Scapular fractures. Anatomical review, classifications and associated injuries

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Learning objectives

1. To revise the anatomy of the scapular bone and the scapular girdle tendons and muscles.

2. To describe the mechanisms of fracture of the scapula and the different classifications.

3. To understand the management of such lesions.
Background

The scapula is an integral part of the connection between the upper extremity and the axial skeleton. This highly mobile, thin sheet of bone articulates in three different joints: with the humerus in the glenohumeral joint, with the clavicle in the acromioclavicular joint, and with the thorax in the scapulothoracic joint. To accomplish a full range of shoulder motion, a smooth coordination is required of motion in all three articulations. Therefore, a complex interaction of several muscles that envelope the scapula is necessary.

Besides its assistance in the movements of the arm in the shoulder joint, the scapula has two other functions. It is a mobile platform for the humeral head and upper extremity to work against, and it serves as a point of attachment for muscles, tendons, and ligaments. No less than 18 different muscles insert on or originate from the scapula allowing six basic movements of the shoulder blade over the posterior chest wall: elevation, depression, upward rotation, downward rotation, protraction, and retraction.
ANATOMY

The scapula is a flat and triangular bone, with a thin translucent body, surrounded by borders that are well developed because of their positions as muscular origins and insertions. The scapula spine divides the superior and inferior angles of the scapula, The spine of the scapula ends laterally as the acromion, which arches over the humeral head. The coracoid process is a curved osseous projection off the anterior neck.(Fig.1)

The pear-shaped glenoid fossa lies at the lateral angle, its margin covered by a fibrocartilaginous labrum, which is confluent above with the long head of the biceps tendon at the supraglenoid tubercle. This labrum enhances the depth of the glenoid by 50%.

The back of the scapula is divided by the scapular spine into the supraspinatus and infraspinatus fossae, which are origins for their respectively named muscles. Its concave anterior surface serves as a broad origin for the subscapularis muscle. Along with the clavicle, the acromion serves as origin for the deltoid muscle. The trapezius also originates on the acromion and spine anteriorly (Fig.2).

The medial border of the scapula is the site of attachment of the serratus anterior, which functions in scapula protraction, and rhomboid muscles, the function of which is scapula retraction.

The levator scapulae muscle inserts on the superior medial border and is specifically named for its function. (Fig.3)

The lateral border of the scapula forms a thick condensation of bone that ends in the neck of the scapula and is the site of origin of the teres major and minor muscles, as well as the insertion for the long head of the triceps on the neck (Fig.4), and part of latissimus dorsi at the inferior angle.

The coracoid process is the origin for the coracoclavicular and coracoacromial ligaments, and for the coracobrachialis and short head of biceps muscles, as well as the insertion for the pectoralis minor.

Just proximal to the coracoid on the superior margin is the scapula incisura, traversed by the transverse scapular ligament, above which lies the suprascapular artery and below which runs the same nerve. The axillary nerve emerges from the quadrilateral space below Teres minor (Fig.5).
MECHANICS

Motion of the humerus results from simultaneous motion at the sternoclavicular, acromioclavicular, scapulothoracic, and glenohumeral articulations. This concert of muscular forces constrain the scapula body on the thorax at approximately 35° anteverted to the coronal plane, and position the glenoid fulcrum so that the rotator cuff can function as a dynamic stabilizer of the proximal humerus. This force vector of the rotator cuff, compressing the humeral head against the glenoid, counteracts the shear forces on the glenohumeral joint imparted by the large deltoid muscle. These forces are formidable even during ordinary activities; when the arm is held in 90° of abduction, the joint reactive force is 90% of body weight.

The unrestrained configuration of the shoulder and associated joints results in exceptional axial and rotational mobility. At less than 90 degrees of abduction the deltoid muscle force creates a shear vector in the glenoid fossa. This force is neutralized by the rotator cuff muscle, which generates a stabilizing compressive force across the glenoid. If there is an alteration in the glenoid axis caused by a displaced fracture displacement, the lever arm of the rotator cuff muscle is distorted, converting the compressive force into a shear or sliding force. Then forces are magnified at 45 degrees or more of glenoid fracture tilt. In addition, a fracture of the scapular spine may cause rotator cuff dysfunction because the entire scapula collapses with hortening, with resultant shortening of the rotator cuff lever arm.

Frequency

Scapula fractures are relatively uncommon. Approximately 50% of scapula fractures involve the body and spine. Glenoid neck constitute about 25%, fractures of the glenoid cavity (glenoid rim and fossa) make up approximately 10% of scapula fractures. The acromial and coracoid processes account for 8% and 7%, respectively.

Mechanism of injury & Associated injuries

Scapular fractures are caused by different mechanisms, of which blunt trauma is probably the most common. This direct force may cause fractures in all anatomic areas of the scapula. Other mechanisms are indirect injuries: (1) traction by muscles or ligaments may induce avulsion fractures of the acromion or coracoid, which in rare cases are caused by a seizure or an electrical shock; and (2) impaction of the humeral head into the glenoid fossa which may induce glenoid and some scapular neck fractures. As in general with high-energy trauma, traffic accidents are the main cause of scapular fractures (occupants of motor vehicles in about 50% of cases and pedestrians in 20%). Other causes are
motorcycle accidents, fall from heights, crush injuries, or sporting activities (horseback riding, skiing, and contact sports).

