Management of Scapula Fractures and Floating Shoulder

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INTRODUCTION

Scapula, a triangular shaped bone, links the appendicular skeleton with the axial skeleton. Scapular fractures are uncommon injuries, typically result from high-energy mechanism. They account for 1% of all fractures, and 3 to 5 % of upper extremity fractures. The mean age has been reported to be between 35 to 42 years. Displaced scapular fractures have to potential to cause significant morbidity including malunion, non-union, arthrosis, scapula-thoracic dyskinesia, and impingement syndrome.

CLINICAL EVALUATION

Given the high-energy nature of these injuries, scapular fractures patients should initially be managed according to ATLS protocol with particular attention towards airway, breathing and circulation. Other life and limb threatening injuries should be prioritized and managed accordingly before focusing on scapular fractures. A substantial number of patients have additional injuries (80 to 95%), most importantly to thorax, cranium, spine, and pelvis. Potentially life threatening associated injuries may include pneumothorax, pulmonary contusion, arterial injury, closed head injury, and splenic or liver laceration, with the associated mortality rate reaching nearly 15 %.[1]

Patients with scapular fractures typically present with shoulder asymmetry with ipsilateral extremity immobilised and adducted closed to the body. Tenderness, swelling, crepitus are typically noted around shoulder girdle. Range-of-motion elicits pain particularly during abduction. Detailed neuro-vascular examination should be carefully elicited and documented. Suprascapular and axillary nerves are particularly prone to injury. Approximately 5 to 13% cases have associated brachial plexus injury, which is an independent predictor of poor outcome.[1] Any skin abrasion and/or laceration should be carefully looked for, which is particularly important with regard to surgical timing. Surgery is usually deferred until skin lesions have re-epithelialized.

DIAGNOSIS

Trauma series chest radiograph and cervical spine radiograph should be carefully evaluated to detect associated pneumo and/ or hemothorax and cervical spine injury respectively. Patients with suspected scapular fractures should additionally be subjected to true scapular AP view, axillary view, and scapular Y view. Weight bearing AP shoulder radiograph is advocated in case of suspected disruption of superior shoulder suspensory complex (SSSC). In AP radiograph (Fig. 1), Glenopolar angle (GPA if formed by intersection of line drawn from inferior apex of glenoid to superior apex, and a line drawn from superior apex of glenoid to inferior angle of scapula), and lateral border offset (LBO) or medialisation (medial displacement of proximal fragment, relative to distal fragment at the lateral border) should be assessed (Fig. 2). Angulation (angle between line drawn parallel to proximal and distal fragments) should also be assessed in scapular Y view (Fig. 2). These radiographic measurements are potentially valuable in deciding need for surgical treatment. Because of complex osseous anatomy, we prefer to get CT scan with 3D reconstruction in presence of substantial displacement, which accurately elucidates fracture configuration, and found to be more reliable than plain radiography in the assessment with regard to scapular angulation, translation, and glenopolar angle measurements.

