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Management of floating shoulder injury with dual surgical approach

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Abstract
Background: The floating shoulder is an uncommon but important injury pattern. Although it is frequently defined as an ipsilateral fracture of the clavicle and scapular neck, studies suggest that ligament disruption associated with a scapular neck fracture contributes to the functional equivalent of this injury pattern, with or without an associated clavicle fracture. Minimally displaced fractures typically do well with nonsurgical care. However, the degree of fracture displacement and ligament disruption that results in less predictable outcomes after nonsurgical treatment is uncertain. Internal fixation of a displaced clavicle fracture restores the contour of the shoulder, regulates soft-tissue tension, but it does not reduces the scapular neck fracture. Hence fixation of both fractures is recommended in certain fracture patterns.
Material & Methods: This is a study of 10 cases of floating shoulder injury operated by front (ant. Approach for # clavicle) and back (modified Judets posterior approach for scapula #) from Jan 2012 to March 2016. All cases were assessed with Constant shoulder score at the end of six months.
Results: Results of our study shows that majority of pt. had excellent to good results. There were complications in two cases; 1.Broken Clavicle plate which needed revision, 2.Failure to anatomically reduce scapula neck fracture and proximal screw penetration in to the joint.
Conclusion: We propose the combined anterior and posterior surgical approach to be the method of choice for the treatment of unstable and displaced floating shoulder injuries.

Keywords: Floating shoulder, fracture clavicle, fracture scapula neck, Judet" post, approach

1. Introduction
The 'floating shoulder' is a rare injury (aprox. 0.1% of all fractures) [1] `consisting of ipsilateral fractures of the clavicle and glenoid neck. It was first described by Ganz and Noesberger in 1975 [2]. Subsequently, Goss [3] expanded on their definition by describing it as a 'double disruption' of the superior shoulder suspensory complex. It usually results from a high velocity trauma and most of the cases are associated with concomitant injuries like rib fracture, pneumothorax, haemothorax, brachial plexus injuries; head injury etc. resulting in under diagnosis and under treatment. Since it is relatively rare and therefore there are no randomized trials on the treatment of such an injury. Most of the literature consists of case reports, case series or retrospective observational cohort studies.
It is also necessary to understand the anatomy and biomechanics of the superior shoulder suspensory complex (SSSC). The SSSC is essentially a bone and soft tissue ring secured to the trunk superior and inferior bony struts from which the upper extremity is suspended. The ring is composed of bony elements (1. Glenoid process, 2. Distal clavicle, 3. Acromion process, 4. Coracoid process) and soft tissue elements (1. Coracoclavicular ligament, 2. Acromioclavicular ligament, 3. Coracoacromial ligament). The superior strut is the middle third of the clavicle, while the inferior strut is the junction of the most lateral portion the scapular body and the most medial portion of the glenoid neck. Each component of SSSC has its own individual function and it serves as a point of attachment for a variety of musculotendinous and ligamentous structures. It allows limited but significant movement to occur through the Coracoclavicular ligament and the acromioclavicular articulation and also maintains a stable relationship between the upper extremity and the axial skeleton. It should be appreciated that the clavicle is the only bony connection between the upper extremity and the axial skeleton. The scapula is hung or suspended from the clavicle by the Coracoclavicular ligaments and the acromioclavicular joint.

