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REVIEW ARTICLE

The floating shoulder

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Ipsilateral fracture of the clavicle and scapula is considered to be a relatively rare injury. It is perceived as an unstable injury and is at times called floating shoulder. Understanding of the role played by the bony and ligament stability is important to identify true floating shoulder injury and to offer an appropriate treatment. Both conservative and surgical treatment modalities are described in the literature. Recent literature has shown the important role played by the ligaments in providing stability in ipsilateral fracture of the clavicle and scapula. In a true floating shoulder injury, it seems important to stabilise the injury by fixation of the scapular fracture. This article reviews the literature to identify the injury pattern of true floating shoulder and to look at the current evidence for the treatment of such an injury.

INTRODUCTION

Fracture of either the clavicle or the scapula by itself is thought to be a stable injury. However ipsilateral fracture of the clavicle and scapular neck is thought to be unstable, and many surgeons would advocate internal fixation. Although much of the early literature favours internal fixation of such an injury, the recent literature does show favourable results without internal fixation. Ipsilateral fracture of the scapular neck and the clavicle usually results from a high-velocity injury ; it is relatively rare and therefore there are no randomised trials on the treatment of such an injury. Most of the literature consists of case reports, case series or retrospective observational cohort studies.

The aim of our review was to identify the pattern of true floating shoulder injury and summarise the current evidence for the treatment of such an injury.

LITERATURE REVIEW

Diverging opinions are reported in the literature regarding the choice for the treatment of ipsilateral fracture of the scapula and clavicle, which is thought to be floating shoulder injury. The initial trend was towards surgical treatment, which included fixation of either clavicle (*9, 11, 14*) or scapula (*16*) or of both (*10*). However some recent studies did favour conservative treatment (*4, 13, 16*). Understanding of the floating shoulder has also changed and not all ipsilateral clavicle and scapular fracture are floating shoulder injuries (*17*).

Herscovici *et al* in 1992 retrospectively reviewed 9 patients with ipsilateral midshaft fracture of clavicle and scapular neck fracture (*9*). All patients had closed injury : their mean age was 29.6 years and

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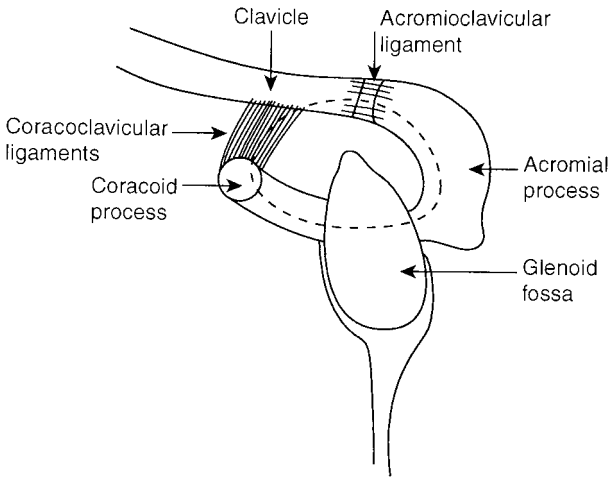

Fig. 1. — Superior Shoulder Suspensory Complex

the mean follow-up was 48.5 months. Seven patients had surgical treatment in the form of fixation of the clavicular fracture ; two patients had conservative treatment. All 7 patients who had surgical treatment were rated excellent at the time of follow-up ; of the two patients treated conservatively, one had a good and one a poor result. Both however had significant thoracic wall and lung injury. Patients treated conservatively showed drooping of their injured shoulders. The authors recommended operative treatment of such an injury.

Goss in 1993 introduced the concept of the superior shoulder suspensory complex (SSSC) (*7*). He described it as a bony / soft tissue ring at the end of a superior and inferior bony strut. The ring is composed of the glenoid fossa, the coracoid process, the coracoclavicular ligaments, the distal clavicle, the acromioclavicular joint and the acromial process (fig 1). The superior strut is the middle clavicle while the inferior strut is the lateral scapular body / spine. This complex maintains a normal stable relationship between the scapula and the axial skeleton. According to the author, double disruption of the ring, i.e. failure of the ring at two places creates an unstable anatomic situation.