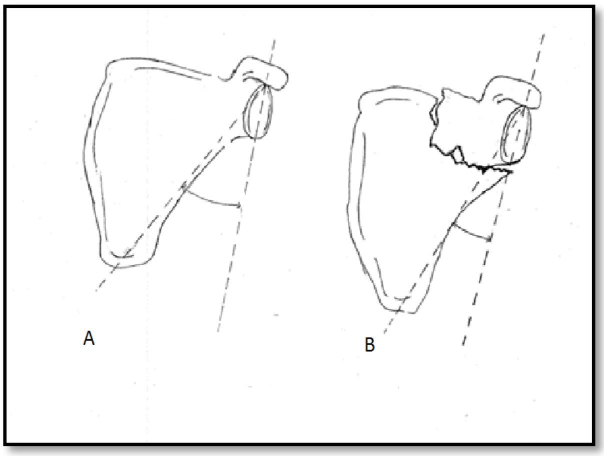


Figure 1

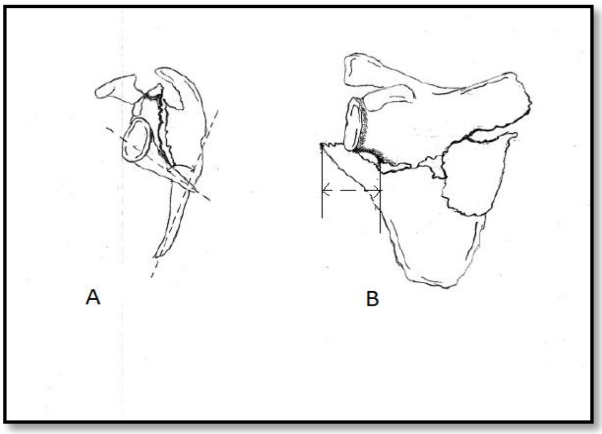


Figure 2

CLASSIFICATION

Classification of scapular fractures have evolved over time, however, there is no generally accepted standard classification. Zdravkovic and Damholt [2] divided scapular fractures into three types: type 1, fracture of the body; type 2, fracture of the apophysis (acromion and coracoid); type 3, fracture of the superior lateral angle, including glenoid and neck.

The most commonly accepted classification of glenoid fracture is proposed by Ideberg et al.[3] Goss [4] later modified it by subdividing type 5 and including type 6. (Fig. 3)

Type I:
- a: Anterior rim fracture
- b: Posterior rim fracture

Type II: Fracture line through the glenoid fossa exiting at the lateral scapular border
Type III: Fracture line through the glenoid fossa exiting at the superior scapular border
Type IV: Fracture line through the glenoid fossa exiting at the medial scapular border
Type V:
- a: Combination of type II and IV
- b: Combination of type III and IV
- c: Combination of type II, III, and IV

Type VI: Comminuted fracture

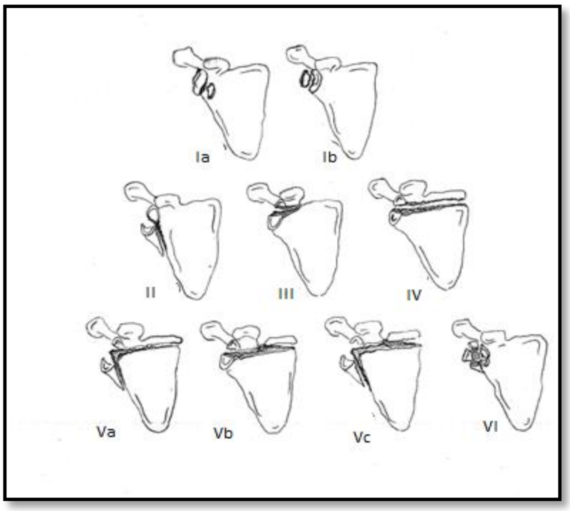


Figure 3

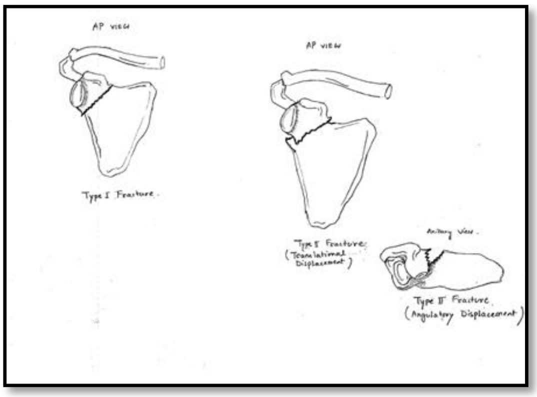


Figure 4

Goss [4] broadly classified fracture of scapular neck in two types: (Fig. 4)
Type I: Include all undisplaced or minimally displaced fractures
Type II: Includes all significantly displaced fractures (either translational or angulatory)

Kuhn [5] had proposed a classification for acromion fractures:
Type I: Nondisplaced fractures
Type II: Displaced fractures without reduction of subacromion space
Type III: Displaced fractures with reduction of subacromion space

Ogawa [6] classified coracoids fractures into two different types:
Type I: Fracture situated proximal to the coracoclavicular ligament attachment
Type II: Fracture situated distal to the ligament attachment.