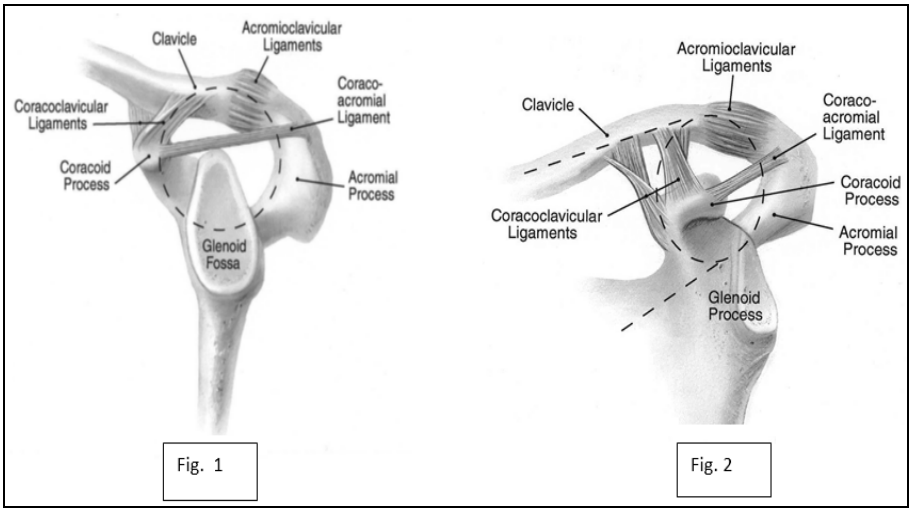


Diagram of the superior shoulder suspensory complex showing fig. 1) a lateral view of the bony soft-tissue ring and fig. 2) an anterioposterior view of the bony soft-tissue ring and the superior and inferior bony struts.

When the complex is disrupted in two places (a double disruption), the integrity of the superior shoulder suspensory complex is breached and a potentially unstable anatomical situation is created. If significant displacement occurs at either or both sites, there may be problems with healing, such as delayed union, malunion, and nonunion, as well as adverse long-term functional difficulties, such as subacromial impingement, weakness and discomfort due to muscle fatigue, neurovascular compromise from a drooping shoulder, and degenerative joint disease, depending on the nature of the particular injury [4].

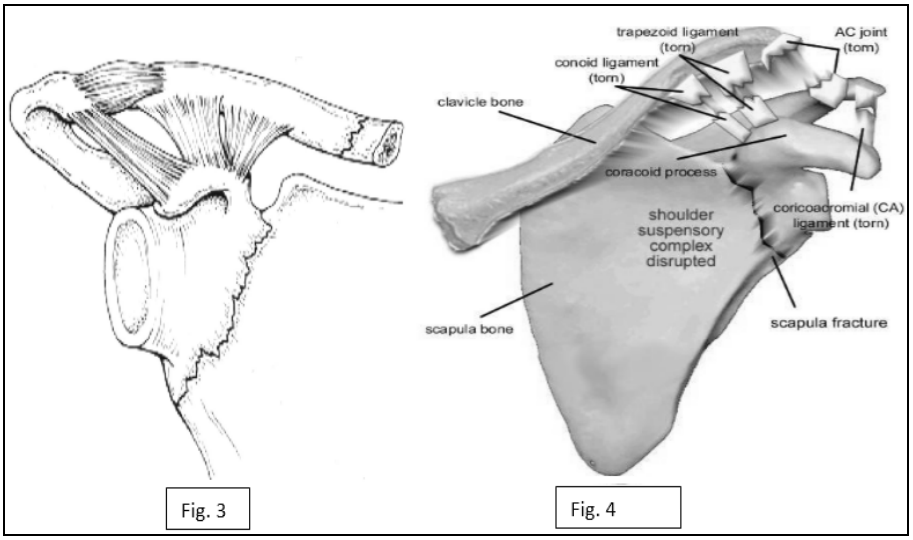


Fig 3: shows double disruption of SSSC with bony lesions at glenoid neck and mid third of clavicle, while fig 4: shows double disruption of SSSC with bony lesion at glenoid neck and soft tissue lesion (ligament disruption) at the other end.

Williams *et al* [5] conducted a cadaver study to determine the stability afforded by specific structures. They concluded that the floating shoulder only becomes unstable when there is an associated disruption of Coracoacromial and Acromioclavicular ligaments. But the interpretation of its results is controversial.

Although typical injury patterns of scapular fractures have been described [6] and the majority of scapular fractures does not involve the scapular neck and thus does not represent the "typical" floating shoulder, there is no known systematic classification of periscapular complex shoulder injuries.

2. Material & Methods

This is a Prospective study from Jan 2012 to March 2016. Study group was defined as patients with a complex scapular injury with concomitant injury of the Superior Shoulder Suspensory Complex (SSSC) including trauma of the ipsilateral clavicle, the acromioclavicular joint, and the scapula. AP x-ray of shoulder & CT scan of shoulder with 3D reconstruction were obtained in all the cases.

There were total 10 cases included in this series in the age group of 20 to 50 yr. old with clinical and radiological floating shoulder. Patients with pediatric and geriatric age group, with scapulothoracic dissociation and compound injuries were excluded. Majority of patients in our series were male (9: M, 1: F) and 6 out of 10 cases had injuries to right shoulder. 8 patients in our series had other injuries including the head injury. Most of the patients were operated with in the first ten days of injury except one case in which surgery was delayed due to post traumatic mangitis.