Leung *et al* in 1993 reviewed the outcome of surgical treatment of ipsilateral fracture of the clavicle and scapular neck in 15 patients (*10*). Two patients had open grade II injury of the clavicle. The mean age of the patients was 31.5 years ; the mean follow-up was 25 months. All the patients were treated by open reduction and internal fixation of both fractures. The average time to fracture healing was 8 weeks for the scapular fractures and 7 weeks for the clavicular fractures. According to the scoring system of Rowe (*15*), eight patients had an excellent functional result, six had a good result and one had a fair result. The authors recommended fixation of both fractures, to provide stability to the shoulder complex and allow early postoperative mobilisation. According to the authors, postoperative rehabilitation is greatly facilitated following fixation of both fractures, and the results in their series appeared superior to those that had been reported for isolated fixation of either the scapular or clavicular facture.

Rikli *et al* in 1995 retrospectively reviewed 12 cases with an average age of 38 years (*14*). Ten patients had ipsilateral clavicle and scapular neck fracture. One patient had a scapular neck fracture and AC joint dislocation and one patient had bilateral scapular neck fracture and AC joint dislocation on one side and clavicle fracture on the other side. All patients had clavicle fixation. Additional fixation of scapula was performed in one case due to the intra-articular nature of the scapular fracture. The authors classified the results according to the Constant score and showed excellent functional results in nearly all cases. They recommended surgical fixation of the clavicle only, as the scapular neck fracture is usually reduced indirectly and is stable enough for functional aftertreatment. Six patients in their series did have symptoms suggestive of rotator cuff problems but according to the authors, they were minimal and did not justify further investigation. They recommended surgical fixation of the scapula only when there is intra-articular extension of the fracture.

Hardegger *et al* in 1984 classified scapular neck fractures into anatomical and surgical neck fractures (*8*). The surgical neck of the scapula is medial to the base of the coracoid process whilst the anatomical scapular neck is lateral to the base of the coracoid process. According to this

pathoanatomy, fractures of the anatomical neck are unstable and operative treatment is indicated even if other components of the suspensory complex are intact (*2*).

Ramos *et al* in 1997 reviewed 13 patients with ipsilateral fracture of the clavicle and scapular neck treated conservatively (*13*). The average follow-up was 7.5 years. Using Herscovici's scoring method, they reported 84.6% excellent, 7.7% good and 7.7% fair results. The authors were of the opinion that the success of the nonoperative treatment was due to intense physical therapy, and to the fact that most clavicular and scapular fractures do not require formal reduction for healing and malunions are well tolerated by most patients.

Low *et al* in 2000 retrospectively reviewed four patients with ipsilateral scapular neck and clavicle fracture treated surgically with fixation of the clavicle fracture (*11*). Mean follow-up duration was 3.3 years. Functional outcomes were rated using Rowe's score. Excellent results were recorded in three and good in one patient. Simultaneous fixation of the scapula was not performed by the authors for two main reasons : first, they considered, based on previous studies, that clavicle fixation alone gives excellent result ; on the other hand, they considered that a posterior approach for scapular fixation will prolong the operative time and will cause additional trauma to the scapular musculature, and pain from both anterior and posterior wounds may interfere with the postoperative rehabilitation program.

Edwards *et al* in 2000 retrospectively reviewed 20 patients with floating shoulder injuries treated conservatively (*4*). They evaluated patients with three separate scoring systems : those of Herscovici *et al*, Rowe, and Constant and Murley. They concluded that nonoperative treatment of floating shoulder injuries, especially those with less than five millimetres of fracture displacement, can achieve satisfactory results that are probably equal or superior to those reported after operative treatment without the risk of operative complications. Most of the scapular fractures in this study were minimally displaced, so the outcome of significantly displaced scapular fracture in floating shoulder injury cannot be predicted based on this study.