Associated injuries:

Usually, high energy is required to fracture a scapula, hence scapular fractures are commonly associated with concomitant injuries. Research shows that 61%-98% of scapula fractures have associated injuries. These associated injuries may be multiple and may need priority in treatment. As a result, diagnosis and treatment of scapular injuries may be delayed or suboptimal.

A wide variety of regional and remote injuries have been reported which may be life-threatening:

- Rib fractures - 25-45%
- Pulmonary injury - 15-55%
- Humeral fractures - 12%
- Skull fractures - 25%
- CNS deficits 5%
- Major vascular injury - 11%
- Splenic injury - 8%

Brachial plexus injury is present in 5% to 13% and is often the most important prognostic factor with regard to the final clinical outcome, whether fracture treatment be conservative or otherwise. The reported mortality rate of patients with scapular fractures from the concomitant injuries varies between 2% and 15%.

DIAGNOSIS

Due to the often associated life threatening and more clinically urgent injuries scapula fractures are often diagnosed later, once the patient is stable. It may be noted on the Advanced Trauma Life Support (ATLS) chest radiographs. Essentially, a high index of suspicion of scapula fractures should be applied to all major chest trauma.

Radiographs:

AP of Shoulder: it is essential to rule out articular involvement with a high quality AP view in which there is no overlap of the humerus over the glenoid; ideally, the view should be purely tangential to the glenoid; 45º cephalic tilt allows evaluation of coracoid fracture.
Apical Oblique View: is useful to assess the lateral displacement of the fractures.

**CT Scanning**

CT scans allow more accurate assessment of articular step off, as well as displacement and angulation of glenoid neck. CT scanning is particularly helpful in evaluation of intra-articular glenoid fracture.

**Classification**

Scapular fractures are generally classified by anatomic area (body and spine, glenoid cavity, glenoid [scapular] neck, acromion, and coracoid).

Fractures of the body and spine are the most common (approximately 50%), followed by the scapular neck (25%), glenoid cavity (10%), acromion (8%), and coracoid process (7%).

**Glenoid Fractures** (Fig. 6-9)

The most commonly used classification scheme concerning glenoid fractures is the one devised by Ideberg et al., who described five different fracture types. Goss modified this system by subdividing type 5 and introducing type 6, a stellate glenoid fracture with extensive intra-articular comminution.

The diagnosis of glenoid neck fractures can be made with the standard three-view trauma series. The axillary radiograph combined with CT scanning is used to demonstrate any subluxation or displacement.

**Scapular Neck Fractures** (Fig.10-12)

Scapular neck fractures are extra-articular fractures by definition. Although three fracture patterns have been described as scapular neck fractures, only two run through the scapular neck.

One fracture pattern runs lateral from the origin of the coracoid to the lateral border of the scapula (anatomic neck), and the other runs medial from the coracoid to the lateral border of the scapula.
Diagnosis of a scapular neck fracture is reliably made by plain films, in contrast with assessment of the amount of fracture displacement and angulation. A common method to determine angulation deformity and shortening, as described by Bestard, is on an AP radiograph of the scapula. Three-dimensional CT reconstruction images may be of more benefit in assessment of displacement and angulation, in contrast with the images of a conventional CT scan.

**Acromion Fractures** (Fig. 13-14)

Kuhn has proposed a subclassification of acromion fractures to help determine the need for operative intervention. According to the classification of Kuhn, type 1 are nondisplaced fractures, type 2 displaced fractures without reduction of the subacromial space, and type 3 displaced fractures with reduction of the subacromial space.

The diagnosis is radiographic. A three-view trauma series, including an AP view, a lateral view, and an axillary view of the scapula, will detect most acromial fractures. Caution should be used to differentiate an acromial fracture from an os acromiale. An axillary radiograph of the contralateral shoulder may be helpful, because an os acromiale is bilateral in approximately 45% to 62% of the cases. Occasionally, a CT scan is necessary to define the configuration of the fracture precisely.

**Coracoid Fractures** (Fig. 15-16)

Ogawa, who simplified the classification scheme of Eyres, classified coracoid fractures into two different types. Type 1 is situated proximal to the coracoclavicular ligament attachment and type 2 distal to these ligaments. Ogawa suggested that a type 1 fracture may disturb the scapulothoracic connection.

**Scapulothoracic Dissociation**

Scapulothoracic dislocation is an infrequent but severe injury of the shoulder girdle with a high mortality rate and a poorly functional outcome. The injury was originally described in 1984 by Oreck et al. and is characterised by a complete disruption of the scapulothoracic articulation with lateral scapular displacement and intact skin. This injury may be associated with a spectrum of musculoskeletal and neurovascular injuries.