<u>MANAGEMENT</u>

With the exception of glenoid fracture, treatment rationale of most scapular fracture had traditionally been "benign neglect". This assertion was because of the fact that most scapular fracture heal uneventfully with little dysfunction owing to rich muscular envelope, and in part due to generous mobility of shoulder girdle, which compensate for any loss due to scapular fracture. However, there are growing evidences revealing the fact that, not all scapular fractures do well with non-operative treatment. Of late, there has been renewed interest in the surgical treatment of both itra- and extra-articular scapular fractures, with better understanding of fracture anatomy, approaches and fixation methods. Nevertheless, generally accepted concrete guidelines are still lacking for management of these injuries.

Zlowodzki et al.[7] in their systematic review of 520 scapular fractures, reported that, eighty percent of glenoid fractures were being treated operatively with excellent or good results in 82% of the cases; ninety-percent of all isolated scapular body fractures were being treated non-operatively with excellent or good results in 86% of the cases; eighty-three percent of all neck fractures treated non-operative had achieved excellent or good results in 77% of the cases. Jones et al. [8] in their retrospective review of 182 scapular fractures, concluded that, operative treatment of displaced scapular fractures result in similar healing, return to work, pain, and complications as non-operative treatment.

1. Non-operative treatment:

Most scapular fractures are undisplaced or minimally displaced and do not meet the surgical criteria, are therefore candidate for non-operative treatment. There is a growing belief that non-operative management of extraarticular scapular fractures is best reserved for those displaced less than 15-20 mm and angulated less than $30^0 – 45^o$ secondary to uniformly good outcomes with non-operative treatment.[9] Non-operative treatment is also considered for displaced intra- or extra-articular fractures, when general and/or local conditions preclude operative interventions. Close follow-up with weekly radiograph for initial 3 weeks is advocated to detect any subsequent displacement. Treatment includes sling immobilisation for 2 to 3 weeks followed by progressive physical therapy. Progressive passive range-of-motion is commenced once pain has subsided. This is followed by full active range-of-motion exercises after 4 weeks. Progressive strengthening program is gradually started aiming lifting all restriction at 3 months after injury with return to normal activities.

2. Operative treatment:

Significant debate is going on with regard to surgical indications of scapular fractures, and continues to remain elusive. Cole et al. [9, 10] penned down the explicit surgical indications, which include;

a) Intra-articular step-off or gap greater than or equal to 4 mm or 25 % glenoid involvement.
b) Lateral border offset (medialisation) greater than 20 mm on AP view
c) Angular deformity greater than or equal to 45^0 seen on scapular Y view
d) Lateral border offset greater than 15 mm and angular deformity greater than 30^0
e) Glenopolar angle less than or equal to 22^0
f) Displaced double lesions of superior shoulder suspensory complex
    - Both clavicle and scapula displaced greater than or equal to 10 mm
    - Complete acromioclavicular dislocation and scapula fracture displaced greater than or equal to 10mm

Finally, glenoid fracture resulting in glenohumeral subluxation and/or dislocation, and scapular fracture associated with scapulothoracic dissociation, demand surgical interventions. However, the above mentioned surgical criteria should always be put alongside of patient’s age, health, activity level, hand dominance to contemplate an individualised rational treatment approach.

2.1. Surgical approach and fixation:

Selection of appropriate surgical approach is paramount taking into account the fracture anatomy. Anterior deltopectoral approach is suitable for accessing anterior and inferior glenoid. Substantial intra-articular comminution calls for anterior or posterior gleno-humeral approach as deemed necessary. As scapular body and neck fracture make up approximately 90% of the injuries, posterior approach is the cornerstone for fixation.