William *et al* in 2001 performed a cadaveric study to determine the osseous and ligamentous contributions to the stability of experimentally created scapular neck fractures (*17*). They used 12 fresh-frozen human cadaveric shoulders for their biomechanical testing. They concluded that ipsilateral fractures of the scapular neck and the clavicular shaft do not cause floating shoulder without additional disruption of the coracoacromial and acromioclavicular ligaments. In their view operative fixation of ipsilateral fractures of the scapular neck and the clavicle may not be necessary in the absence of concomitant injury to the coracoacromial and acromioclavicular ligaments characterised by marked medial displacement. This study had its limitation because it was a cadaveric study ; it did not consider the dynamic stabilising effect of muscles around the shoulder joint and the displacement force applied was uniaxial, only in the medial direction while clinical deforming forces following fracture are multidirectional. Also they did not test all possible combinations of bony and ligamentous injury.

Van Noort *et al* in 2001 performed a retrospective multicentre study reviewing 46 patients with ipsilateral fractures of the neck of the scapula and of the clavicle (*16*). Thirty-five patients were available for the final follow-up. Of these 35 patients, 28 patients were treated conservatively, 4 patients had surgical treatment and 3 patients underwent secondary reconstructive surgery. Of the conservatively treated patients, they found that in 6 patients where the glenoid was dislocated caudally, the mean Constant score was 42 only while in the remaining 22 patients without this dislocation, the score was 76. In 3 patients they had malunion of the fracture of the neck of the scapula, despite anatomical reduction and internal fixation of the clavicle, and this could be related to the associated ligamentous injury which is not visible on plain film. They concluded that ipsilateral fracture of clavicle and scapula is not inherently unstable and, in the absence of caudal dislocation of the glenoid, conservative treatment gives a good functional outcome. They suggested that caudal dislocation of the glenoid would suggest the injury to the important ligamentous structure making it a true floating

shoulder injury. In further correspondence, they suggested that the rotational malalignment of the glenoid was assessed by measuring the inclination of the glenoid on an anteroposterior radiograph in the scapular plane. This is the angle formed by the two perpendicular lines drawn on the line connecting the most cranial with the most caudal point of the glenoid cavity and the tangent along the medial border of the scapula. They arbitrarily defined the glenoid as 'caudally dislocated' if the inferior angulation was 20° or more (*6*).

Eagol *et al* in 2001 reviewed the outcome of both operative and nonoperative treatment of 19 patients who sustained a displaced fracture of the glenoid neck with an ipsilateral clavicular fracture or acromioclavicular separation (*3*). They observed good results both with and without operative treatment and recommended that treatment must be individualised for each patient.

Oh *et al* in 2002 reviewed 13 cases of double disruption of the superior shoulder suspensory complex at a mean follow-up of one year (*12*). Three patients were treated conservatively, 5 patients had fixation of the clavicle only and 5 patients had fixation of both clavicle and scapula. Functional assessment by the Rowe score was 88 in surgically treated cases compared to 77 in conservatively treated patients. The authors recommended surgical treatment of double disruption of the superior shoulder suspensory complex.

DISCUSSION

Understanding of floating shoulder

The term "floating shoulder" was first used by Ganz and Noseberger in 1975 (*5*). In 1993, Goss described the concept of the superior shoulder suspensory complex to elucidate the pathoanatomy of shoulder injury (*7*). The superior shoulder suspensory complex consists of a bone and soft-tissue ring (glenoid, coracoid process, coracoclavicular ligament, distal clavicle, acromioclavicular joint and acromion process) (fig 1). Disruption of one component of the superior shoulder suspensory complex is relatively common and does not compromise its overall suspensory function. However, double disruptions of the superior shoulder suspensory complex are thought to be unstable. One such double disruption is the ipsilateral fracture of the clavicle and scapular neck of the so called floating shoulder.

Most of the time, the scapular neck fracture is at the surgical neck and very rarely at the anatomical neck. Fractures of the surgical neck of the scapula produce the distal fragment consisting of the glenoid and the coracoid process and a proximal fragment consisting of the acromion, scapular spine and scapular body. The distal fragment is attached to the proximal fragment by the coracoacromial ligament and to the axial skeleton, through the clavicular shaft, by the coracoclavicular ligament. The indirect attachment of the distal fragment to the proximal fragment is through the acromioclavicular ligament. For the scapular neck fracture to produce a floating shoulder, there has to be damage to its attachments to the proximal fragment and to the axial skeleton as well (*17*).