The diagnosis of scapulothoracic dissociation is based on history, clinical findings, and radiography. The difficulty for the treating physician is that the severe associated injuries may divert attention away from the sometimes subtle clinical signs of the scapulothoracic
dissociation. The clinical signs may vary between swelling from a dissecting hematoma and a flail and pulseless extremity. A well-centered chest radiograph will demonstrate lateral displacement of the scapula on the injured side, which is pathognomonic of a scapulothoracic dissociation. The degree of lateralization can be quantified using the scapula index (Fig. 16).

**MANAGEMENT**

Historically, scapula fractures have been treated with closed means. One of the earliest descriptions of treating scapula fractures was published in 1805 in Desault's treatise on fractures. More recently, indications for operative management have been described. Hardegger et al reported that if significant displacement occurs, conservative treatment alone cannot restore congruence, and stiffness and pain may result, thereby indicating open reduction and stabilization.

The management of scapula fractures has historically been nonoperative, perhaps in part because of the paucity of information regarding outcomes, combined with a relative unfamiliarity in treating these injuries. Treatment has emphasized symptom relief and early motion to prevent long-term stiffness. After motion is restored in the first four to six weeks, therapy is directed at rehabilitating the rotator cuff and strengthening parascapular musculature. Because more than 90% of scapula fractures are minimally displaced, this noninvasive approach is effective for most. No well-documented role for closed reduction techniques or effective orthotic management exists.

A number of investigators have accumulated data about injury characteristics that may portend a poor prognosis, shedding light on potential indications for surgery. These recommendations fall more in line with contemporary management principles for other periarticular fractures.

Ada & Miller did a follow-up of 16 such patients treated nonoperatively, of whom 50% had pain, 40% had exertional weakness, and 20% had decreased motion at a minimum of 15 months' follow-up. A group of eight patients in this same study were treated operatively, and all achieved a painless range of motion.

Nordqvist and Petersson analyzed 68 patients with a mean 14-year follow-up and found that 50% of patients with residual deformity have shoulder symptoms.

Displaced articular fractures of the glenoid, for example, are the clearest indication for surgery. If humeral head subluxation, early arthrosis, and a poor outcome are to be prevented, open reduction internal fixation (ORIF) should be performed.
Fractures of the scapula neck should be treated operatively if displacement or angulation renders functional imbalance to the parascapular musculature. Ada and Miller have recommended ORIF if the glenoid is medially displaced more than 9 mm or there is more than 40° of angular displacement.

**Floating Shoulder**

Double disruption of the superior shoulder suspensory complex (SSSC) is an entity that has gained distinct attention since Goss discussed its significance in relation to scapula fractures. The significance of this entity was recognized much earlier, however, by a number of investigators noting that the weight of the arm and the muscle forces acting on the humerus result in a typical pattern of displacement inferior and anteromedial. Therefore, treatment recommendations have consisted of stabilizing one or both lesions to restore integrity to the SSSC, thereby preserving its function of maintaining a stable relationship between the upper extremity and axial skeleton, and providing a firm attachment for the many soft tissues that enable shoulder function.

Although there was previously an enthusiasm for fixing the clavicle fracture in all double disruption fractures, it is now preferred to manage each fracture as it's own entity, being aware of the SSSC effects. Therefore, a completely undisplaced fracture does not require fixation, but displaced SSSC, with shortening does require reduction and fixation.
Fig. 1: Scapular anatomy

http://www.highlands.edu/academics/divisions/scipe/biology/faculty/harnden/2121/notes/skeletal.htm
Fig. 2: Medial border muscle insertions

Fig. 3: Overall muscle insertions

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Fig. 4: Lateral border muscle insertions. Quadrangular space

© http://www.cram.com/flashcards/shoulder-anatomy-3355480
Fig. 5: Incisura scapulae

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Fig. 6: Glenoid fractures classification

Fig. 7

© http://www.orthobullets.com/trauma/1013/scapula-fractures
Fig. 8: Anterior rim fracture

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Fig. 9: Humeral head fracture associated with a posterior rim fracture

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Fig. 10: Scapular neck fracture classification

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Fig. 12: Scapular neck fracture Type B

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Fig. 13: Acromial fractures classification

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Fig. 14: Acromial fracture Type Ib

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**Fig. 16:** Fracture of the base of the coracoid

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Fig. 17: Scapula index

© Scapulothoracic dissociation: evaluation and management Peter U. Brucker, , Gary S. Gruen, Robert A. Kaufmann
Conclusion

Scapular fractures are high-energy injuries that occur in a variety of patterns. Surgical indications are evolving as fracture pattern recognition is improving with the use of 3D CT and classification systems are becoming more accurate.

Displaced articular fractures, particularly those associated with glenohumeral joint instability, remain a strong indication for surgical treatment. The threshold of displacement for which body and neck fractures warrant surgery remains poorly defined, but in young, active patients, surgical reduction and fixation of displaced fractures may be necessary to maximize the functional outcome.
References