptoms persist, surgical treatment is indicated.

Sisti & Jobe performed bursectomy of the inferior scapular angle in athletes. An oblique incision distal to the inferior angle is made and trapezius and latissimus dorsi are dissected along their muscle fibers. Physical therapy started 1 week postoperatively and within 6 weeks the athletes were able to perform mild throwing exercises.

McCluskey & Bigliani performed open bursectomy of the superomedial angle with vertical incision on the inside of the medial border of the scapula. After dividing the trapezius, the levator scapula and the rhomboids were subperiostically released from the scapular medial border. The space created between the latissimus dorsi and the thoracic wall enabled the resection of the thickened bursa. Muscles are then reattached. Triangular bandage is used to suspend the arm and after 3 weeks active range of motion exercises begin, while 12 weeks postoperatively strengthening begins.

Ciullo & Jones conducted endoscopic bursae resection with debridement and reconstruction of the superomedial or inferior scapular angle. Arthroscopic bursae resection was described by Matthews. Patient is placed at either lateral or prone positioning, which enables the arthroscopic evaluation of the glenohumeral articulation and the subacromial space. Furthermore, the scapula moves away from the thoracic wall with abduction and internal rotation, facilitating access to the bursa. Three trocar insertion sites are created and the trocars are placed at least 2 cm on the inside of the medial scapular border and between the spine of the scapula and the inferior angle. For the middle insertion site, a needle is placed inside the bursa between the latissimus dorsi and the thoracic wall. The needle should enter between the spine and the inferior angle and at least 3 fingers on the inside of the medial border in order to avoid injury of the suprascapular artery and nerve. The bursa first gets larger with fluid infusion, before the insertion of the instruments. The upper insertion site is created 3 fingers on the inside of the medial scapular border, right under the spine and penetrates the space between the two rhomboids. This site enables access at the superomedial angle. A more medial positioning of the insertion site would jeopardize the suprascapular artery and nerve, the accessory nerve and the circumflex scapular artery. The lower insertion site is placed in a similar way on the inferior angle. Shaver is used for bursa resection. Postoperatively, active mobilization begins immediately.

Conflict of interest:

The authors declared no conflicts of interest.

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ΠΕΡΙΛΗΨΗ

Η ωμική ζώνη κινείται μέσω τριών αρθρώσεων, της γληνο-βραχιονίου, της ακρωμιο-κλειδικής και της θώρακο-ωμοπλατιαίας. Η τελευταία, αν και αποτελεί σημαντικό στοιχείο της λειτουργίας του ώμου, δεν έχει λάβει την απαραίτητη προσοχή σε σχέση με τις δύο πρώτες, τόσο στην ιατρική βιβλιογραφία όσο και στην καθημερινή ιατρική πρακτική Οι παθήσεις της θωρακο-ωμοπλατιαίας άρθρωσης είναι δύσκολα κατανοητές ή και διαγιγνώσκονται ακόμα πιο δύσκολα. Συμβαίνουν συχνά σε χειρώνακτες αλλά και σε αθλητές υγρού στίβου και ρίπτες όπου η διαρκής και έντονη κίνηση των άνω άκρων και του κορμού καθιστά την ωμοπλατιαία χώρα την πλέον ενεργή λειτουργικά περιοχή. Η αιτιοπαθογένεια της θωρακο-ωμοπλατιαίας δυσλειτουργίας είναι συνήθως συνδυασμός ανατομικών, μυϊκών και νευρολογικών διαταραχών που επηρεάζουν την εμβιομηχανική της άρθρωσης αυτής.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: ωμοπλάτη, πτερυγοειδής, δυσκινησία, κριγμός, ορογονοθυλακίτιδα