Fracture of the anatomical neck of the scapula produces floating shoulder (without injury to the stabilising ligament) due to loss of bony and ligamentous continuity with the proximal fragment and axial skeleton (*2*) (fig 2).

Goss did not mention the coracoacromial ligament in his description of the superior shoulder suspensory complex but it is the only direct ligamentous connection between the proximal and distal fragments (*7*). Hence it should be included in the superior shoulder suspensory complex.

It seems that the term "floating shoulder" itself is not fully understood. Many of the previous papers described any injury with ipsilateral scapular neck and clavicle fracture as a floating shoulder injury because of the perceived instability. William *et al* in 2001 defined floating shoulder as a fracture of the neck of the scapula in which the glenoid and glenohumeral joint have lost bony and ligamentous attachment to the scapula and axial skeleton (*17*). Based on this definition, not every patient with an ipsilateral fracture of the neck of the scapula and clavicle has a true 'floating shoulder', because additional disruption of either the coracoacromial or acromioclavicular or coracoacromial and coracoclavicular ligaments is required. Based on the

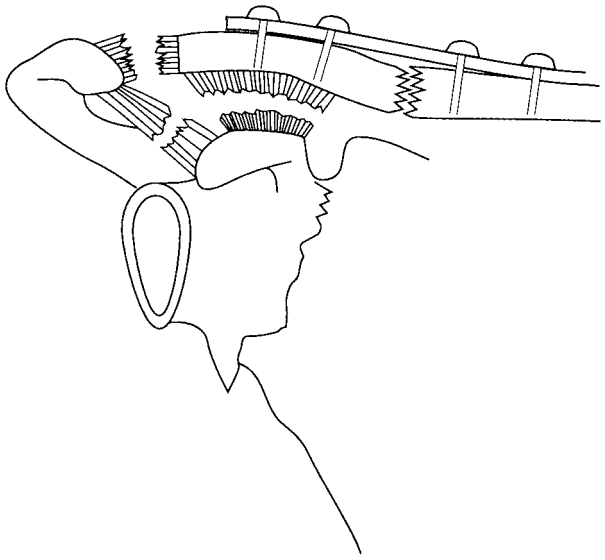

Fig. 2. — Failure of clavicular fracture fixation to stabilise the floating shoulder in ipsilateral fracture of clavicle and scapula with concomitant coracoacromial and coracoclavicular injury.

biomechanical study they recommended that if only the clavicular shaft is fractured, then the coracoacromial and acromioclavicular capsular ligaments must be disrupted to create a floating shoulder. Similarly, if only the scapular spine or the acromion is fractured, the coracoclavicular and acromioclavicular capsular ligaments must be disrupted.

In understanding the floating nature of the injury one should look at the type of scapular fracture (anatomical / surgical neck), presence of absence of clavicular fracture and more importantly the status of the stabilising ligaments. It may be possible that MRI may show the status of these stabilising ligaments and help in deciding appropriate treatment. However there are no such studies found in the literature.

Effect of floating shoulder

It is theorised that in the floating shoulder injury there is loss of the suspensory and stabilising effect of the clavicle. The altered muscle forces about the shoulder and the weight of the upper extremity result in displacement of the scapular neck fracture inferiorly as well as anteromedially. With such displacement, the normal lever arm of the rotator cuff is lost and the relationship of the glenohumeral joint with the acromion is altered, creating a functional imbalance. As a result, weakness on abduction and subacromial pain are common (*1, 8*). However, this functional imbalance is not found to be quantified or specifically tested (*4*).

Treatment of floating shoulder

Literature regarding the treatment of floating shoulder is relatively weak, in the sense that all the papers report retrospective studies without proper control. The criteria to define the injury as a floating shoulder are not identical in all papers. There is no uniformity in the outcome measures to assess the outcome of the individual treatment and also the number of patients reviewed in these studies is not big. This does not help in reaching to a scientific conclusion as regards the best treatment of this injury.

There has been evidence in favour of both conservative and surgical treatment in this so-called floating shoulder injury (*2-4, 8-14, 16, 17*). This controversy is partly because of lack of sufficient biomechanical study and poor understanding of the mechanics of the injury and the functional outcome of such an injury.