Various posterior approaches have been described: extensile judet approach, modified judet approach, and minimally invasive approach. Patient is positioned in floppy lateral decubitus position on bean bag. All bone prominences are offloaded with proper padding. It is critical to prep and drep operative arm free, as intra-operative manipulation is necessary to effect fracture reduction. Judet incision is started in curvilinear fashion starting from lateral end of acromion, coursing 1 cm caudal to scapular spine, and angling down along the vertebral border towards inferior pole as far as necessary depending upon fracture anatomy (Fig. 6D). Incision is carried deep to the fascia, paying particular attention to raise full-thickness fasciocutaneous flap. Deltoid origin is taken off the scapular spine, and retracted laterally (Fig. 6C). A cuff of tissue can be left at scapular spine for later repair of deltoid. For extensile judet approach, infraspinatus is reflected off from medial to lateral along with teres minor on its neurovascular pedicle. Vigilance is required to protect suprascapular nerve which is encountered as it courses from spinoglenoid notch. Extensile exposure is particularly useful in presence of substantial fracture comminution, displacement, and in chronic cases where callus formation is a hindrance. Whereas, minimal comminution and fractures less than 1 week old, are amenable to modified judet approach. Intramuscular interval between infraspinatus and teres minor is developed bluntly with finger, which provides ample exposure of scapular neck, lateral border and posterior glenoid. Axillary nerve is particularly at risk, as it is located at quadrangular space. Meticulous care should be taken during placement of retractor on lateral border of scapula; circumflex scapular artery is located on average 4 cm below the articular surface, if encountered, can be ligated to avoid brisk bleeding. Recently, minimally invasive posterior approach has been described, which is based on dual incisions, one each over medial and lateral border of scapula centered over the fracture exit points. Less soft tissue dissection, and faster rehabilitation have been cited as potential advantages, albeit, only simple fracture patterns (2 exit points) and acute fractures (<10 days old), are particularly amenable to this approach.

After adequate exposure and delineation of fracture fragments, fracture ends are gently debrided. Reduction and fixation is dependent on the fracture configuration and bone quality. Various techniques have been describe to effect reduction; use of lamina spreader to mobilise fracture fragments, using schanz pins as joystick, pointed bone tentaculum, and mini ex-fix using schanz pins, alone or in combination can ease reduction maneuver. Keeping the operative arm drep free can prove fruitful during reduction stage. Mini-fragment screws and plates (2.0 mm, 2.4 mm, 2.7 mm or 3.5 mm LC-DCP, and Recon plate, or 3.5 mm semitubular plate) are commonly used fixation devices (Fig. 5 and 6). Locking plate is particularly advantageous owing to thin nature of bone and poor screw purchase along vertebral border. Some authors advocate precontoured plate for fixation. Choice of implant also depends upon surgeon’s experience and discretion. Wound is closed in layered fashion placing a drain deep to muscle envelope. Meticulous repair of deltoid with heavy nonabsorbable suture is paramount, which is sutured back to cuff of tissue left at the scapular spine, or through bone tunnel. Likewise, infraspinatus is repaired back at the medial border in extensile exposure.

2.2. Post-operative protocol:

Sling or shoulder immobiliser is provided for support and comfort. Drain is removed usually after 48 hours. Full passive and active-assisted range-of-motion exercises are commenced from immediate post-op day (Fig. 6F). Gradual shoulder strengthening starting with 3-5 lb resistance is started after 4 weeks. All restrictions are lifted usually after 12 weeks, with gradual return to normal daily activities.