After initial resuscitation in the emergency department according to the protocol of advanced life trauma support,

further management was based on the amount of fracture displacement and general condition of patient. Since there is no known systematic classification of periscapular complex shoulder injuries we used the combination of available classification of clavicle fracture and scapula fractures. Almost all the patients in this series had more than 20 mm of medialization of scapular neck. All patients were operated with front and back approaches in the same sitting. First the fracture clavicle is fixed with anterior approach in supine position. 9 out of 10 clavicles were fixed with either 3.5 reconstruction plate or 3.5 locking compression plates. One distal third clavicle fracture was fixed with tension band wiring. Following meticulous closure of the clavicle incision, patient is turned prone and Modified Judet's Posterior Approach [7] is used to fix the Scapular fracture. During this approach we tried to access only the lateral border of scapula through the intermuscular interval between infraspinatus and teres minor and did not attempt to directly reduce or fix the fractures extending to scapular body or vertebral border. In this regard we agree with Bartonick *et al* that restoring the lateral border is of paramount importance [8].

Follow up x-rays were obtained at 6 weeks, 3 month & 6 month post-surgery. At the final follow-up, patients were assessed for pain, function, range of movement, and strength using the constant score. [9] and the final results were reported as excellent, good, fair, or poor, depending on the difference in scores of abnormal and normal shoulders (<11, excellent; 11-20, good; 21-30, fair; >30, poor). Complications during perioperative period and the latest follow-up were also recorded.

3. Results

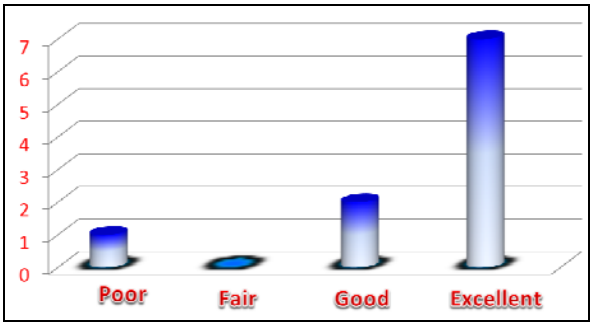
The mean length of hospital stay was 7.5 days. The fracture union was achieved in all cases without further intervention, with overall mean time of 12 weeks for union in this series.

Mean operative time was 110.1.

The average constant score was 11.

Amongst the different parameters of constant score, pain and function were the least affected at the final follow up, whereas range of movement followed by strength were the most severely affected.

There were two complications in this series. In one of the patient surgeon fail to reduce the scapular fracture and the proximal screw went intra articular into the shoulder joint, which needed removal of implants after six weeks. Another patient came after 6 weeks with broken clavicle plate which needed revision of clavicle fracture with reconstruction plate and went on to heal successfully. There was collection of serous fluid in early post op period in scapular area posteriorly in couple of cases which resolved on aspiration.



7 – Excellent result
2- Good result
1- Poor result

Case -1

Fig 1: pre op x-ray, **Fig. 2:** post op x-ray, **Fig 3:** incision.

Fig. 4, 5, 6: Range of movement

Case -2

Fig 1: Pre op x-ray **Fig 2:** Post op x-ray

Fig 3, 4, 5: Range of movement

Case- 3

Fig 1: Pre op x-ray, **Fig 2:** immediate post op x-ray, **Fig 3:** x-ray after 6 month

Fig 4, 5, 6: range of movement after implant removal

4. Discussion

The relative infrequency and benign characteristics of these injuries probably explains the limited attention in the literature.

In isolation, each fracture is generally minimally-displaced and can be managed non-operatively. In combination, however, each disruption can make the other unstable, for example, the glenoid neck fracture may increase the displacement of the clavicular fracture site and *vice versa*. The resultant instability will be greater if there is additional disruption of the clavicular-acromioclavicular joint-acromial strut or coracoacromial ligament [10].