Before 1970, most floating shoulder injuries were treated conservatively (*4*). This trend was changed after Ganz and Noesberger noted that scapular fractures associated with an ipsilateral clavicular fracture were displaced more often and more severely than scapular fractures that were not associated with an ipsilateral clavicular fracture. Since then, treatment recommendations for all ipsilateral fractures of the clavicle and scapula, even if minimally displaced, had focused on some form of internal fixation to reduce the risk of scapular fracture displacement. However, recent reports (*4, 13, 16*) have suggested successful conservative treatment for ipsilateral clavicle fracture and minimally displaced fracture of the scapular neck.

The advocates of surgical treatment of an unstable shoulder girdle suggest that it is nearly always the result of a high-energy direct trauma and is

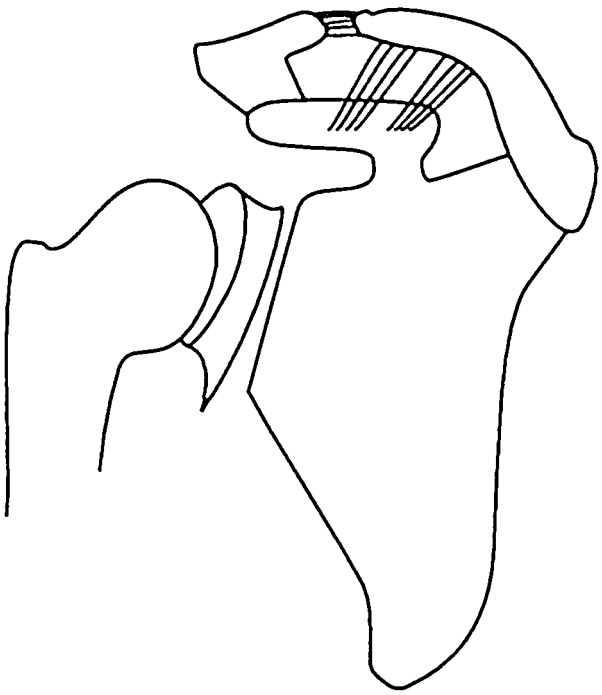

Fig. 3. — Fracture of the anatomical neck of scapula producing floating shoulder.

consequently often associated with injuries of the thorax. This is an additional reason for an operative stabilisation because these patients require an intensive respiratory therapy. The recommended operative techniques have varied and have included isolated fixation of the clavicle, isolated fixation of the scapular neck and combined fixation of the clavicle and the scapular neck.

Unreduced fractures of the neck of the scapula are thought to be associated with a poor functional outcome (*1*). Ada and Miller reported a high incidence of rotator cuff dysfunction and cuff injuries in patients with displaced scapular neck and spine fractures treated non-operatively (*1*). Some authors suggested that cuff dysfunction is the result of loss of the normal lever arm of the rotator cuff and recommended ORIF for displaced neck and spine fractures to prevent those problems. However the rotator cuff symptoms could be directly related to the cuff injury associated with shoulder injury rather than due to abnormal glenohumeral joint and subacromial space. The normal lever arm of the rotator cuff is lost when the glenoid is displaced, resulting in weakness of abduction and pain in the subacromial region (*8*). Abduction weakness, decreased range of motion and non-union are the most frequently mentioned complications of non-operative treatment although the prevalence of these complications has not been defined.

Hardegger *et al* concluded that stability of a scapular neck fracture depends on an intact clavicle and coracoclavicular ligament (*8*). They recommended stabilisation of the scapular neck with a posteriorly applied semitubular buttress plate and a lag screw thought the scapular spine into the neck of the scapula. Advocates of only clavicular fixation suggest that it is a relatively simple operation as compared with ORIF of the scapula and by fixing the clavicle, the scapular neck fracture is indirectly reduced (*14*).

Results of the multicenter study by Van Noort *et al* also suggested that the caudal dislocation of the glenoid was the important determinant as to whether the patient should have fixation of the glenoid or not (*16*).