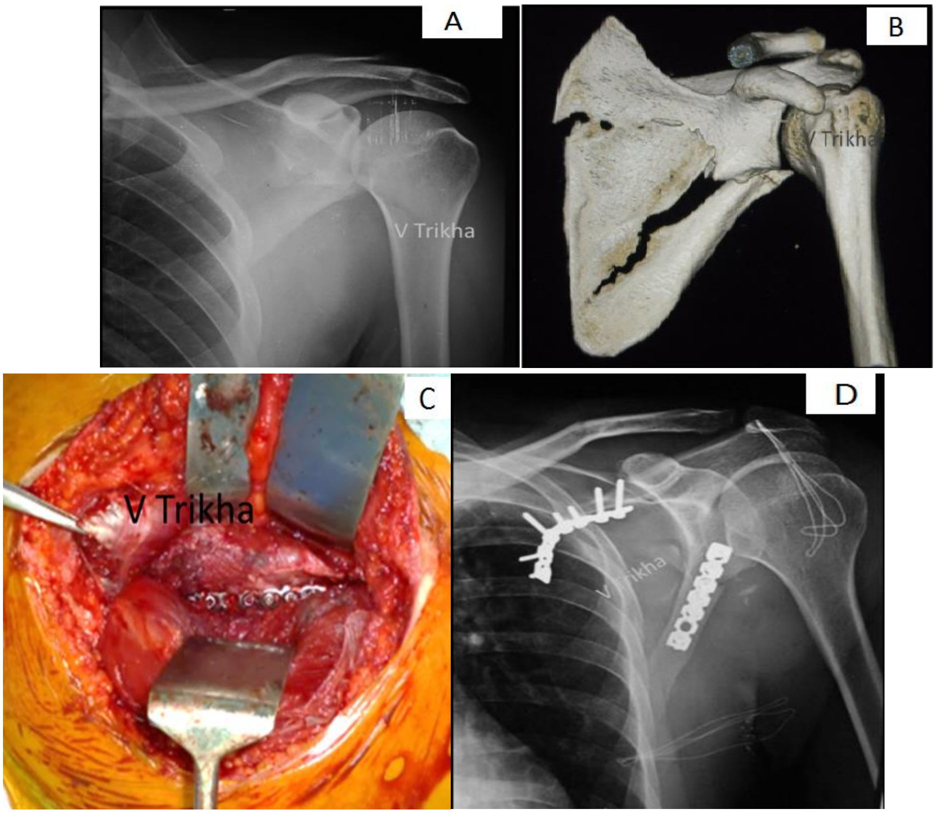
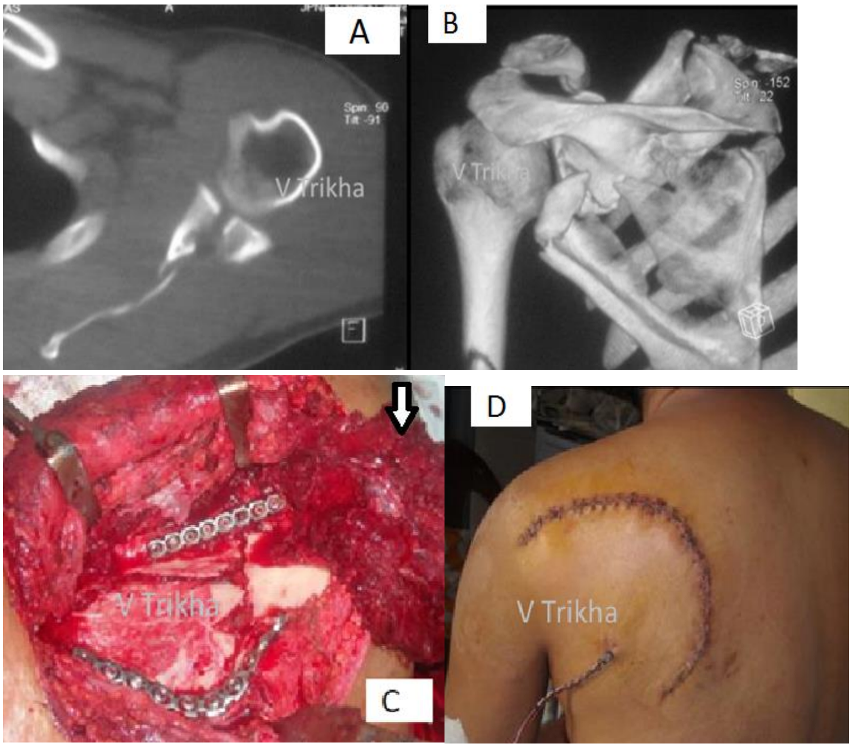