Hardegger, Simpson and Weber [11] felt that these injuries represented a "functional imbalance" owing to the "altered glenohumeral-acromial relationships". By changing the relationships between anatomic structures, muscular forces are altered, resulting in functional difficulty. Hardegger *et al*. [11] recommended surgery in these cases. Reduction and stabilization of the clavicular fracture by screw/plate fixation is advisable if the displacement is unacceptable. It reduces the risk of nonunion, alleviates tension on the brachial plexus, restores normal anatomical relationships, and ensures the restoration of normal shoulder function [12]. They came out with a concept that fracture of the glenoid neck will often indirectly reduce and stabilize as a result of clavicle fixation. However, if significant displacement persists, it should be reduced and fixed. Associated injuries of the Coracoacromial ligament will usually heal satisfactorily if the fracture sites of the glenoid neck and clavicle are treated appropriately. The amount of displacement that is acceptable at the fracture sites of the glenoid neck and clavicle is controversial. Fractures of the clavicle have traditionally been treated non- operatively, unless their displacement is severe [13]. Recent reports, however, have suggested that displacement previously thought acceptable can result in nonunion or malunion and a poor outcome [14-16]. Wick *et al* [16] found that shortening of 2 cm or more of a middle-third fracture of the clavicle is a risk factor for nonunion. McKee *et al* [15] reported a series of 15 patients with middle third clavicular malunion treated successfully by surgery. These injuries had united in a shortened position (mean 2.9 cm) resulting in pain, weakness, and neurological symptoms [15]. Hill, McGuire and Crosby [17] found that an initial fracture shortening of 2 cm or more was the only significant risk factor for nonunion in a series of 52 middle-third fractures of the clavicle. Based upon this data, operative fixation has been recommended for middle-third fractures that are shortened by 2 cm or more. Middle third fractures in which the fragments either lack cortical apposition and/or are comminuted may also have a poor outcome. The precise amount of displacement and comminution needed has not been determined. In a floating shoulder, the further destabilizing effect of a fracture of the glenoid neck makes operative fixation imperative.

Fractures of the glenoid neck can be classified in two ways. Goss T P [18] describes the first type by position of the fracture in relation to the Coracoid process [18]. Fractures medial to the Coracoid process are surgical neck fractures (the most common injury pattern), while fractures lateral to the Coracoid process are anatomical neck fractures. The latter are highly unstable, as there is no attachment of the glenoid fragment to the clavicular-acromioclavicular joint-acromial strut and often require surgical management [11, 19].

The second method is based upon the degree of displacement at the fracture site [18]. Type I fractures according to the system of Goss [18] are insignificantly displaced and constitute more than 90% of cases. These injuries can be managed conservatively, and a good to excellent functional result can be expected. Type II fractures are significantly displaced, as defined by translational displacement of the glenoid fragment by 1 cm or more and/or angulatory displacement of the fragment of 40° or more in either the coronal or sagittal plane as well as medialization of glenoid by more than 20 mm [18]. These injuries, whether involving the surgical or anatomical neck, should at least be considered for open reduction and stabilization.

Hashiguchi and Ito [20] published a series of five patients with ipsilateral fractures of the clavicle and glenoid neck, for whom only fixation of the clavicle was performed. He brought the concept of indirectly reducing the glenoid fracture by fixing the clavicle alone, however failed to demonstrate the reduction of glenoid fracture in any of his cases.

Leung *et al* in 1993 reviewed the outcome of surgical treatment of ipsilateral fracture of the clavicle and scapular neck in 15 patients [21]. 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 [22], 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 mobilization. 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.

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 [23]. They observed good results both with and without operative treatment and recommended that treatment must be individualized 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 [24]. 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 [22] 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.

Unreduced fractures of the neck of the scapula are thought to be associated with a poor functional outcome (25). 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 [25]. 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 [11]. 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.

There has been evidence in favor of both conservative and surgical treatment in this so-called floating shoulder injury [5, 19, 20, 21, 23, 24]. 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.

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 stabilizing ligaments. It may be possible that MRI may show the status of these stabilizing ligaments and help in deciding appropriate treatment. However there are no such studies found in the literature

5. Conclusion

It seems reasonable to conclude that surgical intervention should at least be considered for all floating shoulder injuries. Acceptable results can be expected for patients with minimally-displaced fractures treated non-operatively. Significant displacement at one or both fracture sites can result in a poor functional outcome which can be improved with surgical intervention.

Operative fixation of only clavicle does not satisfactorily reduces the displaced fracture of the glenoid neck. Hence, open reduction and internal fixation of the second site must be performed if significant displacement persists.

It seems that anatomical fixation of the scapula neck fracture is important for good functional outcome. 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 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.

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