CONCLUSION

We believe that it is important to understand the pathoanatomy of floating shoulder, especially the important role played by the stabilising ligaments. For the injury to be of true floating shoulder nature, there has to be discontinuity between distal fragment and proximal fragment and distal fragment and axial skeleton. This can occur as a result of various combinations of bony and ligamentous injury (*17*). It is easy to identify disruption of the acromioclavicular ligament clinically and radiologically, but injury to the coracoclavicular ligament and coracoacromial ligament is difficult to identify. Maybe the displacement of scapular neck fracture is more marked when there is injury to the latter two ligaments and this degree of displacement could provide an indirect clue to the injury to the coracoclavicular and coracoacromial ligament. The authors are not aware of any study looking at the correlation of degree of displacement of the scapular neck fracture and its association with ligamentous injury. A recent study did suggest that caudal

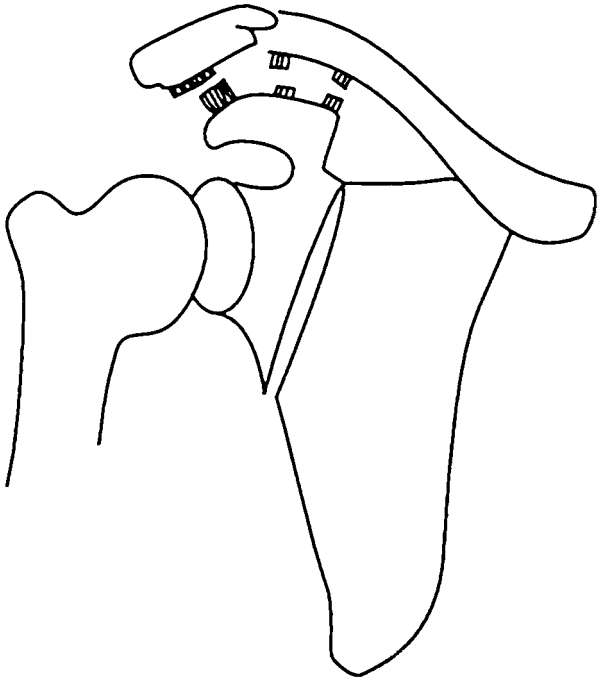

Fig. 4. — Fracture of surgical neck of scapula with injury to coracoacromial and coracoclavicular ligament producing floating shoulder.

dislocation of the fractured glenoid had a poor outcome, indicating possible ligamentous injury in those patients (*16*). It was also interesting to note that even after anatomical fixation of the clavicle, there were three cases of malunion of the scapular fracture, further indicating the role played by the stabilising ligaments. It seems that the anatomical fixation of the scapular neck fracture is important for good functional outcome. Maybe MRI scan in such an injury may help to identify the status of the ligaments, thereby deciding the treatment method.

Until we have good evidence for the correlation of clinical and radiological findings of injury to the ligaments (coracoacromial and coracoclavicular), the authors recommend conservative treatment for undisplaced or minimally displaced fracture of the ipsilateral clavicle and scapular neck fracture, based on the fact that ligaments are intact in such an injury pattern and it is not a true floating shoulder injury. If there is significant displacement of the scapular neck fracture, it indicates injury to the coracoclavicular and / or coracoacromial ligament and anatomical fixation of the scapular fracture should be considered, as fixation of the clavicle alone will not reduce the scapular neck fracture (fig 2) and the functional results seem to depend on reduction and restoration of scapular neck anatomy.

One may consider performing MRI scan to look at the status of the ligaments before deciding the treatment in patients with displaced fractures of the scapular neck with or without fracture of the clavicle. However there is no study to be found in the literature to provide an evidence to support this. The following combinations of bony (scapular neck fracture and / or clavicle fracture) and ligamentous injuries result in floating shoulder injury.

1. Fracture of anatomical neck of scapula (fig 3).
2. Fracture of surgical neck of scapula + disruption of coracoclavicular ligament + disruption of coracoacromial ligament +/- disruption of acromioclavicular ligament (fig 4).
3. Fracture of surgical neck of scapula + fracture of clavicle + disruption of coracoacromial ligament +/- disruption of acromioclavicular ligament.

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