Figure 5



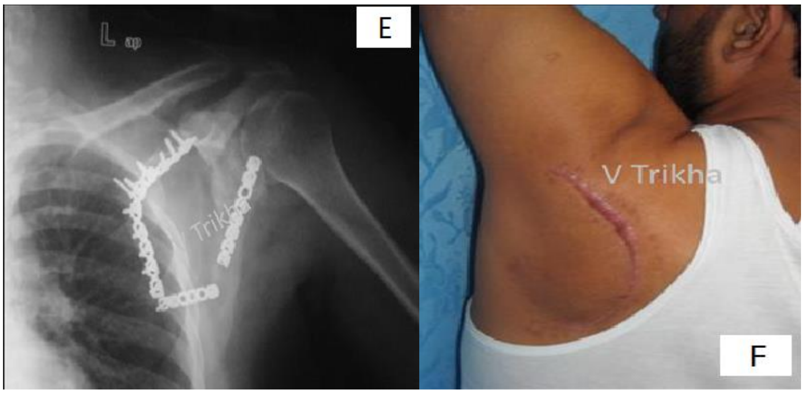


Figure 6

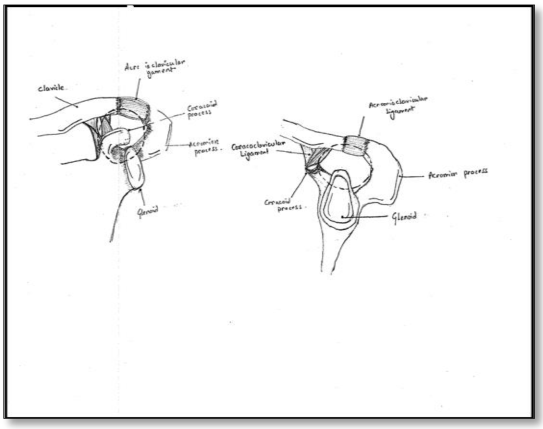


Figure 7

SUPERIOR SHOULDER SUSPENSORY COMPLEX

In 1993, Goss [11] coined the term Superior shoulder suspensory complex (SSSC). The SSSC (Fig. 5) is an osseoligamentous ring, consisting of glenoid fossa, coracoids process, acromion process, coracoclavicular ligament (CC), and acromioclavicular ligament (AC). It maintains a stable relationship between axial and appendicular skeleton. Goss postulated that, traumatic single disruption of any location of SSSC complex is stable enough, and can be managed conservatively. Substantially violent injuries can disrupt SSSC in any of the two locations (double disruption), which is a potentially unstable situation, and can lead to long term adverse functional consequences: malunion, nonunion, degenerative arthrosis, decreased shoulder girdle muscle strength and endurance etc. According to Goss, double disruption with significant displacement demands surgical stabilization and fixation. However, surgery is not indicated when each component of the double disruption is stable and minimally displaced (<10 mm). The most common double lesion of the SSSC involving ipsilateral scapular neck and concomitant clavicular fractures, are also referred to as “floating shoulder”. Dearth of ample evidences in literature has led to substantial debate concerning optimal management. Nevertheless, it is apparent that undisplaced or minimally displaced ipsilateral clavicle and scapular neck fracture can be treated conservatively with good outcome. However, no concrete conclusions have been reached regarding whether to fix only the clavicle fracture or both fractures. Some authors advocate fixation of clavicle only, with the presumption that, fixation of clavicle would indirectly reduce and stabilize scapular neck fracture, whereas, other authors refute it and demonstrated good results with simultaneous fixation of both clavicle and scapular neck fractures. Currently, no evidence exists to suggest that fixation of the clavicle fracture alone reduces the scapula and gleno-humeral joint. Fixation of both the clavicular and scapular fracture does restore stability, thereby allowing for potentially faster rehabilitation and a reduction in the number and magnitude of symptoms related to malunion.[10] In our practice, we prefer to fix clavicle only with the assertion of minimizing surgical trauma and therefore better prospect for post-op rehabilitation; nonetheless, we follow an individualized approach, and proceed for both clavicle and scapular fixation in presence of substantial displacement.

ISOLATED PROCESS FRACTURE

Isolated fractures of acromion or coracoids process are uncommon injuries; most commonly result from direct trauma to superior shoulder region or avulsion injuries. Little has been reported concerning the management of these injuries, and standard consensus is still lacking. However, most authors advocate nonoperative treatment of nondisplaced or minimally displaced process fractures. Good to excellent results have been reported with sling immobilisation for 2 to 3 weeks followed by gradual rehabilitation program. Fracture displacement more than 1 cm, concomitant ipsilateral scapular fracture requiring surgery, two or more disruptions of the SSSC, painful nonunion have been cited as surgical criteria.[10] Displaced acromion fracture compromising subacromion space also demands operative fixation. Various fixation options are available including: tension band wiring, plate, interfragmentary screw, sutures, and staples. Anavian et al. [12] stated good outcome following ORIF of 13 acromion and 14 coracoid fractures. Only complication reported was hardware prominence and soft tissue irritation requiring removal in 3 patients.

KEY POINTS

- **Most scapular fractures are associated with high-energy trauma.**
- **Manage other life- and limb-threatening injuries before scapular fractures.**
- **CT scan with 3D reconstruction is pivotal for better delineation of fracture anatomy, and therefore critical for decision making.**
- **Most scapular fractures of the body can be managed conservatively.**
- **Surgical criteria are debatable. Substantially displaced intra- and/or extra-articular fractures with articular step-off > 4mm, LBO > 15-20 mm, angulation > 30-45^0, GPA < 22^0, glenoid involvement of > 25 % are the most explicitly cited surgical indications.**
- **Double disruption of SSSC with substantial displacement (> 10 mm) also demands surgical stabilization.**
- **Posterior approach (Judet incision) is the workhorse for scapular fixation.**
- **Early involvement of physical therapy is paramount for good outcome.**
- **Nerve injury (brachial plexus, axillary, suprascapular) is the independent predictor of poor outcome.**

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FIGURE LEGENDS

Figure 1: Depicting Glenopolar angle measurement. A: Normal (Range 30-45^0); B: Abnormal.

Figure 2: Illustrating measurement of displacement. A: Angulation; B: Lateral border offset (distance measured between lateral-most point of distal fragment and lateral-most point of proximal fragment).

Figure 3: Classification of glenoid fracture.

Figure 4: Classification of scapular neck fracture.

Figure 5: Case example 1. Antero-posterior radiograph (A) and 3 D CT scan of shoulder demonstrating high-energy scapular fracture. Intra-operative photograph (C) of extensile Judet exposure depicting stabilization of fracture with plate. Post-operative antero-posterior shoulder radiograph (D) showing restoration of scapular anatomy with plate.

Figure 6: Case example 2. Axial CT (A) and 3D CT scan (B) of shoulder showing high-energy scapular fracture with comminution and glenoid involvement. Intra-operative photograph (C) showing extensile Judet exposure and fracture stabilization with mini-fragment plates. Deltoid had been released from scapular spine and reflected laterally (white arrow). Post-operative image (D) depicting Judet incision. Restoration of scapular anatomy is evident in post-operative antero-posterior shoulder radiograph (E). Patient regained excellent range-of-motion of involved shoulder (F).

Figure 7: Diagram depicting anatomy of superior shoulder suspensory complex.